Project Research for Disaster Prevention in Southern Africa

Final Report

March 2022

Pacific Consultants Co., Ltd.
Oriental Consultants Global Co., Ltd.
Nippon Koei Co., Ltd.

Table of Contents

Abbreviations

Abbreviation	Name
AAL	Average Annual Loss
ACC	Area Control Center
ACM	Aviation Civile de Madagascar
ACZ	Airports Company of Zimbabwe
ADEMA	Aéroports de Madagascar
ADM	Aeroportos de Moçambique
AFD	Agence française de développement
AfDB	African Development Bank
AIAS	Administração de Infra-Estruturas de Água e Saneamento
AML	Airports of Mauritius Co. Ltd
ANACM	National Agency of Aviation and Meteorology
ANAM	National Agency of Maritime Affairs
ANE	Administração Nacional de Estradas / National Road Administration
APC	Port Authority of the Comoros
APMF	Agence Portuaire Maritime et Fluviale
ARM	Autorité Routière de Madagascar
ARPOC	Project on Strengthening Resilience in Cyclone Idai-Affected Areas
ARTEC	Autorité de Régulation des Technologies de Communication
AU	African Union
AURA	Autoridade Reguladora de Água
BBB	Build Back Better
BCP	Business Continuity Plan
BLP	Building and Land Use Permit
BNGRC	Bureau National de Gestion des Risques et des Catastrophes
BWB	Blantyre Water Board
C/P	Counterpart
CAAZ	Civil Aviation Authority of Zimbabwe
CEAR	Central East African Railways
CEB	Central Electricity Board
CFM	Portos e Caminhos de Ferro de Moçambique
CHCL	Cargo Handling Corporation Ltd
CIF	Climate Investment Funds
CMB	Conselho Municipal da Beira
CMI	Corridor Management Institution
COMESA	Common Market for Eastern and Southern Africa
CPF	Country Partnership Framework
CPGU	Cellule de Prévention et Gestion des Urgences
CSP	Country Strategy Paper
DCA	Department of Civil Aviation
DICT	Department of Information Communications Technology
DGM	Direction Générale de Météorologie

Abbreviation	**Name**
DNAAS	Direcção Nacional de Abastecimento de Água e Saneamento
DNGRH	Direcção Nacional de Gestão de Recursos Hídricos
DoDMA	Department of Disaster Management Affairs
DoT	Department of Transport
DRM	Disaster Risk Management
DRRMP	Disaster Risk Reduction Management Platform
DRTSS	Department of Road Traffic and Safety Services
EAC	East African Committee
EGENCO	Electricity Generation Company of Malawi
EIB	European Investment Bank
EPZ	Export Processing Zone
ESCOM	Electricity Supply Corporation of Malawi
ETC	Emergency Telecommunications Cluster
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FIPAG	Fundo de Investimento e Património do Abastecimento de Água
FIC	Flight Information Center
FIR	Flight Information Region
GFATM	Global Fund to Fight AIDS， Tuberculosis and Malaria
GAVI	Global Alliance for Vaccines and Immunization
GCF	Green Climate Fund
GFDRR	Global Facility for Disaster Reduction and Recovery
GEF	Global Environment Facility
GIZ	Gesellschaft für Internationale Zusammenarbeit
GREPOC	Gabinete de Reconstrução Pós-Ciclone Idai / Post Cyclone Reconstruction Cabinet
ICAO	International Civil Aviation Organization
ICZM	Integrated Coastal Zone Management
IDA	International Development Association
INAM	National Institute of Meteorology
INCM	Instituto Nacional das Comunicações de Moçambique
INGC	The National Institute of Disaster Management
INGD	Instituto Nacional de Gestão Redução do Risco de Desastres
IORA	The Indian Ocean Rim Association
IWRM	National Integrated Water Resource Management
JICA	Japan International Cooperation Agency
JIRAMA	Jiro sy rano malagasy
JTSR	Joint Transport Sector Review
JV	Joint Venture
LRT	Light Rapid Transit
LWB	Lilongwe Water Board
MAEP	Ministère de l'Agriculture, de l'Elevage et de la Pêche
MTP	Ministère des Travaux Publics
MAIWD	Ministry of Agriculture, Irrigation and Water Development

Abbreviation	Name
MDHAEC	Ministry of Defense, Home Affairs and External Communications
MEAH	Ministère de l'Eau, l'Assainissement et de Hygiène
MEECC	Ministry of Environment, Energy and Climate Change
MEL	Metro Express Limited
MGDS	Malawi Growth and Development Strategy
MINEDH	Ministério de Educação e Desenvolvimento Humano
MITADER	Ministério da Terra , Ambiente eE Desenvolvimento Rural
MMS	Mauritius Meteorological Service
MNICD	Ministry of National Infrastructure and Community Development
MOPHRH	Ministério das Obras Públicas, Habitação e Recursos Hídricos
MoTID	Ministry of Transport and Infrastructure Development
MoTPW	Ministry of Transport and Public Works
MPA	Mauritius Port Authority
MPWH	Ministry of Public Works and Housing
MTA	Ministry of Land and Environment
MTC	Ministério dos Transportes e Comunicações
NAP	National Adaptation Plan
NAPA	National Adaptation Programe of Action
NCCAMS	National Climate Change Adaptation and Mitigation Strategy
NCCAPF	National Climate Change Adaptation Policy Framework
NCCIP	National Climate Change Investment Plan
NCCRS	National Climate Change Response Strategy
NDC	National Determinded Contribution
NDMC	National Disaster Management Centre
NDRRMC	National Disaster Risk Reduction and Management Centre
NEPAD	New Partnership for Africa's Development
NRZ	National Railways of Zimbabwe
NTMP	Malawi National Transport Master Plan
OCHA	UN Office for the Coordination of Humanitarian Affairs
ODA	Official Development Assistance
PDNA	Post Disaster Needs Assessment
PMO	Paritra Malagasy zary Ohabolana
PND	Plan National de Developpement
PNI	Programa Nacional de Irrigação 2017-2042
PNT	Plan National de Transport
PPCR	Pilot Programme for Climate Resilience
PPP	Public Private Partnership
PQG	Programa Quinquenal do Governo 2020-2024
PR	Public Relations
PRONASAR	Programa Nacional de Abastecimento de Água e Saneamento Rural
PUDi	Plan d'Urbanisme Directeur
RA	Roads Authority
RDA	Road Development Authority
RFF	Rescue Fire Fighting
RINA	Zimbabwe Rapid Impact and Needs Assessment

Abbreviation	**Name**
RTC	Road Transport Commission
SAA	Seychelles Agricultural Agency
SADC	Southern African Development Community
SCA2D	Stratégie de Croissance Accélérée et de Développement Durable 2015-2019
SLTA	Seychelles Land Transport Authority
SMMC	Société de Manutention des Marchandises Conventionnelles
SNS	Social Networking Service
SPA	Seychelles Ports Authority
SPAT	Société du Port à Gestion Autonome de Toamasina
SPCR	Strategic Programme for Climate Resilience
SSR International Airport	Sir Seewoosagur Ramgoolam International Airport
TaToM	Tananarive-Toamasina, Madagscar
TTTFP	Tripartite Transport &Transit Facilitation Programme
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UN-Habitat	United Nations Human Settlement Programme
UNICEF	United Nations Children's Fund
UNISDR	United Nations International Strategy for Disaster Reduction
USAID	United States Agency for International Development
WB	World Bank
WFP	World Food Programme
WHO	World Health Organization
WMO	World Meteorological Organization
WUAs	Water User Associations
ZILGA	Zimbabwe Local Government Association
ZINARA	Zimbabwe National Road Administration

Schedule of Field Survey

The Field surveys were conducted on 4 target countries as following schedule;

Country	Schedule
Mozambique	10/6~11/16, 2021
Mauritius	1st Survey：10/17~11/6, 2021
	2nd survey：1/12~2/3, 2022
Madagascar	1st Survey：10/17~11/6, 2021
	2nd survey：**※Canceled due to the spread of Covid-19**
Malawi	2/3～2/18, 2022
Zimbabwe	**※Canceled due to the spread of Covid-19 and coodination of acceptance** Desktop survey only
Comoros	Desktop survey only
Seychelles	Desktop survey only
South Africa	Desktop survey only

(1) Mozambique

a) Members

	Name	Roles and Responsibilities	Schedule
1	Sungjoon HONG	Mainstream Disaster Risk Reduction in Critical Infrastructure (Transportation)	10/18~11/6, 2021
2	Toshihiro KATSUMATA	Mainstream Disaster Risk Reduction in Critical Infrastructure (Telecommunications)	10/18~11/6, 2021
3	Ai SHIGEMATSU	Mainstream Disaster Risk Reduction in Critical Infrastructure (Water and sanitation)	10/18~11/6, 2021
4	Takuya ITO	Mainstream Disaster Risk Reduction in Critical Infrastructure (River and coastal management)	10/6~11/6, 2021 (Work Period：7 days)
5	Yusuke YAMASAKI	Mainstream Disaster Risk Reduction in Critical Infrastructure (Urban flood)	10/6~11/16, 2021 (Work Period:10/6-10/23, 11/11-11/16)
6	Natsuki FUJIMOTO	Mainstream Disaster Risk Reduction in Critical Infrastructure (Education and health) 3	10/18~11/6, 2021 (Work Period: 7 days)
7	Motoyo ARAKI	Urban Development Plans 2	10/6~11/11, 2021 （Work Period: 7 days）
8	Daiki TSUJIO	Disaster Risk Assessment	10/25~11/11, 2021 (Work Period: 10/25-10/31, 11/6-11/11）
9	Ayuu HORIUCHI	Training Plans (workshops, etc.)/Project Coordination 2-1	10/18~11/6, 2021

b) Institutions Visited in the Survey

	Agency	Sector
1	National Road Administration（ANE）	Transportation, Infrastructure, Telecommunication
2	Portos e Caminhos de Ferro de Moçambique（CFM）	
3	Beira International Airport	
4	CENOE	
5	WFP Mozambique	
6	Direcção Nacional de Abastecimento de Água e Saneamento（DNAAS）, Administração de Infra-Estruturas de Água e Saneamento（AIAS）	River, Drainage, Water and sanitation
7	ARA Sul	
8	Serviço Autónomo de Saneamento da Beira（SASB）	
9	National Institute of Meteorology（INAM）	
10	Direcção Nacional de Gestão de Recursos Hídricos（DNGRH）	
11	Instituto Nacional de Irrigação（INIR）	Agriculture
12	Ministério de Educação e Desenvolvimento Humano（MINEDH）	Education and health
13	Ministério da Saúde（MISAU）	
14	Instituto Nacional de Gestão Redução do Risco de Desastres（INGD）	Urban Development Plans, DRR
15	Maputo State Secretary, Ministry of Land and Environment（MTA）	
16	Maputo City	
17	Matola City	

(2) Mauritius

1) First Trip

a) Members

	Name	Roles and Responsibilities	Schedule
1	Massaki CHIIDA	Project Manager/Disaster Prevention Administration 1/Local Disaster Prevention Plan 1	11/6~11/14, 2021
2	Masato AKASHI	Deputy Project Manager/Disaster Prevention Administration 2/Local Disaster Prevention Plan 2	11/6~11/14, 2021
3	Yumi TAKAYAMA	Support on Local Disaster Prevention Plans 2/Project Coordination 1	11/6~11/14, 2021

b) Institutions Visited in the Survey

	Agency	Sector
1	Ministry of Local Government, Disaster and Risk Management	Urban Development Plans, DRR
2	National Disaster Risk Reduction and Management Centre（NDRRMC）	
3	National Development Unit	Transportation
4	Land and Drainage Authority（LDA）	Water and sanitation
5	Wastewater Management Authority（WMA）	
6	Mauritius - Ministry of Environment, Solid Waste Management and Climate Change	River and coastal management
7	Mauritius Meteorological Service（MMS）	Climate change
8	12 Municipals (DRR officers)	Local government
9	UN-HABITAT	Donor
10	Indian Ocean Commission（IOC）	

2） Second Trip

a) Members

	Name	Roles and Responsibilities	Schedule
1	Massaki CHIIDA	Project Manager/Disaster Prevention Administration 1/Local Disaster Prevention Plan 1	1/12~2/3, 2022
2	Motoyo ARAKI	Urban Development Plans 2	1/12~2/3, 2022
3	Yumi TAKAYAMA	Support on Local Disaster Prevention Plans 2/Project Coordination 1	1/12~1/25, 2022
4	Ayuu HORIUCHI	Training Plans (workshops, etc.)/Project Coordination 2-1	1/12~2/1, 2022
5	Asuka SUZUKI	Training Plans (workshops, etc.)/Project Coordination 2-2	1/12~1/25, 2022

b) Institutions Visited in the Survey

	Agency	Sector
1	Embassy of Japan in Mauritius	Urban Development Plans, DRR
2	National Disaster Risk Reduction and Management Centre（NDRRMC）	
3	Land and Drainage Authority（LDA）	Drainage, Urban Development Plans, DRR
4	University of Mauritius	DRR regional network
5	Grand Port District Council	Local government
6	Municipality Beau-Bassin Rose-Hill	
7	Savanne District Council	

(3) Malawi

a) Members

	Name	Roles and Responsibilities	Schedule
1	Massaki CHIIDA	Project Manager/Disaster Prevention Administration 1/Local Disaster Prevention Plan 1	2/3～2/18, 2022
2	Motoyo ARAKI	Urban Development Plans 2	2/3～2/18, 2022
3	Hitomi OBARA	Mainstream Disaster Risk Reduction in Critical Infrastructure (Agriculture)	2/3～2/16, 2022
4	Takuya ITO	Mainstream Disaster Risk Reduction in Critical Infrastructure (River and coastal management)	2/3～2/18, 2022

b) Institutions Visited in the Survey

	Agency	Sector
1	Blantyre Water Board (BWB) ※Interview didn't be set, only documents were provided	Water and sanitation
2	Walkers Ferry Water Treatment Plant	
3	Roads Authority (RA) ※Interview didn't be set, only documents were provided	Road, Transportation, Infrastructure
4	Malawi Communications Regulatory Authority（MACRA） ※Interview didn't be set, only documents were provided	Telecommunication
5	Department of Disaster Management Affairs（DoDMA）	River, Agriculture
6	Department of Agricultural Planning Services	
7	Blantyre City Council　Directorate of Urban Planning and Estate Management	Urban Development Plans
8	Lilongwe City Civil Protection Committee	
9	Cblantyre City Civil Protection Committee	Local government
10	Lilongwe City	

(4) Madagascar

a) Members

	Name	Roles and Responsibilities	Schedule
1	Massaki CHIIDA	Project Manager/Disaster Prevention Administration 1/Local Disaster Prevention Plan 1	10/17~11/6, 2021
2	Masato AKASHI	Deputy Project Manager/Disaster Prevention Administration 2/Local Disaster Prevention Plan 2	10/17~11/6, 2021
3	Yumi TAKAYAMA	Support on Local Disaster Prevention Plans 2/Project Coordination 1	10/17~11/6, 2021

b) Institutions Visited in the Survey

	Agency	Sector
1	Bureau National de Gestion des Risques et des Catastrophes（BNGRC）	Urban Development Plans, DRR
2	Aviation Civile de Madagascar (ACM)	Transportation
3	Ministry of Public Works	
4	Ministry of Water, Sanitation, and Hygiene	Water and sanitation
5	Agence Portuaire Maritime et Fluviale (APMF)	River and coastal management
6	Société du Port à Gestion Autonome de Toamasina(SPAT)	
7	Ministre de l'Environnement et du Développement Durable	Climate change
8	Direction Générale de Météorologie（DGM）	
9	Antananarivo City (Commune)	Local government
10	Toamasina City	

CHAPTER 1 Project Overview

1.1 Project Background

In sub-Saharan Africa, about 90% of the deaths from natural disasters over the past 50 years have been due to drought. On the other hand, in recent years in 2018 and 2019, the East African region has been severely affected by floods, and floods and large cyclones have caused damage every year in the Southern African islands (Mauritius, Seychelles, Reunion, Madagascar, and Comoros) and every few years since 1990 in the continental areas (Mozambique, Malawi, Zimbabwe, and South Africa).

In March 2019, large Cyclone Idai landed in Mozambique, Malawi, and Zimbabwe. In Mozambique, more than 600 people were killed, more than 1,600 injured, and 1.85 million people affected. In Malawi, enormous human suffering occurred with 60 dead, and in Zimbabwe, more than 4,000 buildings were completely or partially destroyed. In addition, the loss of livestock, farming implements, and crop seedlings and seeds due to flooding in these countries causes economic damage and leads to food shortages and malnutrition. In April of the same year, Cyclone Kenneth made landfall in Mozambique and the Comoros, causing extensive damage.

Since 1994, the Southern African region has been affected by major cyclones on the scale of category 5, the largest in the five-level classification of cyclones, which is believed to have been caused by rising sea surface temperatures due to climate change and other factors (OCHA, 2019). The damage caused by cyclones, which used to be limited to islands, is now spreading to the continent. In response to changes in the intensity and frequency of cyclones, disaster risk reduction management in the Southern African region has become an urgent issue. The Mozambican government estimated that about 1.62 million people could have been affected by heavy rains, cyclones, and floods in 2019-2020. Also, according to The World Risk Report 2017, the Southern African region is highly vulnerable to disasters and even less able to respond to them.

The Japan International Cooperation Agency (JICA) has been providing emergency aid, including the provision of emergency relief supplies and the dispatch of international emergency relief teams, whenever natural disasters such as those mentioned previously occur in Africa. In addition, assistance has been provided to some African countries through technical cooperation projects to improve meteorological observation capacity, grant aid for the installation of meteorological radars, and issue-specific training in the field of disaster risk reduction, to help them understand and share disaster risks. In Mozambique, we are also supporting reconstruction and disaster risk reduction measures in Cyclone Idai affected areas. However, the scale of human and economic damage caused by major cyclones in Southern Africa is expected to increase in the future, and it will be necessary to further strengthen disaster risk reduction efforts in order to ensure sustainable development in the region.

In this study, in order to examine and propose specific cooperation that JICA should implement in the mid- to long-term, we will examine and analyze disaster risks and the current status of disaster risk reduction systems and initiatives in Southern Africa, which has recently suffered extensive damage from floods and cyclones. In addition, support will be provided to promote cooperation and knowledge sharing among the countries concerned.

1.2 Objectives and Scope of the Project

1.2.1 Objective

The purpose of this survey is to study and analyze the current status of major disasters occurring in the Southern African region, and plans and systems for disaster risk reduction, infrastructure development, administrative processes, etc., in each country, and to examine and propose specific cooperation proposals that should be promoted in each country, as well as to promote the strengthening of cooperation among the countries concerned.

1.2.2 Target Area

Within the Southern African Region, the target area includes Mozambique, Madagascar, Malawi, Zimbabwe, Mauritius, South Africa, Comoros, and Seychelles (only literature review was conducted for Comoros and Seychelles).

1.2.3 Project Period

The project period is January 25, 2021, to March 15, 2022 (14 months in total).

CHAPTER 2 Methodology of the Study

2.1 Data Collection on Disaster Risk Reduction (DRR) Related Information

2.1.1 Objectives of the Data Collection

We conducted a survey to understand the overview of hazard risks. The purpose of the survey was to understand and organize the overview of the target countries from three perspectives: the overview of the risks, the urban development and donor support, and to select cities and regions that should be studied and investigated intensively in each country. The results of the overview will be described in Chapter 3, Overview of Each Country. In this chapter, we describe the analysis method to identify the overview.

2.1.2 Identification of Hazard and Disaster Risk Information

(1) Identification and Analysis of the Disaster Risk Profile

The JICA survey team conducted data collection and analysis on the following four items in order to identify cities and regions with high disaster risk which has a high possibility of being affected by floods, cyclones, storm surge and landslides. In addition, the team analyzed the damage situation disaggregated by sector.

- Hazard distribution: Results of hazard analysis for flood, cyclone, storm surge and landslides disaster.
- Population: Population of major cities and population distribution (density).
- Potential economic loss: Potential economic loss of each disaster type was calculated based on the distribution of population and hazard using GIS analysis.
- Damage by sector: Actual and estimated damage and loss disaggregated by sector was collected from existing reports such as the Disaster Risk Profile published by the Global Facility for Disaster Reduction and Recovery (GFDRR) or the Post-Disaster Needs Assessment (PDNA) published in previous disasters.

Collected data was visualized with GIS or summarized to be analyzed in order to identify cities and areas with high disaster risk.

The analysis of disaster risk was conducted by narrowing down the target cities in three stages. Cities with large populations also have large property accumulation, and in case of an event of disaster the economic losses would be massive, and thus investing in DRR counter measures in these cities is important to reduce economic loss.

Firstly, we conducted a qualitative assessment of the hazard distribution targeting about five cities in each country, including cities with more than 100,000 population size or major cities at the state level such as state capitals.

Secondly, we selected about two major cities with large populations including the capital city to analyze disaster risks. In case the hazard in the second largest city is not notable and obviously large in other cities, the city with a large hazard was targeted instead of the second largest city. In the analysis of disaster risks, quantitative assessment was conducted to calculate potential economic loss in the cities based on the distribution of hazard and populations in order to better understand the situation of hazard risk and its possible damage and loss.

In addition, in order to identify trends by sector or region, information on estimated or actual damage and loss disaggregated by sector was compiled from previous reports. The flow of the preceding analysis is shown in Figure 2-1 following.

Figure 2-1 Steps in Disaster Risk Analysis

Source: Compiled by the JICA Study Team

Table 2-1 following provides the details and sources of the data used for the Figure 2-1 analysis.

Table 2-1 Data used to identify disaster risks profile

Item		Data used	Source
Hazard type	Flood	Estimated inundation depth for 100-year return period flood based on global scale hydrological analysis	JRC Data Catalogue[1] Aqueduct Floods Hazard Maps[2]
		Map of flooding area based on satellite image analysis	Copernicus[3]
	Cyclones (Strong wind)	Annual cumulative maximum wind speed based on information of past cyclones	UNEP Global Risk Data Platform[4]
	Storm Surges	Estimated inundation areas and inundation depth due to Storm Surge caused by past cyclones	UNEP Global Risk Data Platform[4]
	Landslide	Landslide potential based on Topography, geology, and vegetation information evaluated by satellite image analysis	NASA[5]
Population		Metropolitan area population and estimates of major metropolitan areas.	UN-Habitat urban data site[6]
		Population estimates of major cities	World Population Review[7]
		Population distribution in each country (persons/100m*100m)	WorldPop[8]
Damage and loss disaggregated by sector		Disaster Risk Profile issued by GFDRR	Described in detail following
		PDNA for past disasters	Described in detail following
		Disaster damage statistics compiled by each government	DesInventar[9]

Source URL:
1 https://data.jrc.ec.europa.eu/collection/FLOODS
2 http://wri-projects.s3.amazonaws.com/AqueductFloodTool/download/v2/index.html
3 https://emergency.copernicus.eu/mapping/list-of-activations-rapid
4 https://preview.grid.unep.ch/index.php?preview=data&lang=eng
5 https://earthobservatory.nasa.gov/images/89969/overlooked-landslides
6 https://data.unhabitat.org/datasets/population-in-urban-agglomerations-2000-2035-thousands/explore
7 https://worldpopulationreview.com/countries/mozambique-population
8 www.worldpop.org
9 https://www.desinventar.net/

Source: Compiled by the JICA Study Team

(2) Details of the Data Used for Identification of Hazard Risk Profile

1) Floods

Two types of global scale hydrological models were used to examine the inundation area due to river flooding in the Southern African region. The EU Joint Research Centre (JRC) model and the GLOFRIS model were used.

Since the purpose it is to understand a rough overview of flood risk, the inundation areas of both models are referenced, and the flood risk was visualized by overlapping the inundation of both models. Examples of the risk analysis results for both models are shown in following Figure 2-2 .

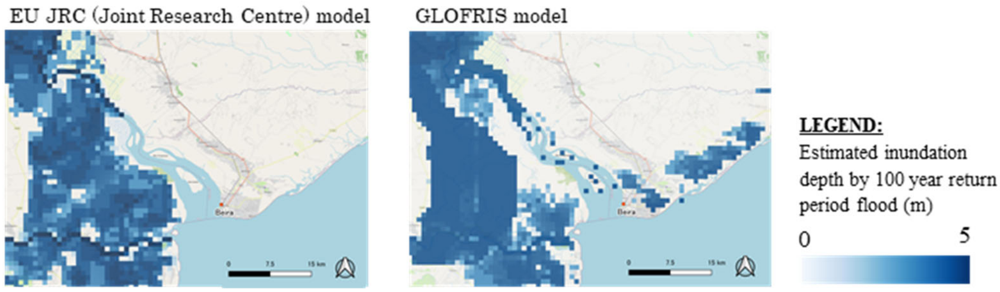


Figure 2-2 Example of flood analysis results using global scale hydrological models

Source: JRC Data Catalogue (left figure), Aqueduct Floods Hazard Maps (right figure), Open Street Map (base map)

If available, inundation areas from previous disasters were also referenced for evaluation of hazard. The following figure shows the example of inundation areas caused by past disasters in northern Madagascar.

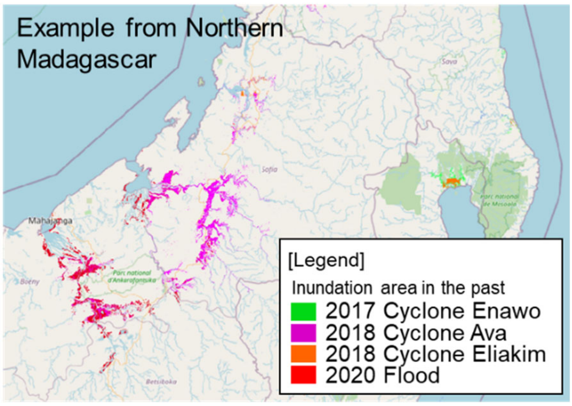


Figure 2-3 Example of inundation area detected from satellite image analysis

Source: Copernicus

2) Cyclones

For cyclone hazards, the annual cumulative maximum wind speed and cyclone routes were referenced. Annual cumulative maximum wind speed of past cyclones for the period 1975 to 2007, and actual cyclone route maps for the period 1970 to 2015, available in the UNEP database, were used. An example of the data is shown in Figure 2-4 following.

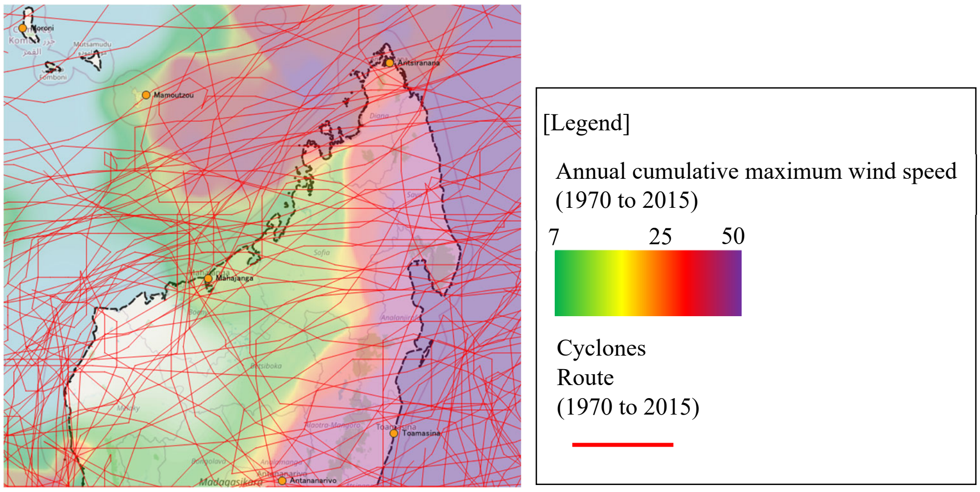


Figure 2-4 Example of data for identifying the hazard of Cyclones (Strong wind)

Source: UNEP Global Risk Data Platform, Open Street Map (base map)

3) Storm Surge

For storm surge, inundation areas caused by past cyclones and the path of cyclone routes were referenced. Inundation areas by storm surge caused by past cyclones for the period 1975 to 2007, and the actual cyclone route for the period 1970 to 2015, available in the UNEP database were used. An example of the data is shown in Figure 2-5 following.

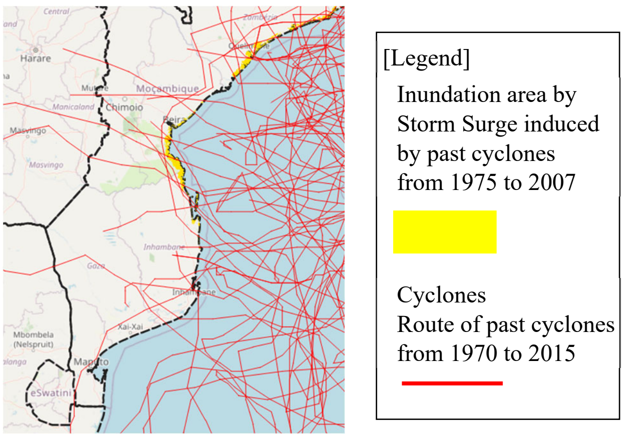


Figure 2-5 Example of data used to identify the hazard of storm surge

Source: UNEP Global Risk Data Platform, Open Street Map (base map)

4) Landslide

For landslide hazard, information from UN-related reports for each country was referenced. Since slopes without infrastructure do not cause impact, detailed analysis must be conducted at the city level. The Landslide potential score analyzed by NASA based on topographical conditions (plains, high ground, adjacent to mountainous areas, etc.) was used. An example of the data is shown in Figure 2-6 following.

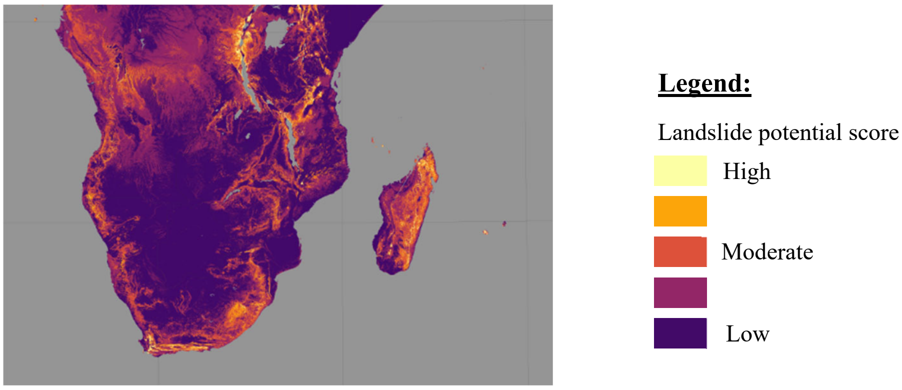


Figure 2-6 Example of data used to identify landslide potential

Source: NASA

5) Population

Information on estimated population was collected to identify the top ten large population cities in each country. Multiple sources were checked to determine the population of major cities. The Database of the United Nations Human Settlements Program (UN-Habitat) was referenced for cities with large population sizes. Opensource data was referenced for cities with smaller populations such as GeoNames, the United Nations population estimates (World Population Prospects 2019), and the World Population Review which summarizes the data from each national statistical office.

For the population distribution, population density data from WorldPop (population per 100m x 100m mesh) was referenced. An example of the data is shown in Figure 2-7 following.

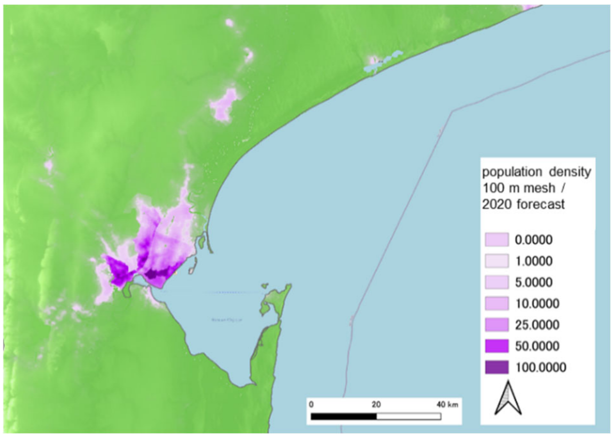


Figure 2-7 Example of population distribution data

Source: WorldPop, NASA SRTM topographic data and Open Street Map(base map)

6) Damage and loss disaggregated by Sector

a) Disaster Risk Profile published by GFDRR

The Global Facility for Disaster Reduction and Recovery (GFDRR) is an institution whose secretariat is served by the World Bank, and which is responsible for promoting the International Disaster Risk Reduction Frameworks based on a partnership of bilateral donors, the United Nations Office for Disaster Risk Reduction (UNDRR) and the World Bank. The GFDRR has published disaster risk profiles for selected African countries. Among the target countries of this survey, disaster risk profiles have been published for Mozambique, Madagascar, Malawi, Mauritius, Comoros, and Seychelles. Based on a database of hazard and asset distributions, the report analyzes the potential damage for each state/province in the following sectors: housing, education and health facilities, roads and railroads, and agriculture. The sources and details of the data to be used will vary from country to country and will be described in the analysis section for each country.

b) PDNA (Post Disaster Needs Assessment) for Past Disasters

PDNA is designed to estimate and evaluate the amount of assistance needed for recovery and reconstruction in affected countries in the event of a major disaster and is prepared based on the standards of guidelines developed by the World Bank and UN agencies. It is able to identify the damage and loss status and reconstruction needs of each sector due to past large-scale disasters by analyzing the PDNA. Countries for which PDNAs have been prepared for past large-scale disasters are as follows.

Table 2-2 List of PDNAs prepared in the target countries of this survey

Target country	Year of PDNA preparation (disaster type)
Mozambique	2019 (Cyclone), 2015 (Flood), 2000 (Flood/Cyclone)
Madagascar	2008 (Cyclone)
Malawi	2019 (Cyclone), 2015 (Flood), 2012 (Flood)
Zimbabwe	2019 (Cyclone)
Mauritius	No PDNAs prepared
Comoros	No PDNAs prepared
Seychelles	2016 (Cyclone), 2013 (Flood)

c) Disaster damage and loss statistics compiled by each government

According to the Sendai Framework for Disaster Risk Reduction (Sendai Framework) adopted in 2015, governments are required to compile disaster damage and loss data and prepare disaster statistics that are disaggregated by region and sector, and the data compiled by governments are available on the website[1].

The disaster damage and loss statistics for each country includes data by sector such as the number of deaths, injuries, damaged houses, damaged farmland area, damaged road extension, and economic losses. The data accuracy of these statistics depends on the capacity of each country, and the items covered differs among countries, however these data were used since these are assumed as an official statistical information approved by each government. Among the target countries of this survey, disaster damage statistics have been developed in Mozambique, Madagascar, Malawi, Mauritius, Comoros, and Seychelles.

(3) Methodologies for Disaster Risk Analysis

1) Qualitative Evaluation of Hazard Distribution

Each hazard was rated from "✓" to "✓✓✓" according to the criteria shown in Table 2-3 following to understand the profile of the hazard in major cities (about five cities in each country).

[1] https://www.desinventar.net/

Table 2-3 Criteria of qualitative evaluation for each disaster type

Evaluation	Disaster type			
	Floods	**Cyclones**	**Storm Surge**	**Landslide**
✓✓✓	There are areas with inundation depths of 5 m or more / more than half of the urbanized area is inundated	Cumulative maximum wind speed of 25 m/sec or more (red to purple)	Large portions of urban areas will be flooded.	Landslide potential is High level (steep mountainous areas, etc.)
✓✓	Less than half of the urbanized area is flooded.	Cumulative maximum wind speed is 25 m/sec or less (green to yellow)	Flooding damage to urban areas and surrounding areas	Landslide potential is Medium level (e.g., districts adjacent to mountainous areas)
✓	Flooded areas exist in urbanized areas.	Affected by cyclones	Located in coastal area and affected by cyclones	Landslide potential exists
—	No or minor risk of flooding	Not affected by cyclones	Not affected by cyclones	No potential of landslide, such as in plain areas

2） Estimation of Potential Economic Loss due to Disasters

Two cities from each country where disaster risk is high and asset accumulation is progressing, and the need for disaster risk reduction measures is high were selected. Potential economic loss was estimated based on the distribution of the population in the hazard area.

In order to estimate the potential economic loss due to disasters, the population located within the area where hazards exceeding a specific threshold estimated based on hazard information and population distribution (population per 100m*100m). The estimated population was then multiplied by the country's GDP per capita (USD/person) to calculate the maximum potential damage that the city could possibly suffer in the event of a disaster. Table 2-4 following shows the threshold for each hazard type. However, since more detailed information is available for Mozambique, data from other sources was also used. For details, see Chapter 3, Country Overview.

Table 2-4 Thresholds used to estimate potential economic loss due to disasters

Disaster type		Data source	Threshold/Remarks
Hazard type	Floods	Estimated inundation area and inundation depth (m) for 100-year return period flood based on global scale hydrological analysis	The whole inundation area
	Cyclones/ Strong Wind	Annual cumulative maximum wind speed based on information of past cyclones (km/h x annual cumulative amount)	117km/h (annual accumulation) *Wind speed that corresponds to 33m/s and is classified as Typhoon or Hurricane in the international classification.[2]
	Storm Surge	Estimated inundation areas and inundation depth due to Storm Surge caused by past cyclones (m)	The whole inundation area
	Landslide	Landslide potential based on Topography, geology, and vegetation information evaluated by satellite image analysis (evaluation score divided from 1 to 5)	Evaluation score 3 or higher
Populati	Population Distribution	Population distribution in each country (persons/100m*100m)	Population per mesh was calculated from the data of population density per 100m mesh.
GDP	GDP per capita	GDP per capita in each country (current USD/person, 2020) *Source: World Bank website, Mozambique National Institute of Statistics.	Potential economic loss was estimated by multiplying affected population by GDP per capita.

3) Identifying Disaster Risks by Sector and Region

Information on disaster damage and loss by sector was collected from various data such as GFDRR disaster risk profiles, PDNAs of each country, and disaster damage statistics.

The GFDRR disaster risk profile identifies the scale of damage in the following sectors: buildings (general), industrial and commercial facilities, public facilities, educational and health facilities, transportation infrastructure, and agriculture, as well as the distribution of disaster risk across the country.

The data collected from PDNA includes disaster damage and loss by industry sector (agriculture, fisheries, industry and commerce, tourism), asset type (housing, education, health), and infrastructure type (transportation, power and telecommunications, water, and sewage) and this was summarized to be able to compare among countries and disaster events within a country.

The disaster damage and loss statistics of the governments of each country includes data disaggregated by sector for housing, educational facilities, health facilities, farmland, livestock, roads, and other items.

2 http://agora.ex.nii.ac.jp/digital-typhoon/help/unit.html.ja

2.1.3 Identification of Urban Development Status

In each of the countries surveyed, development trends at the national level and trends in major cities and for infrastructure development were grasped in order to examine disaster risk reduction measures and infrastructure countermeasures based on local development trends and needs by analyzing them together with the overview of disaster risks. Specifically, we collected and organized information on each country from the perspectives of (1) national land axis and strategically important cities, (2) cross-border infrastructure, (3) location of important industries, and (4) urban development systems (housing, urban planning, etc.).

2.1.4 Identification of DRR Policies and Disaster Management Capacity

In order to understand the current disaster risk reduction systems and plans in each of the countries surveyed, the following were researched: laws, regulations, and policies related to disaster risk reduction at the national and regional levels; the status and content of disaster risk reduction plans; budget allocation and coordination mechanisms related to disaster risk reduction; the responsibilities, budgets, and activities of disaster risk reduction-related organizations; and the status of human resource development in the field of disaster reduction. In addition to collecting and organizing information from existing survey materials available through desktop surveys, etc., interviews were conducted with organizations in charge in each country for information whose status cannot be obtained through desktop surveys.

2.1.5 Identification of Trends in Donor Support

Information on the trends in donor support in the countries surveyed and the status of support for projects related to disaster areas and disaster risk reduction was collected and organized from existing survey materials available through desktop surveys, etc., and aid policies of relevant international organizations, in order to examine effective and efficient disaster reduction measures to be implemented in the future. In particular, we referenced an overview of the World Bank's many projects in the field of disaster risk reduction in Southern African countries, as well as an overview of the African Development Bank's assistance trends.

2.1.6 Identification of Challenges and Possible DRR Measures by Sector

Basic information was collected and analyzed to examine supportive measures for disaster risk prevention and mitigation in the sectors of transportation and traffic, electric power, water supply and sewage, telecommunications, education, medical care, agriculture, and river and coastal management. For each sector, the following information was collected and analyzed: (1) overview of organizations (implementation system and role sharing) and legal systems related to designing and promotion of policies and plans, (2) overview of related development and maintenance plans, donor support status for the sector that is particularly relevant to the sector, plans related to disaster risk reduction measures, and measures and policies under implementation, and (3) issues on disaster risk reduction measures of important facilities and areas or the sectors that require disaster risk reduction measures and policies, based on the previously mentioned risk situation. The survey was conducted through desktop research in Japan and information gathering by local consultants and local people. In addition, we traveled to the area as much as possible to discuss with relevant organizations and gather information, even though there were travel restrictions due to the Corona virus pandemic.

2.2 Analysis to Propose Possible DRR Measures

Based on the information collected on disaster risks and the status of disaster risk reduction initiatives, we analyzed sectoral disaster risk reduction issues in each target country surveyed. In addition, based on the trends of disaster risks and donor support, we discussed and organized the priority disaster risk reduction measures that each country should implement for mainstreaming disaster risk reduction and resolving disaster risk reduction issues. Then, a proposal for disaster risk reduction cooperation measures by Japan was discussed, based on the field survey, online consultations with relevant governmental organizations in each country, understanding of the local situation, and consultations with JICA's local office and other related parties.

In addition, a workshop was held in Mauritius to discuss and share information on disaster risk reduction efforts and issues in each country, as well as regional disaster reduction issues and ways of cooperation. Based on interviews and consultations with relevant organizations, the direction of the Southern African Regional Disaster Management Network was discussed.

CHAPTER 3 Data Collection and Analysis on General Situation and Possible Cooperation in DRR by Sector

3.1 Mozambique

3.1.1 Disaster Risk Profile

(1) Qualitative Evaluation of Hazard Distribution

1) Situation of Hazard Distribution in Mozambique

The hazard data described in "2.1.2 How to identify overview of disaster risk" was visualized in GIS to identify the profile of hazard as shown in the figure below.

- The inundation areas caused by floods is distributed along major rivers including transboundary rivers such as Limpopo, Zambezi, and Buzi.
- The coastal areas south of Nacala and the halfway point between Beira and Maputo are affected by cyclones and suffer from storm surge and strong wind.
- The northern part of the country, near the Malawi and Zimbabwe borders, and the upper stream of the Zambezi river have a high potential of landslides.

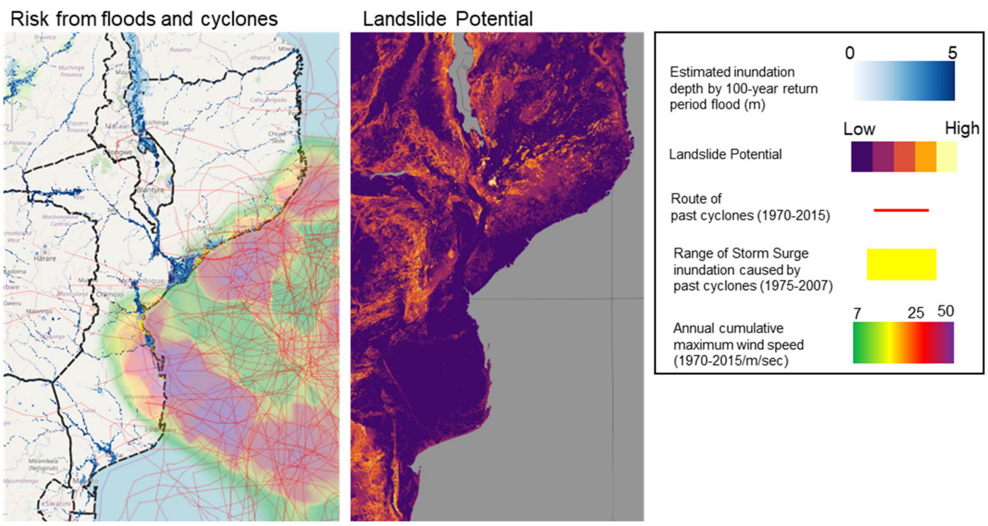


Figure 3-1 Hazard distribution in Mozambique

Source: Each data source is listed in Chapter 2, Open Street Map (background map)

2） Situation of Hazard Distribution in Major Cities of Mozambique

Situation of hazard distribution in each major city was identified according to the criteria shown in "2.1.2 Basic Idea and Methodology to Identify Disaster Risk Profile". The population of major cities was confirmed based on UN-Habitat and World Population Review, and the major cities with large population sizes were sorted out.

Table 3-1 Hazard Status in Major Cities of Mozambique

City name	Population size (thousand persons)	Result of Evaluation			
		Floods	**Cyclones**	**Storm Surge**	**Landslide**
Matola	1,705	✓✓	✓	✓	✓
Maputo	1,110				
Nampula	848	✓	✓✓	—	✓
Beira	570	✓✓✓	✓✓	✓✓✓	—
Chimoio	425	✓	✓	—	✓✓
Quelimane	415	✓✓✓	✓✓	✓✓✓	—
Tete	371	✓✓✓	✓	—	✓✓
Nacala1	225	✓✓	✓✓	✓✓	✓

Source: JICA Study Team

a) Greater Maputo Metropolitan Area

Greater Maputo Metropolitan Area includes the capital city Maputo located in southern Mozambique and the surrounding cities Matola city, Boane city and Marracuene district and the level of hazard was analyzed based on the distribution of each hazard.

Flood hazard was evaluated as “✓✓“ since estimated inundation area is distributed along the rivers surrounding the area, Umbeluzi river in the south, Matola river in the west and Incomati river in the north and, in addition, based on the analysis of the World Bank project[3] the area has a challenge of urban flooding. (Figure bellow (1)).

[3] In the Sanitation and Drainage Master Plan for the Greater Maputo Metropolitan Area developed by AIAS with the support of the World Bank, area where frequently affected by urban flood was mentioned. The area is mentioned in light blue color in the figure.

Storm surge hazard and hazard of the strong wind was evaluated as "✓" since although the Annual accumulative wind speed is not distributed, the area have been damaged by Cyclone Eline in year 2000 and the area are affected by Cyclone occasionally.

Landslide hazard was evaluated as "✓" since the area with high landslide potential score with over the medium level is distributed in city where there is a gap of elevation between the coastal area and the city central area in the south of Maputo (Figure bellow (2)).

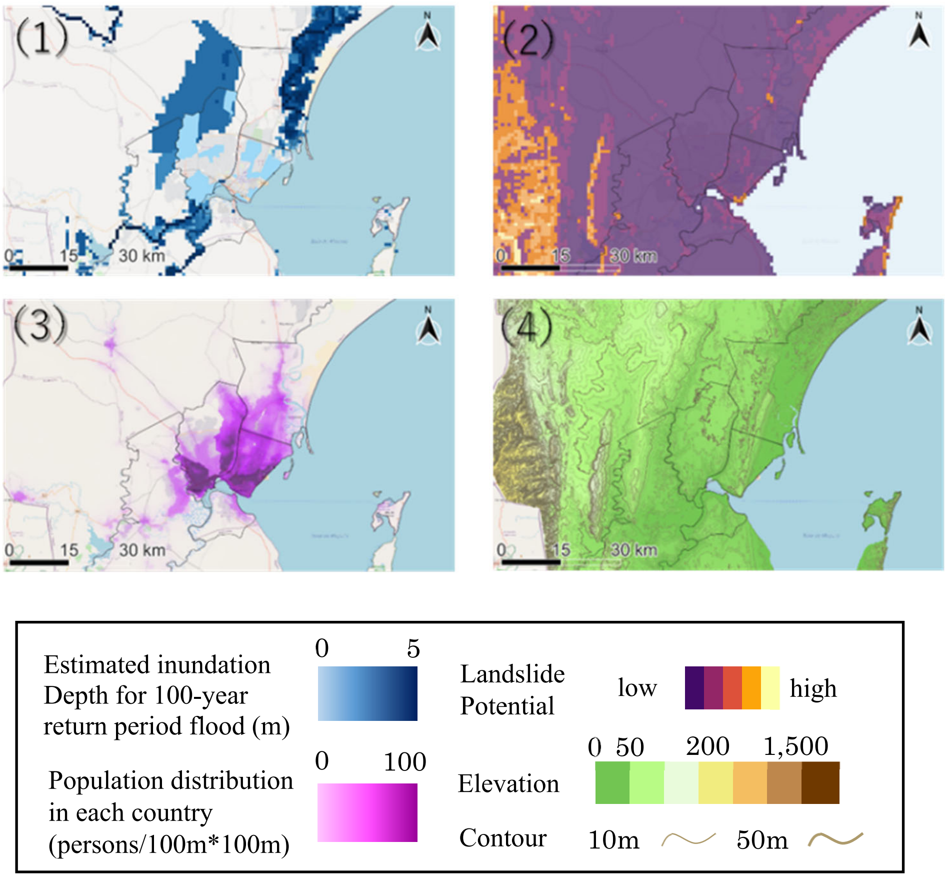


Figure 3-2 Situation of Hazard Distribution in the Greater Maputo Metropolitan Area

Source: JICA Study Team

b) Nampula

Nampula is a city located in northern Mozambique and the level of hazard was analyzed based on the distribution of each hazard.

Flood hazard was evaluated as "-" since estimated inundation area in not distributed in the city (Figure bellow (1)).

Storm surge hazard was evaluated as "-" since it is an inland city. Hazard of the strong wind was evaluated as "✓" since the Annual accumulative wind speed is below 25 m/sec (color in green to yellow) in the whole city area (Figure bellow (5)).

Landslide hazard was evaluated as "✓✓" since the area with high landslide potential score with over the medium level is distributed in the hill side area on the east (Figure bellow (2), (4)).

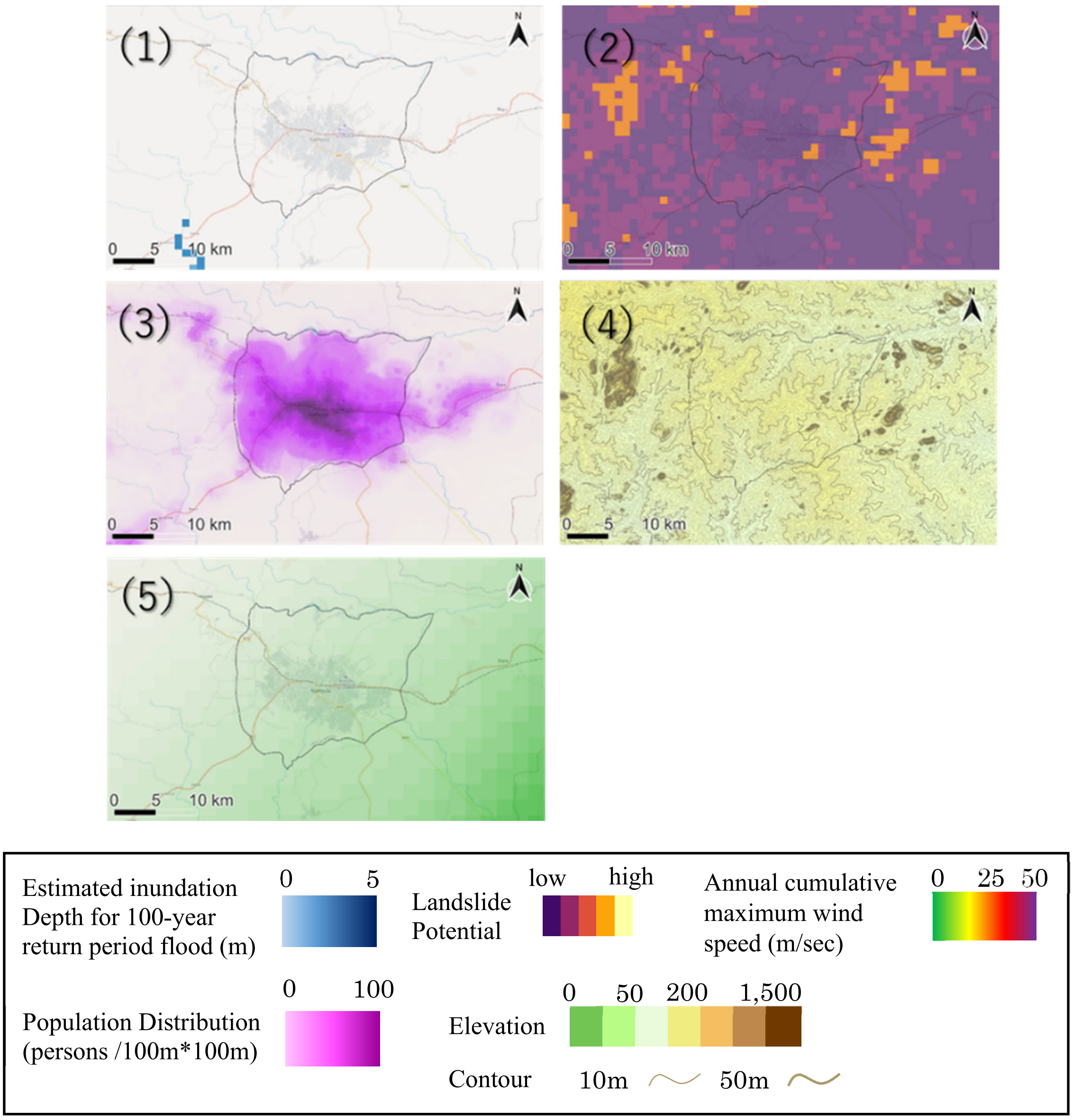


Figure 3-3 Situation of Hazard Distribution in Nampula

Source: JICA Study Team

c) Beira

Beira is a city located in central Mozambique along the coast and the level of hazard was analyzed based on the distribution of each hazard.

Flood hazard was evaluated as "✓✓✓" since the estimated inundation area is distributed in the central area and east low-land area, and in addition based on the hazard simulation by a JICA project[4] hazard of urban flood in low-land area is identified (Figure bellow (1)).

Storm surge hazard was evaluated as "✓✓✓" since the estimated inundation area is distributed in the east low-land area, and in addition based on the inundation simulation by a JICA project [5]it is estimated that in case the Cyclone Idai which struck the area in 2019 was to be making landfall in the spring high tide time, broad area of the city would be inundated (Figure bellow (3)). Hazard of the strong wind was evaluated as "✓✓" since the Annual accumulative wind speed is below 25 m/sec (color in green to yellow) in the whole city area (Figure bellow (4)).

Landslide hazard was evaluated as "-" since Beira is in the coastal area and do not have an area with high landslide potential score over the medium level (Figure bellow (2)).

[4] In the JICA Project on Strengthening Resilience in Cyclone IDAI-Affected Area, inundation simulation for urban flood based on the condition of rain fall in January 2019, which recorded the maximum annual rainfall in the recent 20 years was conducted and the estimated inundation area of depth for more the 0.2 m is mentioned in light blue color in the figure.

[5] In the project mentioned above inundation simulation for storm surge based on the condition of assuming Cyclone Idai shall make landfall in the time of spring high tide was conducted. Estimated inundation area based on the simulation is added to the hazard area mentioned in yellow color in the figure.

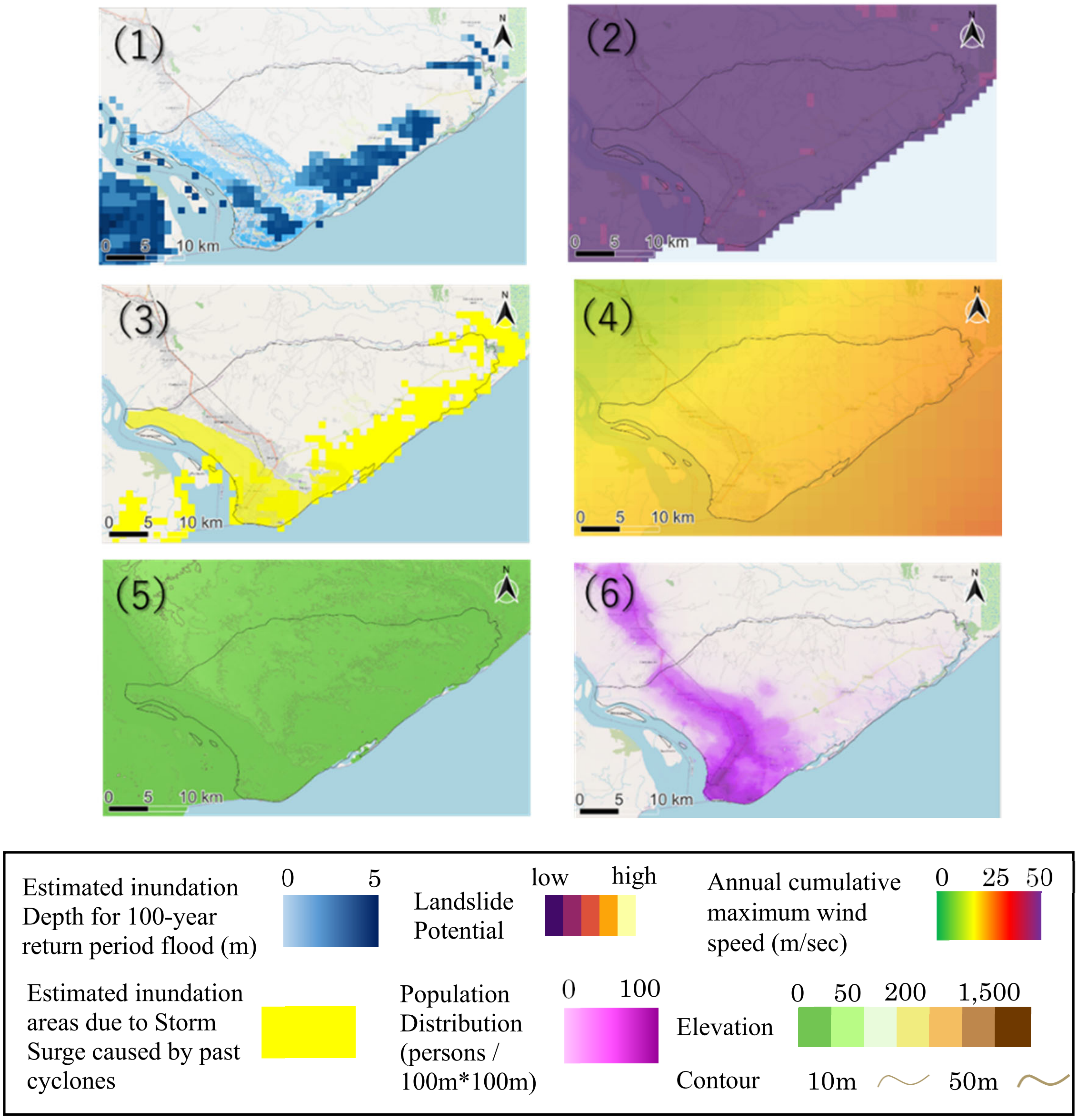


Figure 3-4 Situation of Hazard Distribution in Beira

Source: JICA Study Team

d) Chimoio

Chimoio is a city located in central Mozambique and the level of hazard was analyzed based on the distribution of each hazard.

Flood hazard was evaluated as "-" since estimated inundation area in not distributed in the city (Figure bellow (1)).

Storm surge hazard was evaluated as “-” since it is an inland city. Hazard of the strong wind was evaluated as “✓” based on the fact that Tete is located in central Mozambique and the area is affected by Cyclone occasionally.

Landslide hazard was evaluated as “✓✓” since the area with high landslide potential score with over the medium level is distributed in the steep hill side area on the east (Figure bellow (2)).

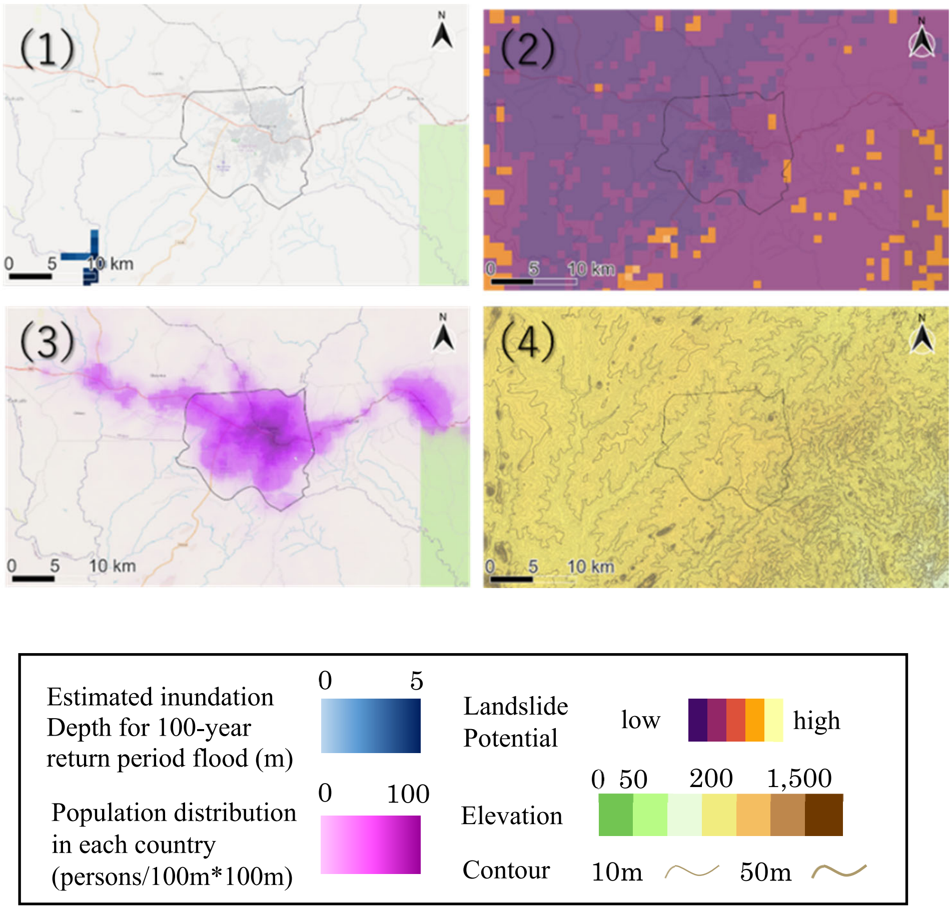


Figure 3-5 Situation of Hazard Distribution in Chimoio

Source: JICA Study Team

e) Quelimane

Quelimane is a city located in central Mozambique along the coast and the level of hazard was analyzed based on the distribution of each hazard.

Flood hazard was evaluated as “✓✓✓” since over half of the city area along the coast are inundation area (Figure bellow (1)).

Storm surge hazard was evaluated as "✓✓✓" since over half of the city area along the coast are estimated inundation area (Figure bellow (2)). Hazard of the strong wind was evaluated as "✓✓✓" since in the coastal area the Annual accumulative wind speed is over 25m/sec (color in red to purple) in the coastal area (Figure bellow (5)).

Landslide hazard was evaluated as "-" since it is in the coastal area and do not have an area with high landslide potential score over the medium level do not exist (Figure bellow (3)).

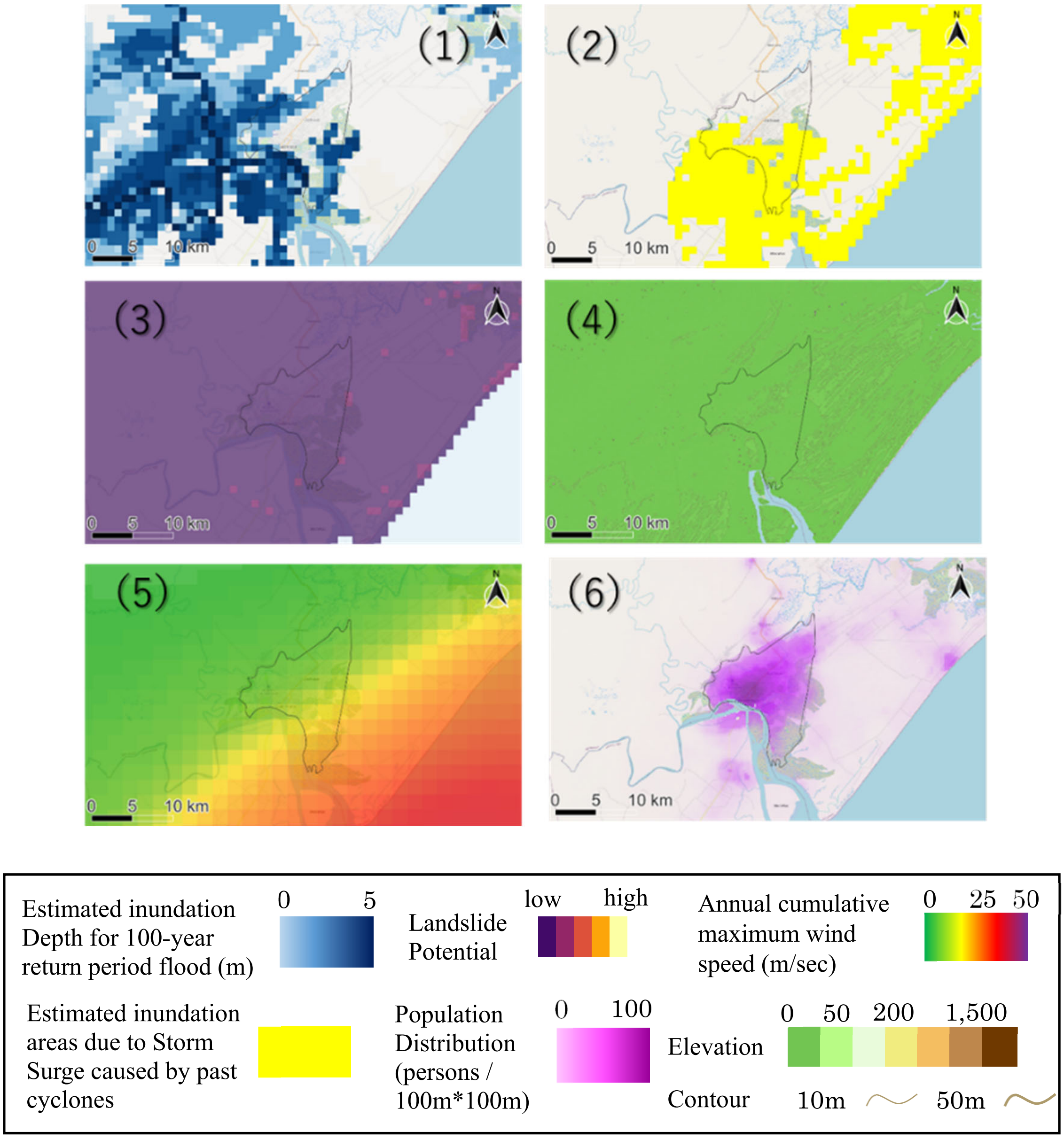


Figure 3-6 Situation of Hazard Distribution in Quelimane

Source: JICA Study Team

f) Tete

Tete is a city located in central Mozambique and the level of hazard was analyzed based on the distribution of each hazard.

Flood hazard was evaluated as "✓✓✓" since the inundation area is distributed along the Zambezi river flowing through the city (Figure bellow (1)).

Storm surge hazard was evaluated as "-" since it is an inland city. Hazard of the strong wind was evaluated as "✓" based on the fact that Tete is located in central Mozambique and the area is affected by Cyclone occasionally.

Landslide hazard was evaluated as "✓✓" since the area with high landslide potential score with over the medium level is distributed in the hill side area on the south (Figure bellow (2)).

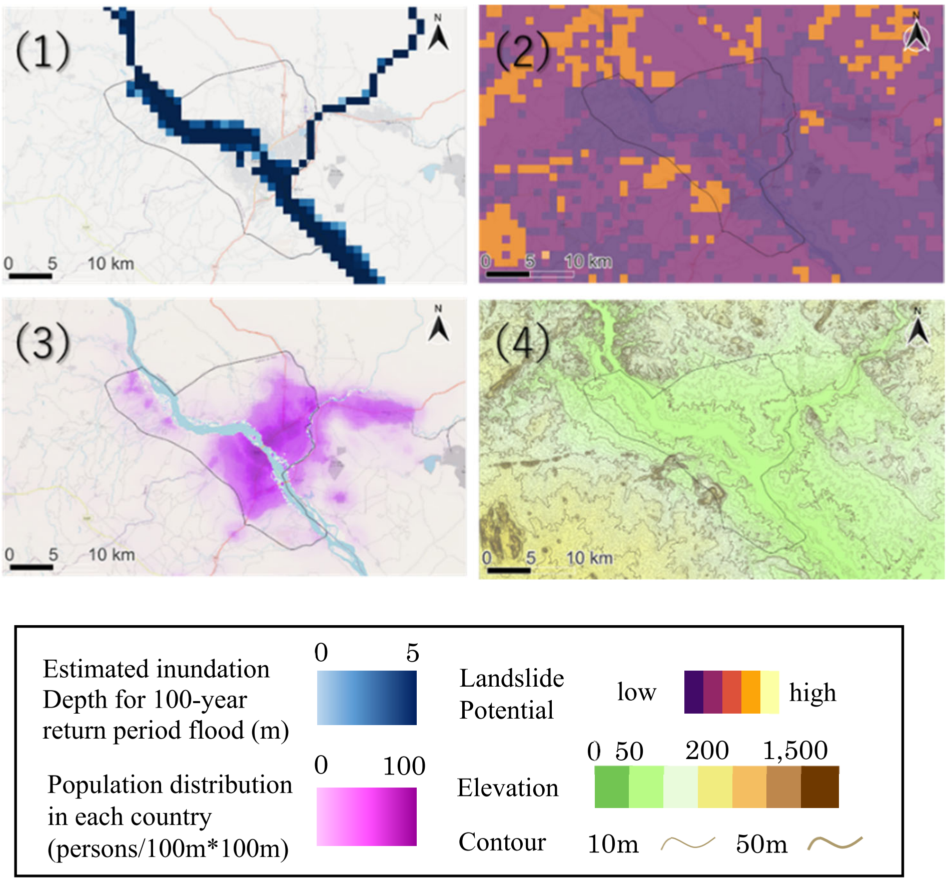


Figure 3-7 Situation of Hazard Distribution in Tete

Source: JICA Study Team

g) Nacala

Nacala is a city located in northern Mozambique along the coast and the level of hazard was analyzed based on the distribution of each hazard.

Flood hazard was evaluated as "✓✓✓" since the inundation area is distributed in the central area of the highland and along the coastline city (Figure bellow (1)).

Storm surge hazard was evaluated as "✓" since Nacala is located in central Mozambique and the area is affected by Cyclone occasionally although the inundation area by storm surge is not distributed in this analyses. . Hazard of the strong wind was evaluated as "✓" since the Annual accumulative wind speed is below 25 m/sec (color in green to yellow) in the whole city area (Figure bellow (5)).

Landslide hazard was evaluated as "✓✓" since the area with high landslide potential score with over the medium level do not exist (Figure bellow (2)).

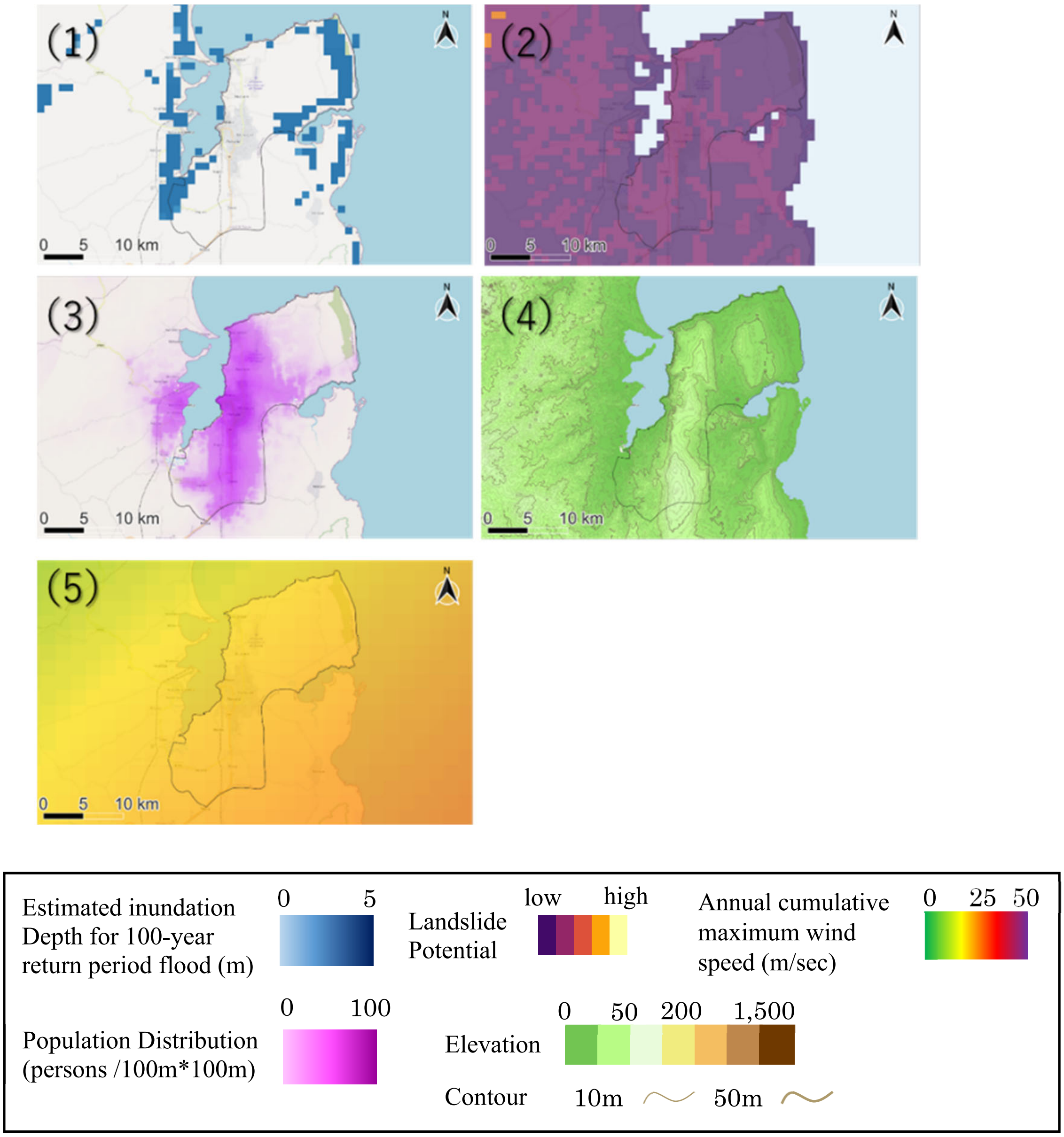


Figure 3-8 Situation of Hazard Distribution in Nacala

Source: JICA Study Team

(2) Estimation of Potential Economic Loss due to Disasters

Based on the results of the qualitative assessment of the hazard distribution, a more detailed assessment of the disaster risk was conducted for the Greater Maputo Metropolitan area (including Maputo City and Matola City, Boerne City, and Marracuene District), which has the largest population size in the country, and Beira City considering the size of the hazard and the population size.

As for flood hazard, since inundation simulation for urban flood induced by the January 2019 rainfall for Beira City is available[5], and inundation area of the simulation was included to estimate the potential economic loss. However, the area with more the inundation depth of 0.2m was used. For Maputo City, area where frequently affected by urban flood had been identified[6], the identified areas were also included to estimate the potential economic loss.

As for storm surge hazard, since inundation simulation for storm surge for Beira City is available, and inundation area of the simulation was included to estimate the potential economic loss. In the inundation simulation mentioned above, the condition of the simulation was set as if the Cyclone with the same external force and route with Cyclone Idai was to make landfall in time of spring high tide and the result of the inundation simulation was handed over to the counterpart institution and published on the INGD homepage[7].

In Mozambique, National Institute of Statistics is publishing a database of GDP per capita for each province. Therefore, to estimate the potential economic loss, we used the value of Maputo Province's for the Greater Maputo Metropolitan area and the value of Sofala Province's for Beira City.

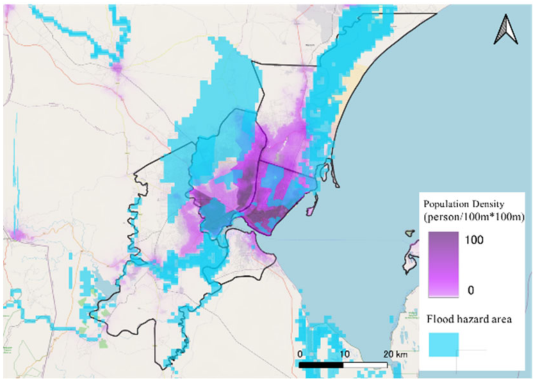
---

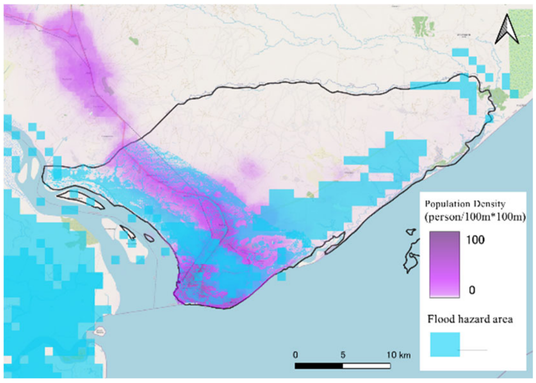
[6] Result of Sanitation and Drainage Master Plan for the Greater Maputo Metropolitan Area

[7] Result of Project on Strengthening Resilience in Cyclone IDAI-Affected Area、JICA

Greater Maputo Metropolitan Area | Beira City

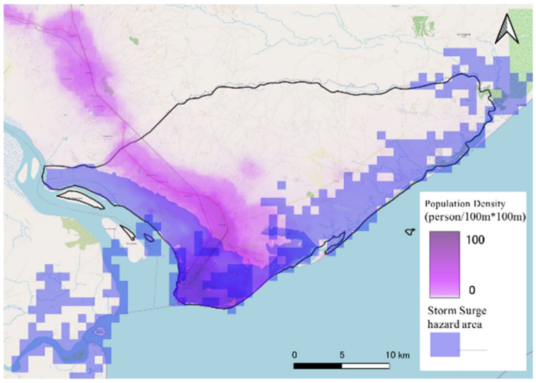
Flood hazard and population distribution



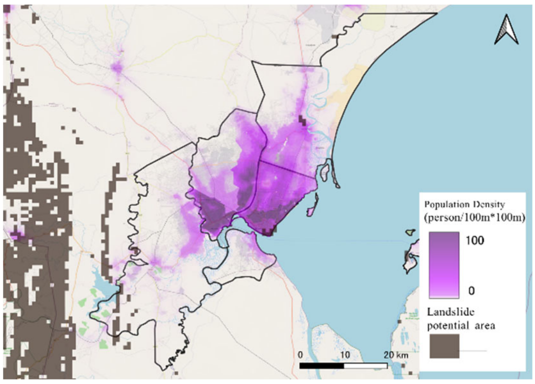


Storm Surge hazard and population distribution

No distribution of Storm Surge hazard in the Greater Maputo Metropolitan Area



Landslide hazard and population distribution



No distribution of Landslide hazard in Beira city

Cyclone (Strong Wind) hazard and population distribution

No distribution of Cyclone (Strong Wind) hazard in the Greater Maputo Metropolitan Area

No distribution of Cyclone (Strong Wind) hazard in Beira city

Figure 3-9 Distribution of Hazard and Population in Major Cities in Mozambique

Source: JICA Study Team

Table 3-2 Potential Economic Loss in Major Cities of Mozambique

Hazard	Target city	Greter Maputo Metropolitan Area	City of Beira
Flood	Damaged area (㎢)	824	195
	Damage area ratio (%)	37%	31%
	Population affected ('0000 persons)	103	21
	Estimated damage (million USD)	**1,143**	**129**
High water	Damaged area (㎢)	0	225
	Damage area ratio (%)	0%	36%
	Population affected ('0000 persons)	0	26
	Estimated damage (million USD)	**0**	**156**
Storm	Damaged area (㎢)	0	0
	Damage area ratio (%)	0%	0%
	Population affected ('0000 persons)	0	0
	Estimated damage (million USD)	**0**	**0**
Sediment disaster	Damaged area (㎢)	34	0
	Damage area ratio (%)	2%	0%
	Population affected ('0000 persons)	3	0
	Estimated damage (million USD)	**34**	**0**

* GDP per Capita (Current USD / person) used the data from Mozambique National Institute of Statistics
the Greater Maputo Metropolitan area used the value for Maputo province (1,111 USD / person)
Beira city used the value for Sofala province (600 USD / person)

Source: JICA Study Team

The above results indicate that the potential economic loss due to flooding including urban flood is higher in the Greater Maputo Metropolitan area, while the potential economic loss due to storm surge is higher in Beira city.

In terms of flood hazards, the Greater Maputo Metropolitan area, has a larger population than Beira, and a higher GDP per capita for the value of Sofala Province. Therefore, the estimated possible affected population was approximately five times larger, and the estimated potential economic loss was approximately ten times larger. From this result, in Greater Maputo Metropolitan area the potential economic loss which can be reduces by implementing countermeasures against floods is higher and the Greater Maputo Metropolitan area is the priority for implementing countermeasures for floods.

As for the city of Beira, both storm surge and flood hazards have a large value of potential economic loss and can be considered that to implement countermeasures for storm surge and flood is the priority.

(3) Damage and Loss Disaggregated by Sector

1） GFDRR Disaster Risk Profile

Damage estimates for cyclones, floods, and landslide in Mozambique are being studied for buildings in general, educational / health facilities, transportation infrastructure, and agricultural infrastructure. Damage estimates are calculated for each sector on a 25-year return period scale, a 50-year return period scale, and a 250-year return period scale. Furthermore, based on these return period scale damage estimates, the Average Annual Loss (AAL) is estimated.

Table 3-3 Sectoral Damage Estimates in Mozambique in GFDRR Disaster Risk Profiles

Disaster type		Cyclones	Flood		Landslide
Conditions for analysis		50-year probability scale	50-year probability scale	Estimated annual damage	Estimated annual damage
Affected population	Affected population (persons)	800,000	450,000	200,000	100
Building	Amount of damage (million USD)	500	1,500	500	1
Education and hygiene	Number of affected facilities (number of buildings)	2,500	1,500	350	-
	Facility damage amount (million USD)	-	-	-	0.04
Traffic Infrastructure	Damage extension (km)	3,500	1,000	300	-
	Amount of damage (million USD)	-	-	-	0.1
Agriculture	Amount of damage (million USD)	350	45	15	-

Source: Summarized by the JICA Study Team from GFDRR Disaster Risk Profile (Mozambique)

In the GFDRR disaster risk profile the distribution of disaster risks by province is visualized by disaster type and by sector as follows:

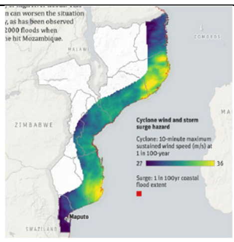
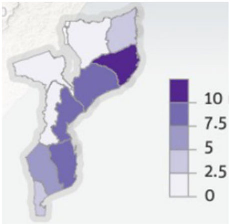
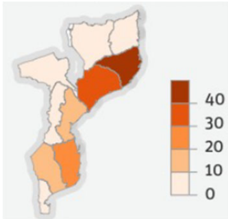
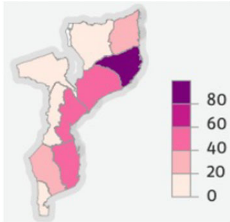
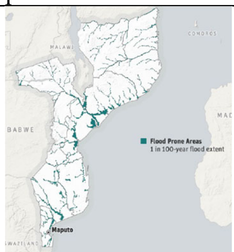
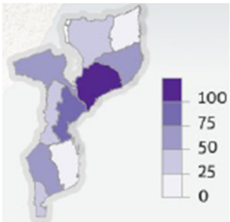
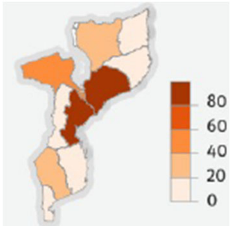
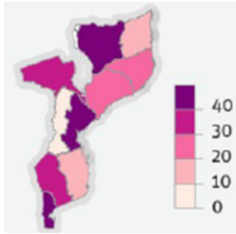
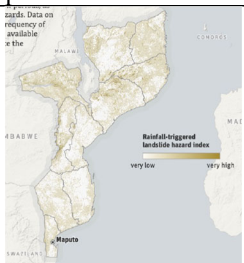
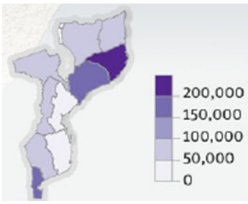
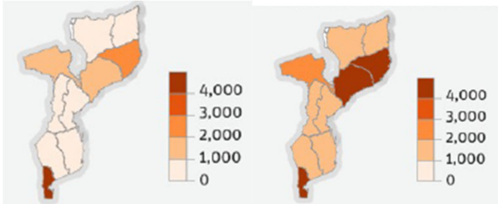
	Hazard distribution	Building damage	Educational and health facilities	Transportation Infrastructure
Cyclones	 *Maximum wind speed and storm surge inundation area of 100-year return period scale	 *Estimated Average Annual Loss (million USD)	 *Estimated annual damage (number of buildings)	 *Estimated annual damage extension (km)
Floods	 *Inundation areas of 100-year return period scale	 *Estimated Average Annual Loss (million USD)	 *Estimated annual damage (number of buildings)	 *Estimated annual damage extension (km)
Landslides	 *Rainfall-triggered Landslide hazard index	 *Estimated Average Annual Loss (USD)	**Health facilities Educational facilities**  *Estimated annual damage (number of buildings)	

Figure 3-10　Distribution of Disaster Risk by Disaster Type and Sector in Mozambique

Source: Summarized by the JICA Study Team from GFDRR Disaster Risk Profile (Mozambique)

Table 3-3 shows that floods cause the largest amount of loss to buildings in general, and according to Figure 3-10 the province with high value is Zambezia province and Sofala provinces, which include the Zambezi River basin. The estimated value of loss to buildings is estimated based on the number and type of buildings in the area where each hazard is distributed and indicates the potential of damage to assets. In terms of the estimated damage to buildings, the amount of damage caused by floods is one digit higher than that of other disaster types, so it is assumed that flood control measures in order to protect assets in urbanized area are effective in reducing the amount of damage.

As for the estimated damage to health and education facilities, the number of buildings damaged by cyclones (storms, storm surges) is large. The geographical distribution of damage to health and education facilities shown in Figure 3-10 shows that damage by floods are concentrated in Sofala province and Zambezia province, and damage by landslides is concentrated in Maputo province and Nampula province. However the damage by Cyclone is distributed widely in the coastal provinces from Nampula to Gaza. In the case of strong wind the hazard is widely distributed along the coast, making it difficult to implementing countermeasures in a specific location. For this reason, it is effective to strengthen the structure of the health and education facilities which are particularly suffer high value of damage by cyclone strong wind.

As for the damage on transportation infrastructure the report simply estimates the damage based on the cyclone hazard distribution and the length of roads in the hazard area, thus since the cyclone hazard is distributed widely along the coast, the damage to transportation infrastructure in estimated high. Since damage to road is not caused by strong wind and rather caused by floods and landslides, therefore the impact of floods and landslides should be confirmed.

The distribution of the estimated damage to transportation infrastructure by province due to flood is shown on Figure 3-10 and the damage is greater in Maputo province, Sofala province and Niassa province. Particularly in Maputo province and Sofala provinces, where there are important roads such as National Road No. 1, it is assumed that disaster countermeasures for transportation infrastructure in these provinces will be effective.

As for the estimated damage to the agricultural sector, cyclone cause the largest amount of damage. Since the report does not provide information on the geographical distribution of the damage, it is difficult to discuss the details but in particular, the distribution of cyclone hazards is widespread in the Zambezia province and Nampula provinces, which are one of the area with high activity of agriculture, thus the estimated damage are likely to be large.

In terms of landslides, the disaster risk is concentrated in the northern provinces of Nampula province and Maputo province, and it is important to consider countermeasures in these areas/ However the scale of damage is small compared to the estimated damage from floods and cyclones. Therefore, with regard to countermeasures for landslides, floods, and cyclones, countermeasures for floods and cyclones (strong wind and storm surges) are considered to have a higher priority.

2） Sectoral Damage Summarized in PDNAs

In Mozambique, PDNAs have been prepared for three disasters: the 2000 flood, the 2015 flood, and the 2019 cyclone, and the amounts of damage are summarized in the table below. The amounts of damage to agriculture, industry and commerce, houses, health facilities, transportation infrastructure, and electric power and communication infrastructure are significant and shown in light blue color on the table. In particular, the PDNA for Cyclone Idai, which made landfall in March 2019, shows that damage to houses and transport infrastructure is noticeably high, so it can be presumed that it is important to implement countermeasures to reduce damage in the housing and transportation sectors. While it is difficult to implement risk reduction measures by international assistance for housing because of housing sector is usually owned by private sectors or individuals, it is relatively feasible to strengthen transportation infrastructure through public projects. For this reason, we presume that support for the strengthening of transportation infrastructure is important.

Table 3-4 Damage to each sector summarized in PDNAs in Mozambique (million USD)

Sector		2019 (Cyclones)	2015 (Flood)	2000 (Flood)	Total
Industry	Agriculture	47.8	85.0	129.6	262.4
	Fishery	16.7	0.3	14.6	31.6
	Industrial, commercial, and other damage	140.1	1.0	124.4	265.5
	Sightseeing	0.0	0.0	12.5	12.5
Social assets	Houses	410.5	5.6	29.1	445.2
	Education	15.0	6.0	18.7	39.7
	Hygiene	81.5	1.5	15.7	98.7
	Other	2.8	0.0	5.2	8.0
Infrastructure	Traffic	441.8	179.0	95.0	715.8
	Electricity and communications	133.5	13.7	24.3	171.5
	Water and sewage	14.9	9.0	13.4	37.3
	Other	0.0	6.8	0.0	6.8

Source: PDNAs

3） Disaster Damage and Loss Statistics

Disaster damage and loss statistics in Mozambique include the number of deaths, damage to houses, economic losses, education and health facilities, agricultural land, livestock, and road damage from 1,500 events between 1979 and 2012 for the targeted disasters (floods, cyclones, high waters, and sediment disasters).

Table 3-5 Sectoral Actual damage according to disaster damage and loss statistics in Mozambique

Targeted disaster types	Floods, cyclones, high waters, Landslide
Target year	1979-2012
Number of disaster events	1,560
Number of deaths	2,644
Total destruction of houses (buildings)	537,373
Partial damage to houses (buildings)	168,494
Economic loss (USD)	10,000
Economic loss (local currency)	1,101,129,300
Educational Facilities	14
Public health facility	1
Agricultural land (ha)	426,910
Livestock (head)	55,361
Road (m)	209,643

Source: Data collected from DesInventar and summarized by JICA Study Team

In addition, the annual trends of the number of disaster events and the number of damaged houses (destroyed + partial damaged) were confirmed to analyze the trend of damage. The number of disaster events shows an increasing trend. In terms of the number of houses damaged, the year 1994, when Cyclone Nadya made landfall was the largest, but there were large numbers in 2000 and 2008, indicating an increasing trend.

Recently (after around 2000), due to the improvement of capacity to collect disaster damage and loss data including small-scale disasters, it is difficult to compare the previous and past statistics on the same basis. On the other hand, DesInventar has summarized information on large-scale disasters from the past, so it is possible to identify the rough trends. In DesInventar, information collected after 2005 will be used to evaluate the achievement of the indicators for the global target of the Sendai Framework for Disaster Risk Reduction, so it is expected that the information will be summarized on a uniform basis. Therefore, it is important to check the trend of the statistics continuously in order to understand the damage trend.

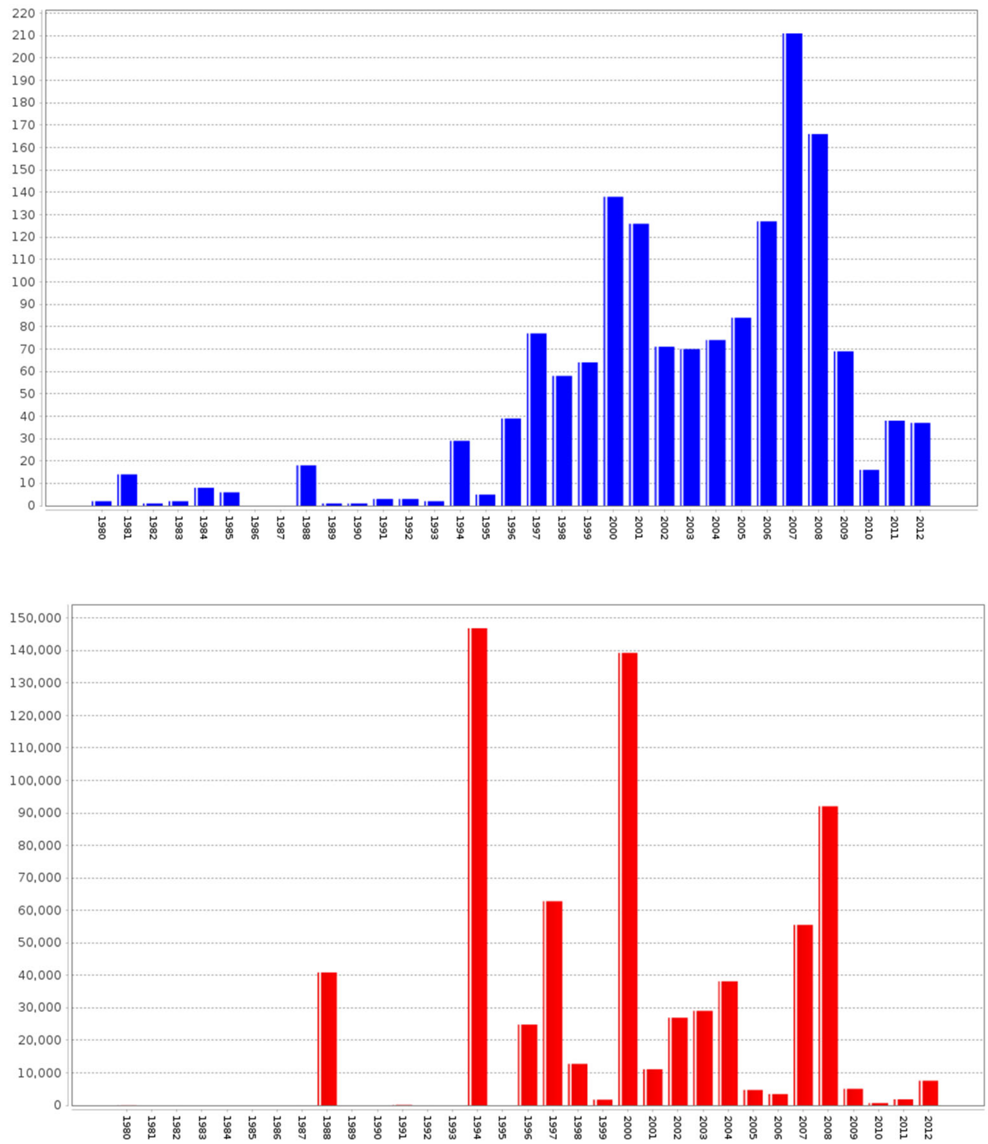


Figure 3-11 Trend of Disaster damage and loss in Mozambique from 1980 to 2012

(Above: Annual Disaster Event, Bellow: Annual damaged houses (destroyed+partial damaged))

Source: DesInventar

3.1.2 Climate Change

(1) Observed and Projected Climate Change

Mozambique has experienced an increase in average temperature of 0.15-0.16°C/year since 1960. In terms of rainfall, the average monthly rainfall has decreased by 2.5 mm per decade. In terms of regional trends, rainfall has increased in the northern regions, while floods and droughts have frequently been observed in the southern regions.

As for the projections, temperatures are projected to increase between 0.84 and 1.28 degrees Celsius by 2050 and between 1.58 and 2.49 degrees Celsius by 2100, compared to 2013. Precipitation is also projected to be changed between -20.65 and 56.27 mm by 2050 and between -63.83 and 50.38 mm by 2100 compared to 2013[8].

In the updated version of the country's NDC submitted to UNFCCC in November 2021, the following items are clearly indicated as future projections on temperature and precipitation[9].

- Temperatures are projected to increase by an average of 1.5°C to 3.0°C between 2046 and 2065 (compared to the average between 1960 and 2005). Hot days will increase, cold days will decrease, and maximum and minimum temperatures will increase.
- Rainfall will become more erratic in terms of amount and seasonal patterns of wet and dry seasons.
- The frequency and intensity of extreme weather events (droughts, floods, tropical cyclones) will increase.
- Prolonged drought

It is also explicitly stated that due to these climate change impacts, many of the country's major coastal cities, such as Maputo, Beira, and Quelimane, are already at risk in terms of their vulnerability to climate change impacts (human lives, property, social infrastructure, etc.).

[8] Projections in the 10-90% range for the SSP2-4.5 scenario, https://climateknowledgeportal.worldbank.org/country/mozambique/climate-data-projections(2022/2/6 accessed)

[9] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Mozambique%20First/NDC_EN_Final.pdf

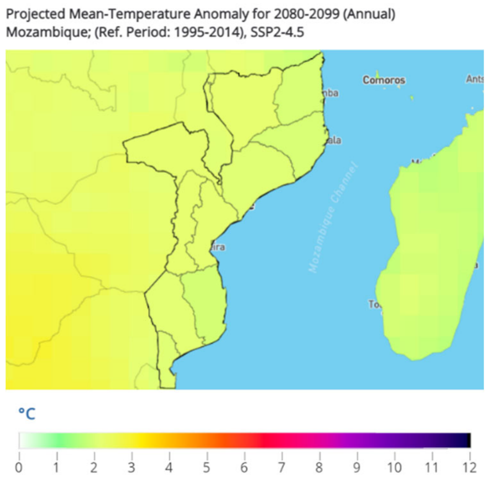


Figure 3-12 Projected Mean temperature anomaly for 2080-2099(ref.:1995-2014), SSP2-4.5

Source：Climate Knowledge portal site, WB, [Jan, 2022]

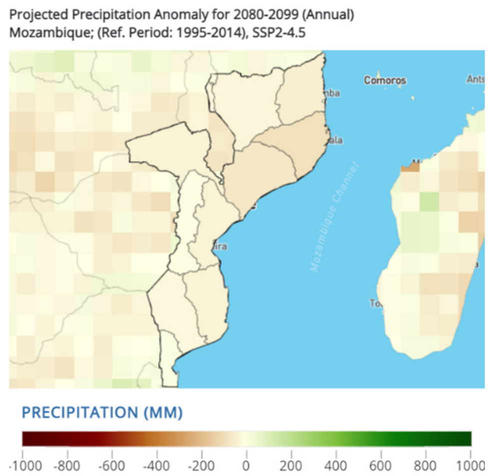


Figure 3-13 Projected precipitation anomaly for 2080-2099(ref.:1995-2014), SSP2-4.5

Source：Climate Knowledge portal site, WB, [Jan, 2022]

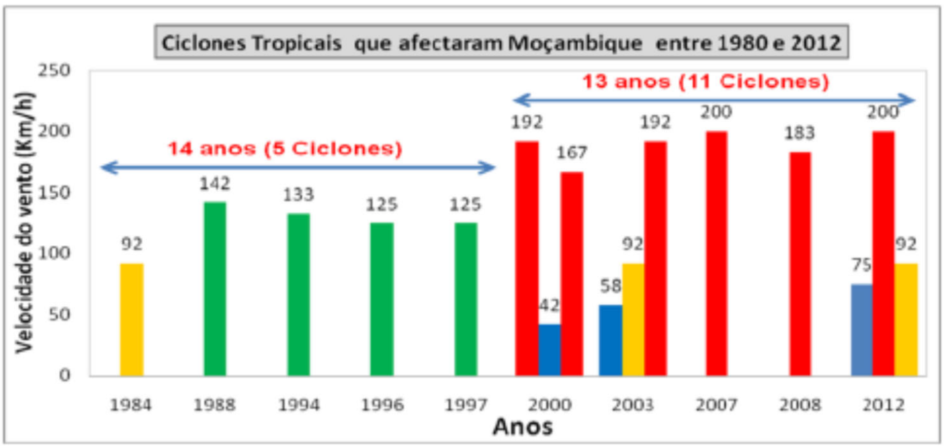
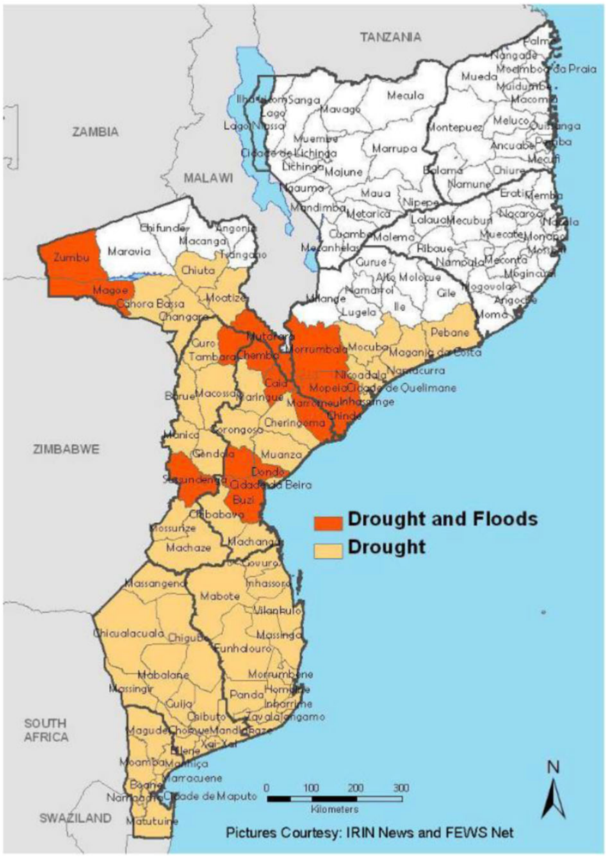


Figure 2. Number of climatic events in the period form 1984 to 2012 (INGC, 2015)

Figure 3-14 Number of climate events in the period from 1984 to 2021 (INGC, 2015)

Source: Intended Nationally Determined Contribution (INDC), 2018

It is predicted that the rate of heavy rainfall will increase and at the same time the dry season will become longer in many climate models. It is also predicted that the intensity of heavy rains will be increased by 10% (2010-2100) and the frequency by 6%. It is projected that the duration of prolonged heatwaves is expected to increase by an average of 17 days from 2010 to 2100 (compared to 1960-2006)[10]. Increase of heavy rainfall and heatwaves are projected to potentially lead to an increase in extreme events such as droughts and floods. In the central and southern parts of the country, an increase in droughts caused by longer heatwaves and dry spells is projected. Cyclones are expected to affect mainly eastern Mozambique. They are expected to be less frequent, but of increasing intensity, with the potential for increased precipitation.



Source: http://www.audiencescapes.org/mozambique-provincial-radio-maputo-radio-mocambique-community-UNESCO-media-project-catholic-manica-central-sofala-tete-zambezia

Figure 3-15 Regions affected by floods and droughts

Source: Climate change Profile, Mozambique Ministry of Foreign Affairs of the Netherland, 2018

The sectors such as agriculture, forests and grasslands, livestock, water resources, disaster prevention and their resources, infrastructure, health and fisheries are projected as being affected by these climate changes. In NDCs, the following impacts in particular are reported to be occurring and are expected to worsen with climate change. More flooding is expected to occur across the country, particularly during the rainy season. Floods are expected to occur more

10 Climate Change Profile, Mozambique, 2018

frequently in the north and to be larger and more damaging in the south. The Limpopo Basin is predicted to be a flood hotspot, with the magnitude of flood peaks predicted to increase by an average of 25%.

Table 3-6 Overview of damages by climate hazards

Event	Impact Summary
Floods	Between 2000 and 2015, 4,629,000 people were affected, 1,204 people died and 1,176,000 houses were damaged (of which 638,700 were destroyed). Damage to infrastructure: the Licungo River in Nante district, damage to the Limpopo embankment in Chokwe, Guija and Xai-Xai, damage to the railway and port. Economic losses: 1,356.9 million USD
Roads	Between 2011 and 2015, 130 aqueducts, 119 bridges and 41 drifts were destroyed or affected, making 15,512 km impassable and causing economic losses of 333 million USD
Agriculture	Between 2005 and 2014, eight major droughts and floods affected a total of 1,199,763 ha of farmland.
Water	Salt water intrusion due to sea level rise were occured in the Umbeluzi, Incomati, Limpopo, Save, Púngoe, Buzi and Zambezi rivers.

Source: Intended Nationally Determined Contribution (INDC). 2018

Significant human suffering in recent years due to extreme weather conditions during the rainy season were reported as follows.

Table 3-7 Damage and Loss due to extreme weather conditions during rainy season

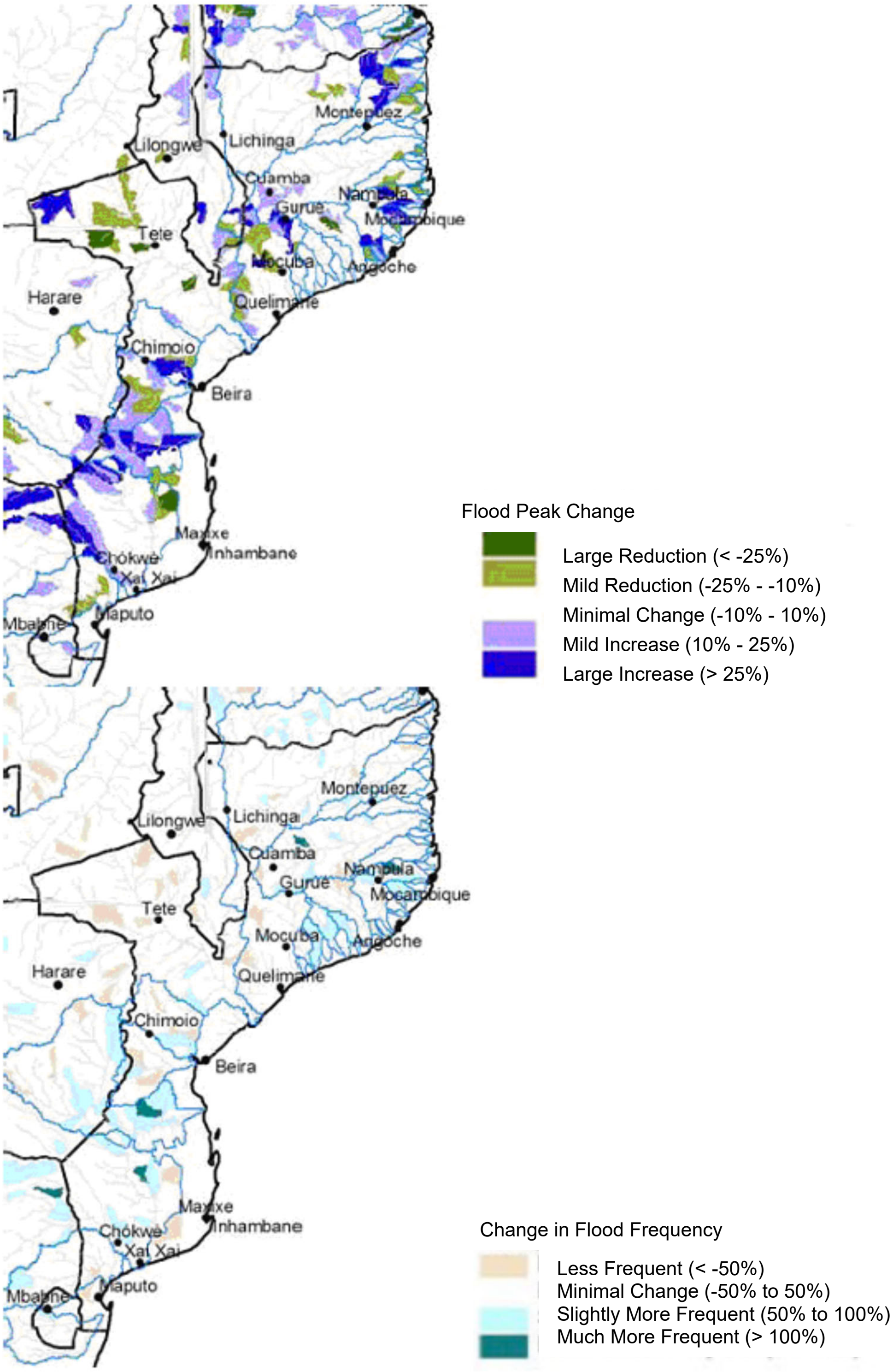
Season	Event	Affected People	Affected Families	Injured	Deaths	Destroyed Houses		Flooded Houses	Worship Locations	Health Units	Destroyed Classrooms		Affected Schools	Affected Students
						Partially	Totally				Partially	Totally		
2016-17	---	1,054,707	216,319	379	73	83,500	43,781	89,078	26	108	486	2,413	693	184,507
2017-18	Heavy rains and winds, strong winds, rains with lightning and gales	152,246	31,146	51	61	14,461	7,313	9,099	44	18	463	201	42	10,088
2018-19	Drought, rain and strong winds, sometimes accompanied by lightning, and Desmond, Idai and Kenneth	2,855,417	574,361	1,872	714	153,274	146,482	30,125	1,144	138	1,801	3,109	699	445,404
2019-20	Heavy rains, strong winds, lightning and floods	195,449	40,892	68	57	11,864	6,221	44,809	89	8	---	---	---	---
	Total	**4,257,819**	**862,718**	**2,370**	**905**	**263,099**	**203,797**	**173,111**	**1,303**	**272**	**2,750**	**5,723**	**1,434**	**639,999**

Source: Mozambique First NDC (2021 Updated)

Coastal areas are the most vulnerable to climate change in the country. In particular, the Central Beira is the most vulnerable area to sea level rise, according to the Climate Change Vulnerability Assessment. Sea level rise between 1990 and 2090 is projected to be in the range of 13-56 cm.

Erosion in coastal areas is expected to become more severe as cyclone intensity increases. The most vulnerable areas are in the vicinity of Beira city (delta and mangrove forests in the north and heavily vegetated sand dunes in the south). In northern Mozambique, erosion is less severe due to the protection of coral reefs. However, corals are under threat from mining activities, overfishing and sea level rise. Under some climate scenarios, coastal erosion is predicted to push parts of Mozambique's coastline up to 500 meters inland, which could pose serious challenges to these densely populated areas.

Map 3 Expected changes in magnitude (top) and frequency (bottom) of floods (2010-2045)



Source: INGC (2009): Study on the impact of climate change on disaster risk in Mozambique.
http://www.irinnews.org/pdf/synthesis_report_final_draft_march09.pdf

Figure 3-16 Expected change in magnitude and frequency of floods

Source: Climate change Profile, Mozambique Ministry of Foreign Affairs of the Netherland, 2018

(2) Policies and Strategies for Climate Change

1) National Level

The Government of Mozambique has long been committed to climate change action, having developed a National Adaptation Program of Action (NAPA) in 2008, followed by a National Climate Change Adaptation and Mitigation Strategy (NCCAMS) in 2012. The National Climate Change Adaptation and Mitigation Strategy (NCCAMS) was developed in 2008 and 2012, and prioritises strengthening the resilience of communities and national economies, including reducing climate risk.

It also aims to promote low-carbon development and a green economy through the integration of adaptation and mitigation measures in sectoral and regional plans. Based on the NCCAMS, climate change vulnerability assessments have been carried out and adaptation actions and indicators have been incorporated into the national Five-Year Development Program 2020-2024. Adaptation actions and indicators are incorporated into national Five-Year Development Programmes 2020-2024.

Table 3-8 List of National policies for climate change

Year	Name of policies	Responsible organization
2003	Initial National Communication	Ministry for the Co-Ordination of Environmental Affairs (MICOA)
2007	National Adaptation Program of Action[11]	Ministry for the Co-Ordination of Environmental Affairs (MICOA)
2008	National Adaptation Program of Action	Ministry for the Co-Ordination of Environmental Affairs (MICOA)
2012	National Climate Change Adaptation and Mitigation Strategy for 2013-2025 (NCCAMS)	Inter Institutional Group on Climate Change (IGCC), representing sectoral ministries, the private sector and civil society, under the coordination of the Ministry for the Coordination of the Environmental Affairs (MICOA)
2014	Climate Change and Gender Action Plan2 Second National Communication	Ministry of Environment Ministry of Lands Natural Resources and Environmental Protection
2018	Intended Nationally Determined Contribution (INDC)	Ministry of Land, Environment and Rural Development
2021	Nationally Determined Contribution (NDC)	Ministry of Land and Environment

Source: JICA Study Team

[11] https://unfccc.int/resource/docs/napa/moz01.pdf

Table 3-9 Mission and objectives of National Climate Change Adaptation and Mitigation Strategy for the period 2013-2025 (NCCAMS)

Mission
Increase resilience in the communities and the national economy including the reduction of climate risks, promote low-carbon development and the green climate economy through the integration of adaptation and mitigation in sectoral and local planning
Objectives
- Adaptation: to become resilient to impacts of climate change, while minimizing climate risks to people and property; - Mitigation: to identify and implement opportunities to reduce greenhouse gases (GHG) emissions; - Capacity and resource: To build institutional and human capacity and explore opportunities to access technology and financial resource to implement this strategy.

Source: JICA Study Team

The Government of Mozambique signed the Paris Agreement on 22 April 2016 and announced its commitments and its priorities for mitigation and adaptation measures through the Nationally Determined Contributions (INDC/NDC) in 2018. In the INDC, the importance of adaptation to climate change is emphasized and the policy for mid- and long-term action is to update the National Adaptation Plan with reference to national and local initiatives. To this end, the NCCAMS vision will be achieved by first increasing resilience at the provincial level and integrating adaptation into provincial development plans so on, between 2020 and 2025, and then taking similar steps at the national level between 2026 and 2030. The strategic actions to be included in the NAP, as set out in the NDC, are as follows.

- Reduce climate risks through the strengthening of the early warning system and of the capacity to prepare and respond to climate risks;
- Improve the capacity for integrated water resource management including building climate resilient hydraulic infrastructures;
- Increase the effectiveness of land use and spatial planning (protection of floodplains, coastal and other areas vulnerable to floods);
- Increase the resilience of agriculture, livestock and fisheries, guaranteeing the adequate levels of food security and nutrition;
- Increase the adaptive capacity of the most vulnerable groups;
- Reduce people’s vulnerability to climate change related vector-borne diseases or other diseases;
- Ensure biodiversity’s protection;
- Reduce soil degradation and promote mechanisms for the planting of trees for local use;
- Develop resilient climate resilience mechanisms for infrastructures, urban areas and other human settlements and tourist and coastal zones;

- Align the legal and institutional framework with the NCCAMS
- Strengthen research and systematic observation institutions for the collection of data related to vulnerability assessment and adaptation to climate change;
- Develop and ameliorate the level of knowledge and capacity to act on climate change; and
- Promote the transfer and adoption of clean and climate change resilient technologies.

In addition, the gaps, barriers and needs for the implementation of climate change adaptation are summarized in the NDC as follows.

Table 3-10 Gap, barriers and needs

Gaps and barriers	
Financial	- Insufficient financing available to climate proof in country, associated with the complexity of the criteria and procedures for accessing the international climate financial resource; - Low public investment and private participation in the adaptation actions; - Lack of funding to maintain and upgrade data collection stations (meteorological, hydrological, hydrographical, air quality, among others); and - Slow payback of the investment in climate change adaptation actions
Technology and knowledge	- Weak capacity to determine the cost of the losses and damages caused by the impacts and of the measures to adapt to climate change and few research and investigation actions addressing climate change; - Unpredictability of the intensity and magnitude of the climate change impacts; - Weak capacity to design projects to access climate change financing and funds; - Unavailability of adaptation technologies; - Low capacity to measure, report and verify (MRV), including the effects of policies, strategies, plans and projects and of the availability and use of financial and technological resource; and - Difficulties and weak capacity to disclose knowledge about the climate change risks and actions, associated with a low capacity to manage and communicate the results of studies and projects.
Political and institutional	- Insufficient incentives to attract the participation of the private sector and civil society in developing initiatives to contribute to climate change adaptation; and - Weak coordination and charge of the sectors in the implementation of the approved policies, strategies and plans, due to a low ability to verify and enforce the laws and regulations associated to a weak capacity to cross-sectoral and integrated planning.
Summary of needs to implement INDC	
- Operationalize the NCCAMM implementation mechanisms namely the Knowledge Management Centre, the National Climate Change Network and the Financial Mechanism; - Assess the capacity needs of the National Climate Change Network and elaborate and implement the capacity plan to conduct research and investigation in the relevant areas; - Strengthen the institutions to collect and manage data and information and create a data base about the existent studies and experts; - Elaborate and implement a strategy for climate change education, awareness raising, communication and public participation; - Assess the adaptation technology needs and formulate and implement the associated plan; - Update the sectoral policies to mainstream climate change adaptation and risk reduction; - Establish climate insurances; and - Build national technical and institutional capacity to design and manage projects to access climate financing.	

Source: Mozambique First NDC (2021) Updated

The Ministry of Land and Environment and the National Institute of Management and Disaster Risk Reduction (INGD) are responsible for climate change-related administration in Mozambique. The National Institute of Meteorology is responsible for meteorological and climatic observations.

2) Regional Level

The City of Maputo developed a Local Adaptation Plan to climate change in 2013. This Local Adaptation Plan to climate change has been developed by the "Climate Planning Committee" (CPC) of Quarteirão 16ª do Bairro de Chamanculo C. The Chamanculo C area was selected for this project because it is particularly vulnerable to the projected impacts of climate change. As the significant impact of climate change was considered to be the increased risk of flooding, the review team put the issue of flooding at the centre of discussions in a participatory process. Each group meeting was followed by a plenary meeting of all group members, where all proposed solutions were discussed. From these discussions, below eight adaptation measures were identified to form the basis of a regional climate change adaptation plan. The CPC had collected further information relating to the eight adaptation measures, assessed their feasibility and made more detailed proposals of the most promising adaptation measures.

1. Rehabilitation of drains
2. Periodical cleaning of the drains by the inhabitants / organization of the inhabitants to manage water / cooperation between the neighbors
3. Construction of new drains and road paving
4. Improvement of waste collection
5. Awareness and manage residents not to dump waste in drains and roads
6. Filling low ground level areas with rubble to improve water flow
7. Construction of sanitary blocks
8. Dialogue with Águas da Região de Maputo about leaking water

Source: Plano Local de Adaptação às Mudanças Climáticas Bairro de Chamanculo 'C' Quarteirão 16A Cidade de Maputo, Moçambique

In addition, the Memba District of Nampula Province developed a Local Adaptation Plan to climate change (PLA) in 2015, which provides individual hazard-specific sectoral adaptation measures.

Table 3-11　Local Adaptation Plan to climate change（PLA）of the Memba District of Nampula Province

Event/ Threats	Activity	Ongoing adaptation actions	Limitations of ongoing actions	Suggested adaptation measures
Irregular rainfall	Fishing	- Fishing done on the high seas	- High physical effort and more time required - insufficiency of fish	- Promotion of the use of motorboats - Promoting the creation of fishermen's associations to facilitate credits - Creation of sanctuaries for fish reproduction intensification of mangrove re crowding - Promotion of fish farming and aquaculture
	Agriculture	- Practice of cultures of short cycle - farming in low-lying areas	- Seed insufficiency improved and short-cycle drought-resistant - Lack of technical knowledge - Refusal on the use/ reception of improved seeds	- Expansion of the agrarian extension network - Create seed multiplication fields that improve short-cycle and drought resistant - Training of communities in the use of improved seeds and new demonstration techniques
	Trade	- Marketing of vegetables, cassava and sweet potato, handicraft, and artisanal mining	- Lack of transport - Degradation of access roads	- -Improve access routes - Expansion of the transport network
	Animal husbandry	- Water retention in containers (drum buckets, etc.)	- Long water search route	- Expansion of opening of water holes - Construction of dams and tanks for water retention
Cyclone	Fishing	- Fishing activity stops	-	-
	Agriculture	- Use of short-cycle crops before the cyclone season	- Insufficiency of improved short-cycle seeds	- Sensitization /promoting the use of improved short-cycle seeds
	Trade	- Use of conventional material in the construction of commercial infrastructures	- Transport difficulties and access routes - Lack of stores selling building material	- Improve access routes - Expansion of the transport network - Promote the opening of stores for the sale of construction material

Event/ Threats	Activity	Ongoing adaptation actions	Limitations of ongoing actions	Suggested adaptation measures
Flood	Agricultu re	- Cultivation of rice, vegetables, sweet potatoes	- High physical effort in - the practice of subsistence agriculture	- Creation of farmers' associations to facilitate government support - Encourage mechanized agriculture for flood-adaptable crops - Encourage the cultivation of crops such as sweet potatoes, etc. - Encourage the practice of agriculture in high areas
	Trade	- Creation of stocks for critical periods - Construction of commercial infrastructure in sandy areas with local material	- High cost for acquisition of building material (cement, bamboos, sticks, etc.) - High transport costs	- Restoration of renewable natural resources (repopulate mangal and reforestation) - Improve access routes - Expand the transport network
Gale	Fishing	- Feed on seafood that is caught in places with vegetation - Use of cages	- Low quantity of fishing products - Long distance travel to obtain bamboo for the manufacture of cages	- Promote the use of motorboats - Repopulate of mangal - Expand the use of cages
	Agriculture	- Creating barriers wind break - Increase sand around the plant to ensure	-	-
	Trade	-	-	-
	Resource explorati on Natural	-	-	-
Pest and diseases	Fishing	-	-	-
	Agricultu re	- Placing barns above the fire at a sustainable height - Scare away pests (mounting traps with water)	- Insufficient agricultural surpluses - High physical exertion - Insufficient buckets	- Improved barn contrition - Spraying - Creation of an association for the manufacture of clay pots - Fixing traps around the macamba

Event/ Threats	Activity	Ongoing adaptation actions	Limitations of ongoing actions	Suggested adaptation measures
	Trade	- Use of pesticides during crop cultivation - Use of preservatives in barns	- Poor capacity of farmers in the acquisition of pesticides and preservatives	- Promote the use of improved barns - Opening of agrarian shops
	Animal husbandr y	- Vaccination of animals - Intradomicile spraying - Training of breeders in vaccination	- Insufficient vaccines - Insufficient technical staff to assist the community in the vaccination process - Lack of incentives for technicians	- Increase the number of vaccines to the District - Stepping up the training of technicians and breeders - in vaccination - Create incentives for technicians - Ensuring access to veterinary care - Build tanks lacking - Promote the construction of improved cures

Source: PLANO LOCAL DE ADAPTAÇÃO CLIMÁTICA [PLA de MEMBA][12]

[12] https://cgcmc.gov.mz/attachments/article/191/PLA%20Memba.pdf

(3) Supports from Other Donors

For Mozambique, a number of international organizations and national donors have provided several ranges of support for climate change-related policy making and project formulation. In particular, the UN-led NAP-GSP (Environment National Adaptation Plan Global Support Programme) has provided support in a wide range of areas.

Table 3-12 Status of donor and other support (2021)

Name of Donors	Sector	Project name
UNDP-UN Environment National Adaptation Plan Global Support Programme (NAP-GSP)[13]	Policies	Supporting Mozambique to advance their NAP Process[14] Outline: Supporting the development of policies, systems, and NAP process implementation.
Pilot Program on Climate Resilience, Climate Investment Funds (CIF)	Overall	Pilot Program on Climate Resilience Outline：Piloting and demonstrating methods to mainstream climate risk and resilience into development policies and plans of each sector. The program itself will be led by the national government and supports the implementation of plans and investment programs to address climate risks and vulnerabilities of relevant national plans and strategies.
GIZ	Water	Adapting to Climate Change (2012-2020) Outline：Improving the adaptation to climate change impacts on water resource of the national framework and the actions taken by relevant stakeholders in the Rio Búzi catchment area
USAID	Coastal area	Mozambique Coastal City Adaptation Project (2014-2019) Outline：To facilitate proactive investments in adaptation in vulnerable Mozambican coastal communities, CCAP is working with municipal governments to increase understanding of urban adaptation issues and enhancing their abilities of the application of management options for urban adaptation.
World Bank	Capacity enhancement of municipalities in infrastructure	Cities and Climate Change - Pilot Program for Climate Resilience of Mozambique (2012-2019) Outline：Strengthening municipal capacity for sustainable urban infrastructure provision and environmental management which enhance resiliency to climate related risks

[13] Financed by the Global Environment Facility (GEF), Least Developed Countries Fund (LDCF), and Special Climate Change Fund (SCCF).
https://www.globalsupportprogramme.org/sites/default/files/resources/profile_mozambique_web.pdf

[14] https://www.globalsupportprogramme.org/resources/project-brief-fact-sheet/national-adaptation-plans-focus-lessons-mozambique

Name of Donors	Sector	Project name
World Bank	Enhanced hydrological and climatic information	Climate Resilience: Transforming Hydro-Meteorological Services Project for Mozambique (2013-2019) Outline: Strengthening hydrological and meteorological information services to deliver reliable and timely climate information to local communities and to support economic development.

Source: JICA Study Team

3.1.3 National and Urban Development

(1) National Axis and Strategic Cities

The territory of Mozambique is very large, and the land use is dominated by low unused land. The economic integration of the country is still in the development stage, and each of the northern, central part including the province of Tete, and the southern part is in the process of strengthening the integration within the region, while expanding their economic ties to the neighboring countries. From the perspective of land transportation, these economic activities can be observed by the following three levels.

1) Three east-west corridors (Maputo, Beira, Nacala) and the main north-south corridors running from south to north

2) Major urban areas (provincial capital cities and ports on the end of the corridor)

3) Rural areas near the feeder road from the corridor

Corridors in Mozambique have been formed by the construction and operation of railways. There are four major independent railways: Nacala Railway, Beira Railroad, Maputo Railway, and Zambezia (Quelimane) Railway. These railways do not form a nationwide network, since they were built for the purpose of exporting inland mineral resources in southern Africa and importing goods from ports to inland. The figure below shows the entire corridor of Mozambique.

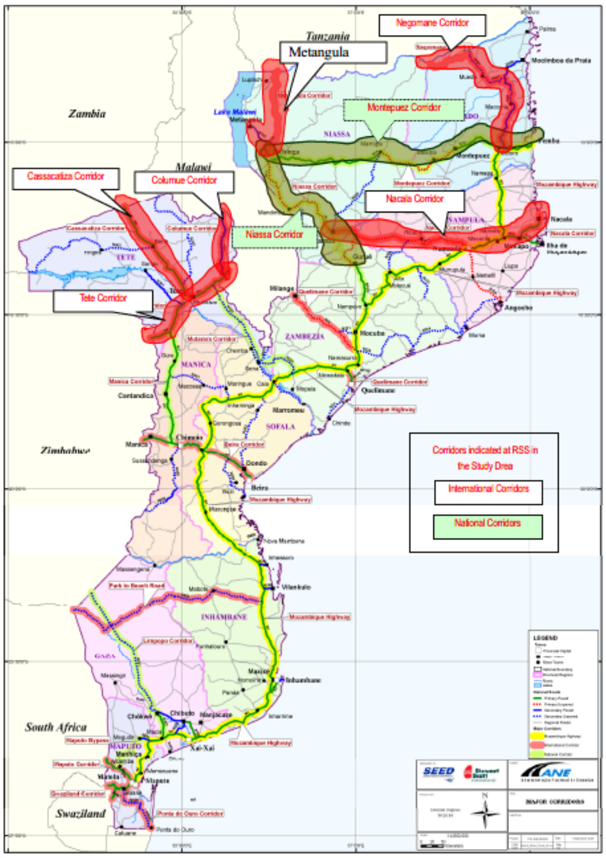


Figure 3-17　Corridors in Mozambique

Source. JICA PEDEC-NACALA

(2)　Cross-border Infrastructure

Since the 1980s, the International Corridors have been advocated by the Southern African Development Coordination Council (SADCC, later the Southern African Development Community (SADC)), the Spatial Development Initiative (SDI), and the New Partnership for Africa's Development (NEPAD). International corridors related to Mozambique include:

- Maputo Corridor (Mozambique-South Africa)　(SADC)
- Beira Corridor (Mozambique-Zimbabwe)　(SADC)
- Nacala Corridor (Mozambique-Malawi-Zambia)　(SADC)
- Maputo Development Corridor (South Africa-Mozambique)（SDI）

(3) Location of Important Industries

The National Development Strategy 2015-2035 calls for industrialization in order to increase the competitiveness of the economy. Strategic pillars defined for realization include: (i) human capital development, (ii) productive infrastructure development, (iii) research, innovation, technology development, (iv) collaboration and coordination between institutions. Agriculture / livestock / fishing, manufacturing, mining, and tourism are prioritized for development. Among the six key factors listed for the success of this strategy, the stable development of the state, the reduction of external dependence by strengthening the territorial management mechanism, and the resources through proper land use and management, and efficient infrastructure development are emphasized. For the above priority fields, policy focus will shift step by step manner starting from agriculture/ livestock / fisheries first, and then export of mining industry, food / textile industry, furniture / household goods, and infrastructure. Development mainly provides the logistical functions of goods and services (electrical energy, natural gas, water resource management, social infrastructure, tourist resorts) as the physical foundation of industrialization.

There are many settlements even in low unused land that occupies most of the country, and small-scale farmers are engaged in self-sufficient agriculture. The production of commercial crops is under rapid development from the areas corresponding to the feeder of the corridors. The existence of mineral resources, however, is still indispensable for the maintenance and development of the corridor.

Although Mozambique's mineral resources are diverse, it is now a major producer of metals, especially aluminum. Exports in 2019 include coal briquettes ($ 1.37 billion), raw aluminum ($ 983 million), oil and gas ($ 361 million), tobacco ($ 292 million), and electricity ($ 288 million). As a metal resource, aluminum accounted for 17.4% of exports and titanium accounted for 4.01%.

(4) Key Cities in Terms of Urban Development

According to the National Territorial Development Plan (December 2019) (hereafter referred to as PNDT), the current development model is characterized by the following points:

- Weak connections between corridors as opposed to cross corridors with summary transportation infrastructure.
- Balanced distribution of the three "port cities", Maputo, Beira and Nacala, in the country.
- Weak inter-city connectivity overall, especially in the north-south direction
- Necessity of development with consideration for a balance of conservation and economic activities
- The location of the capital, a major economic hub, is unusual.

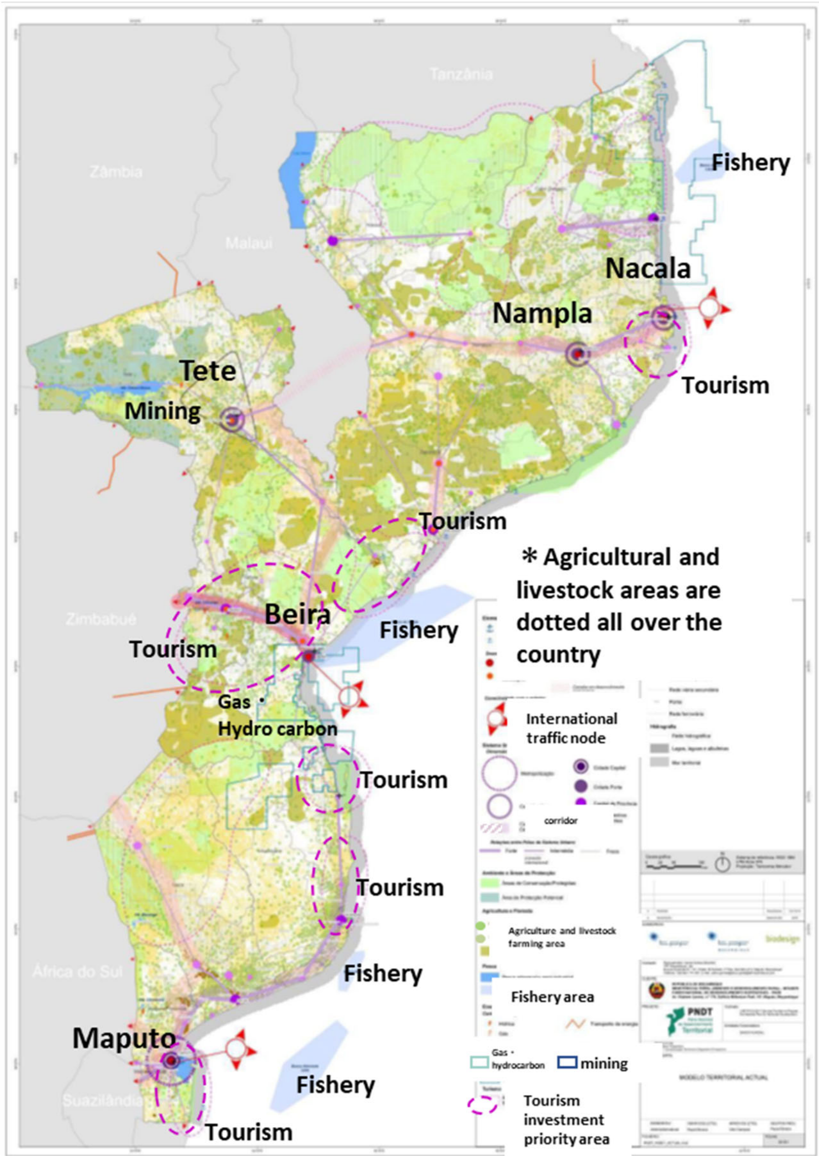


Figure 3-18 National Development Current Model in Mozambique

Source: Prepared by JICA Study Team based on National Territorial Development Plan, December 2019.

In "Analysis of Territorial Status: Opportunities and Threats" in this plan, the “Opportunity” includes the development of agribusiness by utilizing the agriculture, changing infrastructure priorities and regional development, the new frontier of tourism demand, decentralization and the development of self-sufficiency, and the role of ports and their strategic positioning in the country. On the other hand, social inequality, persistent poverty, uncontrolled and diffuse urbanization, and the devastation of the land due to over-prioritization of natural resources and mega-infrastructure have been cited as threats to development.

Furthermore, among the contents listed as "Issues of territorial development", regarding Disaster Risk Reduction (hereinafter referred to as DRR), prevention and mitigation of natural disasters by structural and non-structural measures are mentioned as issues of sustainability and resilience.

Followings are listed as the main policies for regional infrastructure systems in the PNDT:

- Regional integration: Strengthen the role of regional integration to ensure mobility and connectivity across the territory
- Effectiveness and efficiency: Modify priority of the selectivity of new investments and the effectiveness of investments already made etc., in order to produce the intended effect by realizing the investment.
- Feasibility and opportunities: assess the territorial impacts and cost-benefit ratios of investments in territorial infrastructure for alternative uses of applicable public resources.
- Mozambique's regional infrastructure system is perceived as highly inefficient, and therefore requires significant investment, which inevitably makes it a long-term process. It also states the view that the state's investment capacity is also limited, forcing it to rely strongly on foreign investment.
- Specific policies for infrastructure development include: integrating regions and reducing regional disparities; increasing the "national wealth" and promoting the acquisition of human, construction, institutional, and organizational capital; promoting regions to increase the effectiveness of investment and promote economic growth, and diversifying the rural economy through integrated methods. In this way, we can understand the direction of infrastructure development to develop the local economy and reduce regional disparities.

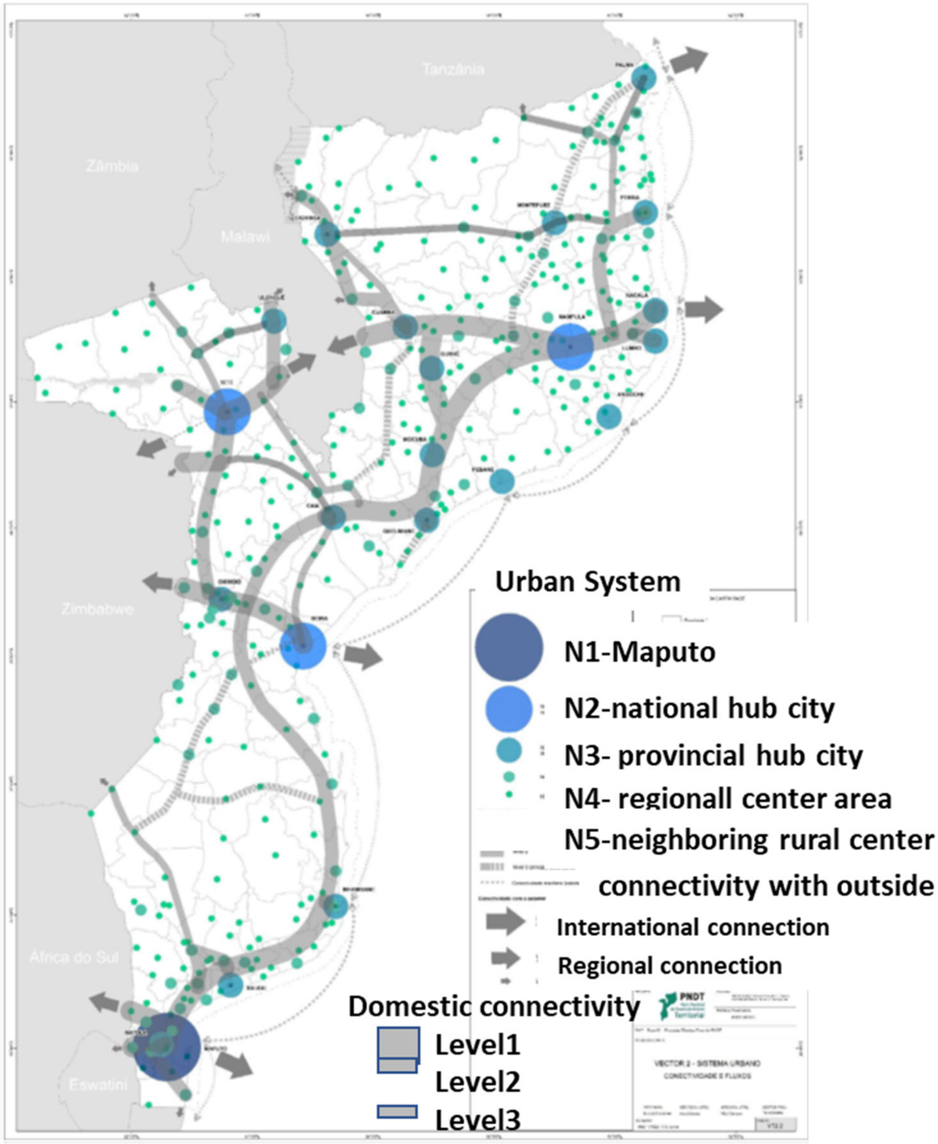


Figure 3-19 Infrastructure connectivity and flows in Mozambique

Source: Prepared by JICA Study Team based on National Territorial Development Plan, December 2019.

Important core cities according to the Territorial Model of the PNDT include Maputo, Beira and Nampula with the ports, and Tete inland and Chimoio on the route from Beira to Zimbabwe.

The direction is to develop these core cities in a well-balanced manner and loosely connect them to reduce regional disparities, aiming to build a comprehensive, creative and competitive network of "central places".

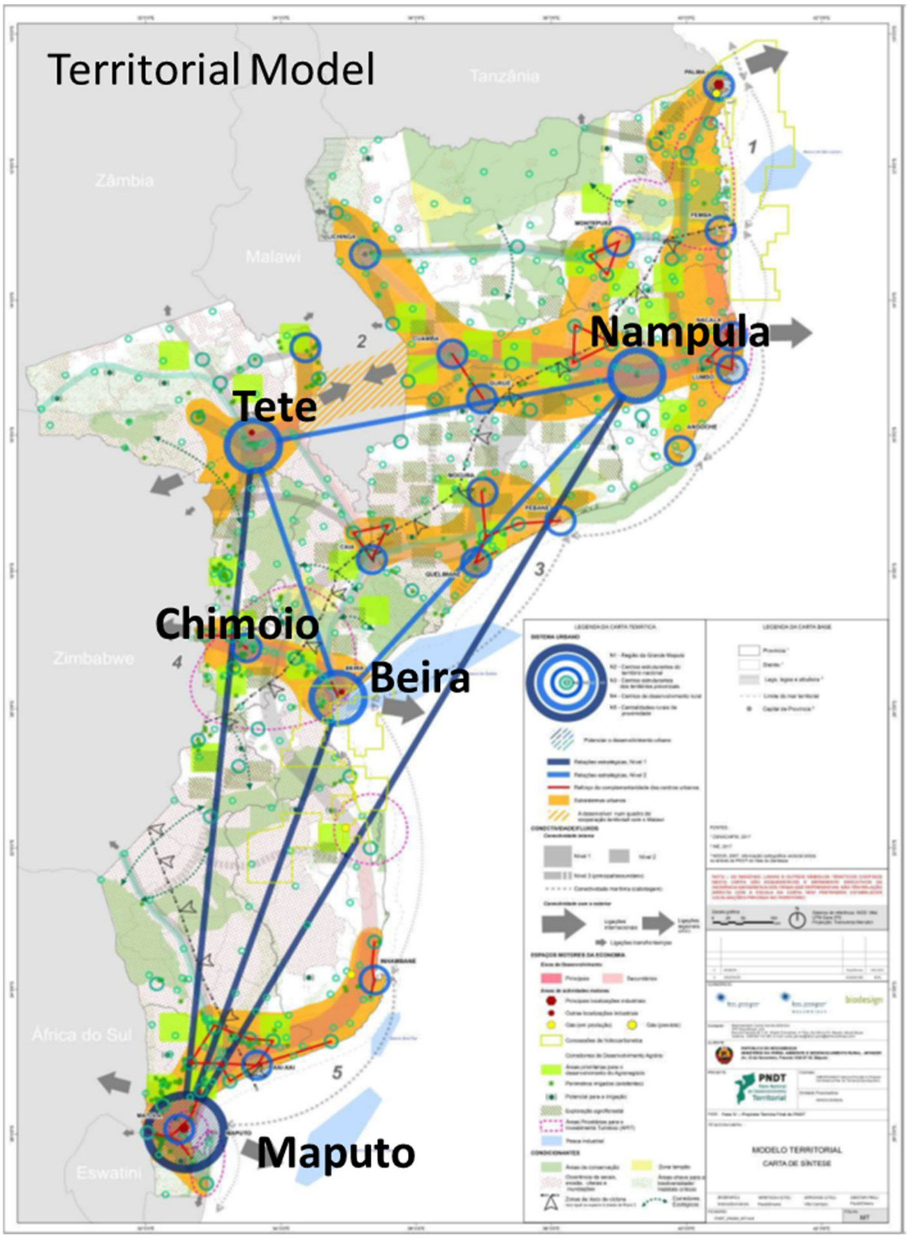


Figure 3-20   Territorial Model of Mozambique

Source: Prepared by JICA Study Team based on National Territorial Development Plan, December 2019.

Superimposing the location map of the above core cities and hazard distribution, it can be said that from the viewpoint of hazard, the disaster risk of Beira is high among the above core cities. In addition, from the perspective of pre-disaster "investment," a certain level of city size is necessary. Simply based on population size, the Nampula has 850,000 people, 570,000 in Beira, and 370,000 in Tete, while the Maputo region has 2 million people, so it can be presumed that when a disaster occurs, the Maputo region will suffer by far the most damage.

On the other hand, since Mozambique has weak coordination among core cities and infrastructure networks within the region, it is also important to create an urban structure in which core cities themselves can realize support without being damaged, so that these cities can serve as a base to support surrounding areas in the event of a disaster.

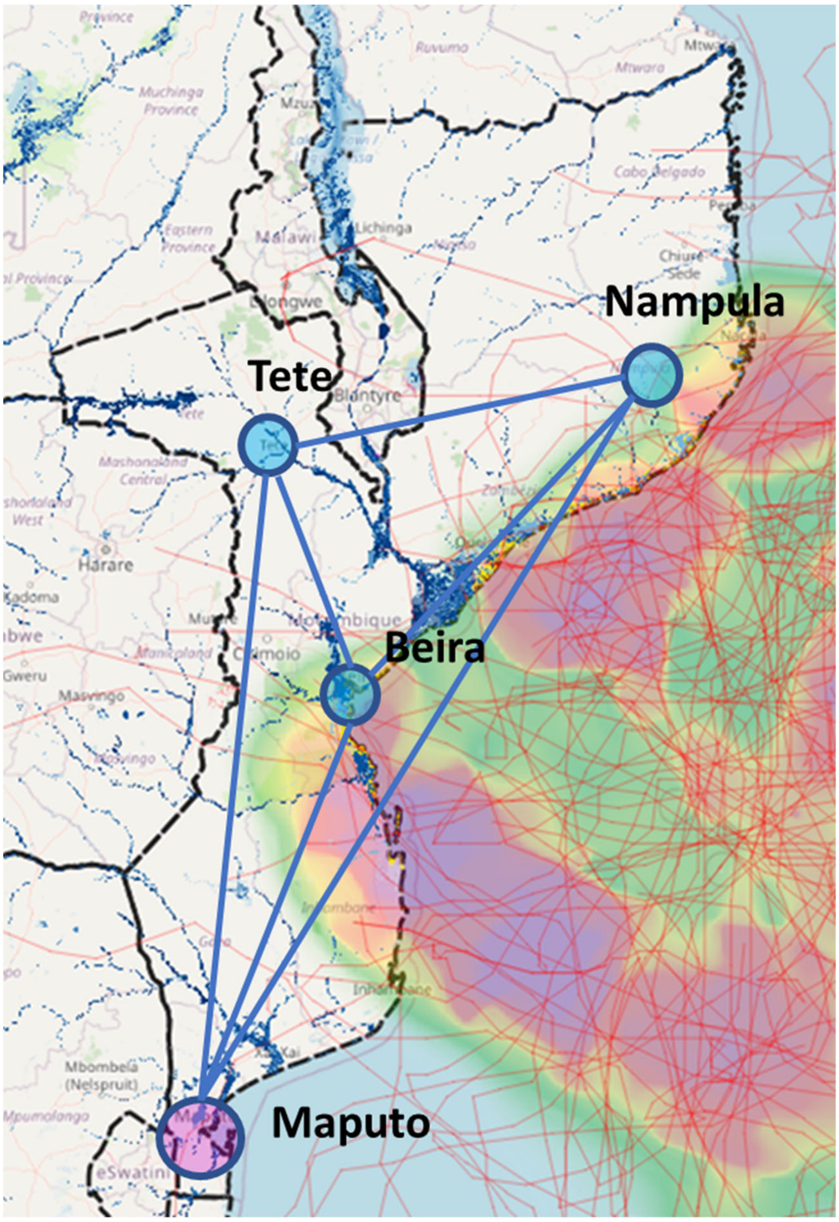


Figure 3-21　Core cities and hazard distribution

Source: Prepared by JICA research team based on UNEP Global Risk Data Platform and Open Street Map (background map).

(5) Urban Development System

1) Land / Housing

The land is publicly owned, and the supply of residential land is in principle publicly allocated. In addition to public allocation (new development and those developed in the Portuguese era including apartments), there are ways to obtain residential land by such factors as: (1) inheritance, (2) long-term usage record, (3) occupancy of unplanned residential land, etc. There are also means such as community allocation in suburban rural areas.

As for the land market, the ratio of public allocation to temporary supply tends to decrease as cities expand, reflecting that public supply cannot catch up with the demand.

The housing land supply policy was prepared by the provinces until 2010, but for 2010-2014 and thereafter, the central government prepared the government plan. Most of the development funds will be provided by the Urbanization Fund (Habitation Fund), which will be used by the municipalities and districts as a source of funding for the project.
The price of residential land supplied by public is set extremely low. In most cases, it is about 300 MT / m2 for housing plots, which are demarcated form lands for roads and other public facilities. Infrastructure / utilities will be developed later, with EDM for electricity and FIPAG for clean water. Road pavement and wastewater treatment basically need to be developed by the local government, and thus usually there is a shortage of funds.

Although there are frauds in public housing (land) supply, most are fairly distributed to applicants. The content of fraud is limited, such as unequal publicity at the time of delivery announcement, by advance notice to the relatives of concerned government officials. The prices of new publicly-supplied residential land are soaring (sometimes more than 100 times the public allocation). Many of the residential land allocated to applicants are purchased by property industries, which causes the soaring of residential land.

A fund has been set up as part of housing policy. In 1990, the system changed from renting to purchasing for apartments built in the Portuguese era. At that time, the fund was established for promoting the purchase by residents. Loans are shifting from publicly allocated land acquirers to publicly constructed condominiums. This is due to the fact that loans to land acquirers are not always used for housing construction. Loans for housing construction are generally 10 to 20 years at a maximum interest rate of 5% / year. (The market interest rate is about 25 %.) A loan of about US $ 400 / m2. The owner uses both the fund and the private loan.

The supply of built-for-sale housing cannot meet the increase of demands. Households who get married immediately after graduating from university are the main purchasers, and there are deduction from salary in many cases.

2） Spatial planning / Urban planning

In principle, spatial plans are prepared by the Districts or, if already established, by the Municipalities. As a planning / realization system in the District, a Land Use Plan will be created as a master plan. This plan is under the jurisdiction of the Ministry of the Environment (MTA) which provides technical standards. In principle, the Land Use Plan is prepared by the District, but due to the rapid decentralization, there are not enough planners/engineers in the District, and the Central MTA and its local agency in provinces are requested to support or create the Land Use Plan. A Detail Plan will be created in line with the Land Use Plan, and the residential land development project will be implemented based on this. (In principle, there are two levels in the planning system.)

The Detail Plan corresponds to the design of residential land development for implementation, and is under the jurisdiction of the Ministry of Public Works and Housing （MPWH) which provides technical standards. Responsibility of formulating the Detail Plan in the Districts are the Districts, it is prepared by requesting the MTA's local agency, as there is a shortage of planners/engineers similar to the case of the Land Use Plan.

On the other hand, in Municipalities, the Structure Plan needs to be formulated as a master plan, then the general urbanization plan (and partial urbanization plan for smaller areas if necessary) for regulating land use, and detailed plan for a project of public land development. In principle, the preparation of these plans is the responsibility of Municipality, and the approver is the Municipal Assembly. The central government has no approval rights and the MTA only "ratifies" it as a procedure. In the case of Municipalities, the government of Municipality will be the main implementing body for residential land development projects which will be carried out based on the Detail Plan.

3.1.4 Disaster Management Plan and Implementation Structure

(1) Legal Framework and Planning for Disaster Management

The definition and principles of disaster management in Mozambique are defined by the Disaster Management Policy (1999), which describes the legal and institutional framework and policies. It describes a policy of creating a culture of prevention through a multi-sectoral approach for vulnerable communities, addressing not only post-disaster response but also prevention and mitigation. It also describes the establishment of the National Institute of Disaster Management (INGD) as the supervisory body for disaster management operations.

The basic law on disaster management is the Disaster Management Act (2014), which was revised in August 2020. The Disaster Management Act indicates the establishment of a legal framework for disaster damage prevention and mitigation, rescue and relief operations, and disaster risk management. The 2020 revision includes changes such as expanding the scope of coverage to include measures against epidemics as well as natural disasters, and making INGD an independent agency and expanding its authority. The Decree on the Disaster Management Act (2016) has established rules and procedures for the application of the Disaster Management Act in disaster prevention, mitigation, response, recovery and reconstruction. The provisions on disaster risk reduction and management systems in the Disaster Management Act are divided into three categories: early warning systems, emergency response systems, and disaster response, damage reduction and resilience systems. However, there are few specific provisions on the development of disaster prevention infrastructure and cooperation with infrastructure-related ministries and agencies for the third point, damage reduction and resilience. The early-warning system, which transmits the disaster information to the people for their preparedness based on the pre-forecast and evaluation of disaster hazard, is divided into two phases, the early warning phase and the alert phase. Although the cover area of the early warning can be changed from the national level to the local level, the coordination and implementation are managed by the national level disaster responsible organizations and the disaster forecasting agencies. The alert phase is categorized in three levels such as yellow alert, orange alert and red alert. The government has to manage the citizens and relevant agencies to take necessary actions according to the alert levels.

The latest plan at the national level is the National Disaster Management Master Plan (2017-2030), which aims to reduce disaster risks. The strategies include improving understanding of disaster risks, enhancing public and private participation in disaster risk reduction, promotion of public investment, land use planning and financial management against disasters and strengthening disaster risk reduction capacity at the provincial and district levels. Although there is no description about the concrete investment plan for the infrastructure development for disaster risk reduction, the enhancement of the investment mechanism for critical infrastructure to decrease the disaster risks is shown as a strategy on the plan. For instance, the following actions are described: 1) evaluation of the disaster damage risk of critical infrastructures based on economic, social and environmental aspects, 2) establishment of the disaster risk management program, and 3) formulation of standards and rules for infrastructure development and maintenance to decrease disaster risks.

The Disaster Management Act refers only to national level disaster management plans and does not stipulate the obligation to formulate plans at the state or district level. In addition, there are no specific examples of disaster management plans at the provincial and district levels, and many provincial and district-level local governments are considered to be in the process of developing such plans. Contingency plans are required to be formulated annually at the national, provincial and district levels by the Cabinet Order related to the Disaster Management Act. Flood and inundation area maps (hazard maps) based on scientific simulations are generally not prepared, although donors sometimes conduct flooding simulations for specific areas when supporting infrastructure projects in the cities concerned.

(2) Implementation Structure of Disaster Risk Reduction and Management

Although the Disaster Management Act and disaster management plans briefly mention policies aimed at reducing risks in the event of a disaster, there is little information on specific disaster mitigation measures or implementation systems related to the promotion of infrastructure development. Many descriptions focus on post-disaster response efforts due to the increased risk of disaster. This indicates that the coordination and cooperation among related organizations for the development of disaster prevention infrastructure is limited and is being promoted through the efforts of each related organization such as the Ministry of Public Works, Housing and Water Resources. In the event of a disaster, INGD will be the secretariat at the national, provincial and district levels, and the Technical Council for Disaster Management and the Emergency Response Center will hold review meetings. In addition, at the community level, the CLGRC (Local Disaster Management Committee) is supposed to implement emergency response, and actual activities are being carried out.

Regarding the budget for DRRM, the government needs to establish the Disaster Management Fund to allocate the accumulated amount to disaster preparedness, emergency response and rehabilitation and recovery works, according to Article 40 of the Disaster Management Act and Decree 53/2017. Article7 of Decree 53/2017 stipulates that the minimum 0.1% of the national budget is allocated to the Disaster Management Fund. Besides, Decree53/2017 describes that the budget for the Disaster Prevention Activities by each sector shall be covered by the normal budget framework of each organization at the national level and the local level.

In the recovery phase, Article30 of the Disaster Management Law stipulates that disaster management responsible organizations at the national level and the municipality level shall coordinate recovery process. The disaster responsible organizations are the District/Municipality Level Emergency Response Center and District/Municipality Technical Council for DRRM. According to the Disaster Recovery Framework (2019) after the Cyclone-Idai, the Post Cyclone-Idai Reconstruction Cabinet (GREPOC) is the responsible organization for the recovery budget management, coordinating with Ministry of Economy and Finance (MEF). The GREPOC manages the recovery finance, coordinating different financial resources such as the amount from the national budget and support from international donors.

3.1.5 Trends in Donor Support

(1) Overview of Donor Support

According to the Ministry of Foreign Affairs of Japan's International Cooperation Bureau's Official Development Assistance (ODA) Country Data Collection, totals for 2000 to 2017, donor aid to Mozambique is dominated by the World Bank Group's International Development Association (IDA), the European Commission, the European Investment Bank, and other European Union (EU) institutions. In terms of major donors, the U.S. has provided the most aid.

Table 3-13 Top five donors' economic cooperation achievements (Unit: in millions of dollars)

Achievements of international organizations in economic cooperation		**Achievements of major donors in economic cooperation**	
IDA	4,090.54	U.S.A	4,697.4
EU Institutions	2,537.7	U.K	1,810.0
AfDF	1,271.6	Sweden	1,267.0
GFATM	792.74	Japan	800.4
IMF-CTF	324.6	Denmark	759.1

Source: Data collection of MOFA's Official Development Assistance by country compiled by JICA Study Team research team (2000 to 2017)

The coordination chart by development cooperation partners shown in the African Development Bank's COUNTRY STRATEGY PAPER (CSP) 2018-2022 shows that sectoral working groups have been created for policy consultation and aid coordination. The working group on climate change and environment is chaired by UNDP, with the World Bank, the African Development Bank, and several other donors for cooperation as participating countries. In particular, aid to the health and education sectors, transportation and communications, agriculture, food, and fisheries is increasing.

Table 3-14 Policy consultation and aid coordination by development cooperation partners

Sector Working Groups	Chair of Group	Partners Participating
Agriculture	World Bank	EU, Belgium, Austria, Finland, USAID, WB, IFC
Private Sector (incl, trade sub-group)	Norway	Netherlands, Germany, UK, Ireland, Finland, Norway, Denmark, Sweden, Austria, France, Italy, Portugal, EU, Switzerland, USAID, Canada, Japan WB, IFC, AFDB, ILO, UNIDO
Energy (incl. renewable, and off-grid sub-group)	World Bank & Sweden	Belgium, France, Sweden, Finland, Norway, Germany, EU, Japan, USAID, WB, IFC, AFDB, UNIDO
Education (incl. sub-groups on primary, secondary, TVET)	Germany	UK, Finland, Norway, Sweden, Germany, Netherlands, Italy, Ireland, Portugal, Canada, Japan, Korea, USAID, WB, UNICEF, GPE, ILO, UNESCO, UNFPA
Health (incl. several sub-groups)	USAID	Canada, USAID, EU, UK, Netherlands, Denmark, Germany, Belgium, Ireland, France, Spain, Italy, Switzerland, WB, Global Fund, WHO, UNFPA, UNICEF, GFF
Social Protection	UNICEF	EU, UK, Sweden, Netherlands, Ireland, Italy, USAID, WB, UNICEF, ILO, WFP, ICDP
Water and Sanitation including Water Resources	UNICEF	Netherlands, Belgium, Germany, Austria, UK, Sweden, France, Portugal, Spain, EU, Switzerland, Japan, Canada, India, Korea, WB, AFDB, UNICEF
Macro Stability & PFM (incl. several sub-groups)	Sweden & IMF	EU, UK, Sweden, Norway, Finland, Denmark, Netherlands, Germany, Belgium, Ireland, Austria, France, Spain, Italy, Portugal, Switzerland, Canada, USAID, Japan, Korea, WB, IMF, AFDB, UNDP, UNICEF, UNFPA
Extractives (incl. EITI)	Norway	UK, Norway, Finland, Denmark, Germany, France, EU, Switzerland, Canada, Australia, USAID, WB, IFC, IMF, AFDB, UNDP
Governance (incl. several sub-groups)	UK	UK, Finland, Sweden, Denmark, Germany, Italy, EU, WB, UNDP
Conservation	Germany	EU, France, Germany, Denmark, USAID, WB, WCS, WWF
Climate Change & Environment	UNDP	UK, Ireland, Germany, Netherlands, Norway, Finland, Sweden, Denmark, France, EU, USAID, Japan, WB, AFDB, UNDP, UN-HABITAT, IFAD, WWF
Urbanization & Decentralization	Switzerland	Canada, USAID, UK, Netherlands, Norway, Denmark, Sweden, Germany, Ireland, Austria, Portugal, Spain, Italy, EU, Switzerland, WB, IMF, AFDB, UNDP, UN-HABITAT, UNICEF, UCLG

Source: AfDB COUNTRY STRATEGY PAPER (CSP) 2018-2022

(2) Trends in Aid from World Bank (WB)

According to the COUNTRY PARTNERSHIP FRAMEWORK (CPF) 2017-2021, which sets out the World Bank's aid policy, the three goals of the CPF for 2017-2021 are to "promote diversified growth and productivity growth," "invest in human capital," and "improve sustainability and Improving Resilience".

In terms of addressing climate risk, the goal is to increase resilience to short-term weather variability and long-term climate change by strengthening planning and capacity of disaster risk management. The program will focus on (a) strengthening institutional and policy responses to address climate change and disaster risk reduction; (b) improving water resource management and planning; (c) investing in climate resilience measures at the local level, such as climate-smart agriculture and natural resource management practices for rangelands, forests, and fisheries resources; (d) improving coastal zone management and protection; and (e) integrating climate risk assessment into planning and infrastructure development. The goal will be achieved through a combination of programmatic analytical work, policy-based financing, and investments aimed at building national capacity for adaptation and resilience to climate change.

According to a vulnerability assessment conducted in 2017, Mozambique is vulnerable to extreme events such as drought (especially in the south), floods (mainly around the flood plains of major river basins such as the Limpopo, Maputo, Buji, Incomati, Save, Pungue, Zambezi, and Umbeluzi rivers), tropical cyclones (which affect the entire country). However, the country lacks adequate social and economic infrastructure to enable prevention, mitigation, and adaptation measures, and

80% of the population is engaged in rainfed agriculture, which makes it vulnerable to crop loss, displacement of people, loss of assets (property and animals), land degradation, saltwater intrusion, and erosion. It has been analysed that the population is more vulnerable to crop loss, displacement, loss of assets (property and animals), land degradation, saltwater intrusion, and erosion.

In order to effectively address these phenomena, it is stated that a large-scale partnership between the government and development partners interested in prioritizing efforts and building resilience to climate change is needed. In the short term, (i) enhancing capacity of INGC, (ii) strengthening and scaling up early warning information dissemination systems in disaster-prone areas; (iii) strengthening the capacity of fire departments across the country; (iv) promoting climate change tolerant varieties of crops that are essential for food security in Mozambique; and (v) accessing financial instruments that guarantee the impact of extreme weather events.

Mozambique is also exposed to the risk of sea level rise since two-thirds of its population and economic infrastructure such as factories, tourist housing, and residential areas are located along its 2,700 km coastline. The city of Beira, which is located below the sea level, is already experiencing damage to roads and other infrastructure due to seawater intrusion, and since the sea level is predicted to rise by 96cm by 2100, it is analysed that not only the city of Beira but the entire coastline is at risk of being flooded. In addition, Mozambique is located downstream of many waterways within SADC, which further increases the risk of flooding, as experienced during the floods in the south in 2000. These mitigation and adaptation measures include (i) implementation of Mozambique's Green Growth Strategy, (ii) capacity building for climate resilient infrastructure planning, and (iii) mobilization of climate finance.

Specific projects implemented to date include not only the reconstruction efforts in Cyclone Idai and Kenneth, but also disaster risk management (DRM). As shown in the table below, several initiatives have been implemented not only in the field of disaster response and prevention, but also in the field of climate change.

Table 3-15 List of relevant projects in the field of disaster response and disaster risk reduction, and climate change

Project Name	Project Objective	Financier	Approval Year
Social Protection Project and Support to Cyclone and Flood Emergencies	To provide temporary income support to extremely poor households and to put in place the building blocks of a social safety net system.	IDA Grant Miscellaneous 1	2019
Mozambique: Cyclone Idai & Kenneth Emergency Recovery and Resilience Project	To support the recovery of public and private infrastructure and livelihoods; (b) to strengthen climate resilience in the areas most affected by Cyclones Idai and Kenneth; and (c) to provide immediate and effective response to an eligible crisis or emergency	IDA Grant Netherlands	2019
Mozambique Disaster Risk Management and Resilience Program	To strengthen the Government of Mozambique's program to finance and prepare for disaster response and to increase the climate resilience of vulnerable education infrastructure in risk-prone areas.	IDA Grant GRiF	2019
Emergency Resilient Recovery Project	To restore the functionality of critical infrastructure in a resilient manner in the disaster-affected provinces; and to improve the Government of Mozambique's capacity to respond promptly and effectively to an eligible crisis or emergency.	IDA	2015
Enhancing Spatial Data for Flood Risk Management Project	To increase the capacity of Mozambique to prepare for and manage flood events in the Limpopo and Zambezi River basins.	Global Facility for Disaster Reduction and Recovery	2014
Water Resources Development Flood Response Additional Financing	To strengthen the management of national water resources and increase the yield from Corumanadam to augment water supply for the Greater Maputo Metropolitan Area.	IDA Credit From CRW	2013
Mozambique-Programmatic Support to Disaster Risk Management Phase I	To strengthen the early warning system and design and pilot mitigation activities in highly vulnerable areas.	Global Facility for Disaster Reduction and Recovery	2011
Flood Emergency Recovery Project	To assist the Government implement, and maintain macroeconomic stability, through the financing of import costs, associated with rebuilding social, and economic infrastructure, and re-establish production levels in response to the damage caused by the recent floods, and cyclones.	IDA	2000

Source: extracted from WB Website Projects & Operations

(3) Trends in Aid from the African Development Bank (AfDB)

The pillars of the COUNTRY STRATEGY PAPER (CSP) 2011-2015, which outlines the AfDB's aid policy, were to strengthen "infrastructure" and "governance," but addressing poverty alleviation in rural Mozambique, revitalization of agriculture, infrastructure gaps, and utilization of the country's abundant natural resources remained a challenge. To this end, CSP 2018-22 clarifies initiatives around the "energy," "transport," and "agriculture" sectors, positioning (1) the development of infrastructure to enable transformative inclusive growth and job creation, and (2) support for agricultural transformation and value chain development as key pillars. Areas of particular strategic emphasis include "governance," "addressing climate change," and "gender equality.

AfDB also has a policy of mainstreaming climate change considerations in all its aid activities. In particular, investments in the agricultural sector will address the need for infrastructure development to combat floods and droughts, support the adoption of climate-sensitive agricultural technologies and techniques, and improve disaster management capacity. It also emphasizes climate change countermeasures in the design and planning of infrastructure and will support the diversification of energy sources and the reduction of deforestation.

Specific projects for DRR related projects include a project to strengthen the resilience of the Limpopo River Basin as well as post-flood emergency response.

Table 3-16 List of relevant projects in the field of disaster response and disaster risk reduction, and climate change

Project Name	Project Objective	Financier	Starting Year
Mozambique - Baixo Limpopo Irrigation and Climate Resilience Project (BLICRP)	To contribute towards poverty reduction through increased value addition and provision of climate resilient (CR) infrastructure for increased agricultural productivity through support for the development of 3,050 ha for cash crops and provision of marketing and agro-processing facilities.	African Development Fund	2012
Mozambique - Feasibility Studies for Building Climate Resilience of Limpopo Basin in Mozambique	To develop a multi-purpose water storage capacity (at Mapai or elsewhere in the basin) that would provide a significant long-term response to the hydrological variability and climate change induced challenges.	Africa Water Facility Fund Fund for African Private Sector Assistance	2014

Source: extracted from AfDB Website Projects & Operations

(4) Trends in Aid from Other Donors

In Mozambique, which was severely affected by cyclones in the past, several international donors are providing assistance for disaster recovery and strengthening disaster management systems parallelly in national and regional levels. It is hard to grasp entire contents.

In 2019, UNDP agreed to provide medium- and long-term support for economic empowerment, housing and community infrastructure development, and strengthening of the structure of the Recovery Agency as the UNDP Recovery Facility to support rapid recovery and resilience building after Cyclone Idai and Kenneth.

The EU provides funding for GFDRR's disaster risk management and climate change adaptation projects through the ACP-EU NDRR Program (The Africa Caribbean Pacific-Europe Union Natural Disaster Risk Reduction Program) launched in 2011. So far, projects such as flood risk management, preparation of district development plans adapted to disaster risk reduction and strengthening disaster risk management and adaptation to climate change have been implemented in cooperation with other donors[15].

The Government of the Netherlands has been developing drinking water supply infrastructure in the priority areas of Beira City and the province of Carbo Delgado in the central Zambezi Plateau, but since the area was affected by the 2019 cyclone, the program has been partially changed to support reconstruction. For Cyclone Idai, a task force of experts prepared the "Beira Recovery and Rehabilitation Plan" and provided funds for reconstruction, while new investment in coastal protection and drainage is also being considered. An Integrated Water Resources Management Fund has been launched to develop a more resilient drinking water supply infrastructure in the central and northern parts of the country[16].

[15] https://www.gfdrr.org/en/acp-eu/projects

[16] https://www.dutchdevelopmentresults.nl/2019/countries/mozambique#

3.1.6 Selection of Key Cities

Based on the above overview of disaster risk, climate change, land development and urban development in Mozambique, as well as trends in donor support, it was decided that this study would focus on disaster risk management issues at the city level and the potential for support projects in the Maputo Metropolitan area, and Beira as key cities. As for inter-city infrastructure, it was decided to focus on the Limpopo River Basin and development along the Nacala Corridor. The study will focus particularly on these important cities and inter-city infrastructure, but the study of potential support projects will not be limited to these but will be conducted flexibly as appropriate based on sectoral conditions, local needs, and issues related to regional disaster risk reduction.

3.1.7 Information Collection and Analysis for Cooperation in the Field of Disaster Risk Reduction in Each Sector

(1) Urban Development and Disaster Risk Reduction

1） Maputo Metropolitan Area

【Current status of urbanization and formulation of land use plan】

Maputo municipality is the capital city, the economic and political center of the country, and the top priority is not to stop functioning as capital city in the event of a disaster, compared to other cities. In addition, urban expansion is underway in Maputo municipality, and urbanization into hazard areas is a concern. Since investment in disaster risk reduction is a new concept for Mozambique, it can be effectively implemented in the form of a national policy first. Given these circumstances, it is focused on the Maputo Metropolitan area, Maputo municipality and Matola municipality.

Maputo municipality is undergoing rapid urbanization and is expanding from the center of Maputo to the north-south direction and to the neighboring municipality of Matra. Especially since 2000, more and more development has been taking place in the suburbs and in areas vulnerable to flooding, such as along rivers.

The Structure Plan of Maputo City was formulated in 2008 and is due for revision, but due to budget constraints, it has not yet been revised. Comparing the actual land use (2008) with the land use plan at the time, the plan is to include new urbanization promotion areas in green and blue (considered recreational and flooding areas), which are currently considered ecological impact areas. In the case of such development, it is important from the standpoint of environmental conservation and disaster risk reduction to implement appropriate development management. However, based on discussions with Maputo City, the issue of low capacity to manage land use and development regulations has been a issue, and the city is aware of the need to improve this situation. There is a concern for a sprawl outside the development area.

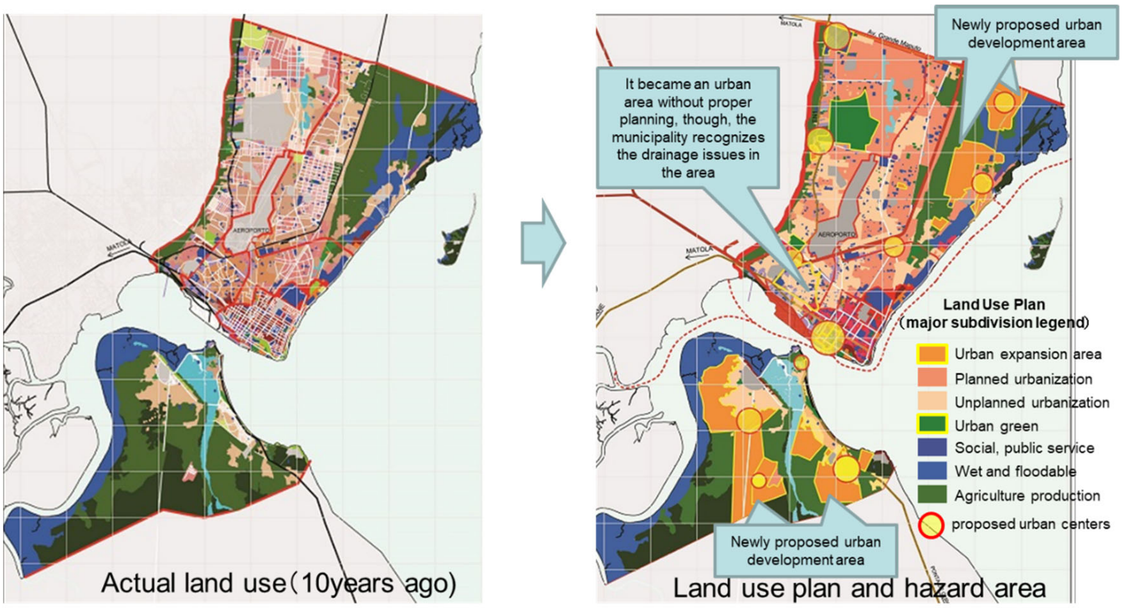


Figure 3-22 Land Use Plan of Maputo Municipality

Source: Prepared by JICA Study Team based on Urban Structure Plan for the Municipality of Maputo.

Matola's Structure Plan was formulated in 2010, and like Maputo's, it is due for revision. The municipality of Matola has a Memorandum of Understanding (MOU) with a consultant in 2019, but has not yet signed a contract. Due to the lack of budget, GIS and updating of equipment, etc., are not in progress is one of the reasons that has not been made.

Comparing the actual land use (2010) with the land use plan at that time, the plan is to use the area along national road (N2) and the ring road as industrial and multi-functional areas, and fill the space in between with housing, in accordance with the plan to have the ring road pass through an area that is not currently planned as a residential area. The north side of the ring road is assumed to be an urbanized area. Although there are regulations on the area of green space in urbanized areas, as in Maputo City, there is a lack of proper management of such regulations, and there is a concern that if urbanization continues at a rapid pace in the future, the amount of runoff into the watershed will become uncontrollable.

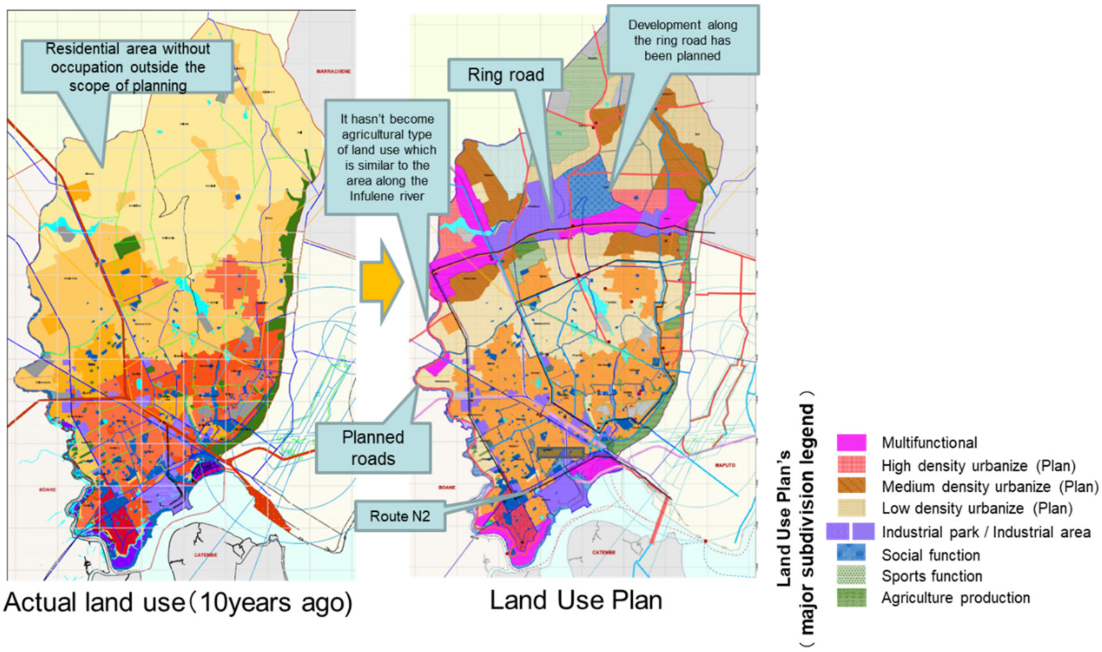


Figure 3-23 Land Use Plan of Matola Municipality

Source: Prepared by JICA Study Team based on Urban Structure Plan for the Municipality of Matola.

【Development situation in Maputo Municipality and Matola Municipality 】

The points identified as flooded areas by Maputo and Matola municipalities were mostly located in lowland or wetland areas, which are basically prone to flooding. People who moved from the countryside during the civil war began to live in these flood-prone areas, and after the end of the civil war, they brought their families and settled down. This is the background of the urbanizing of these areas.

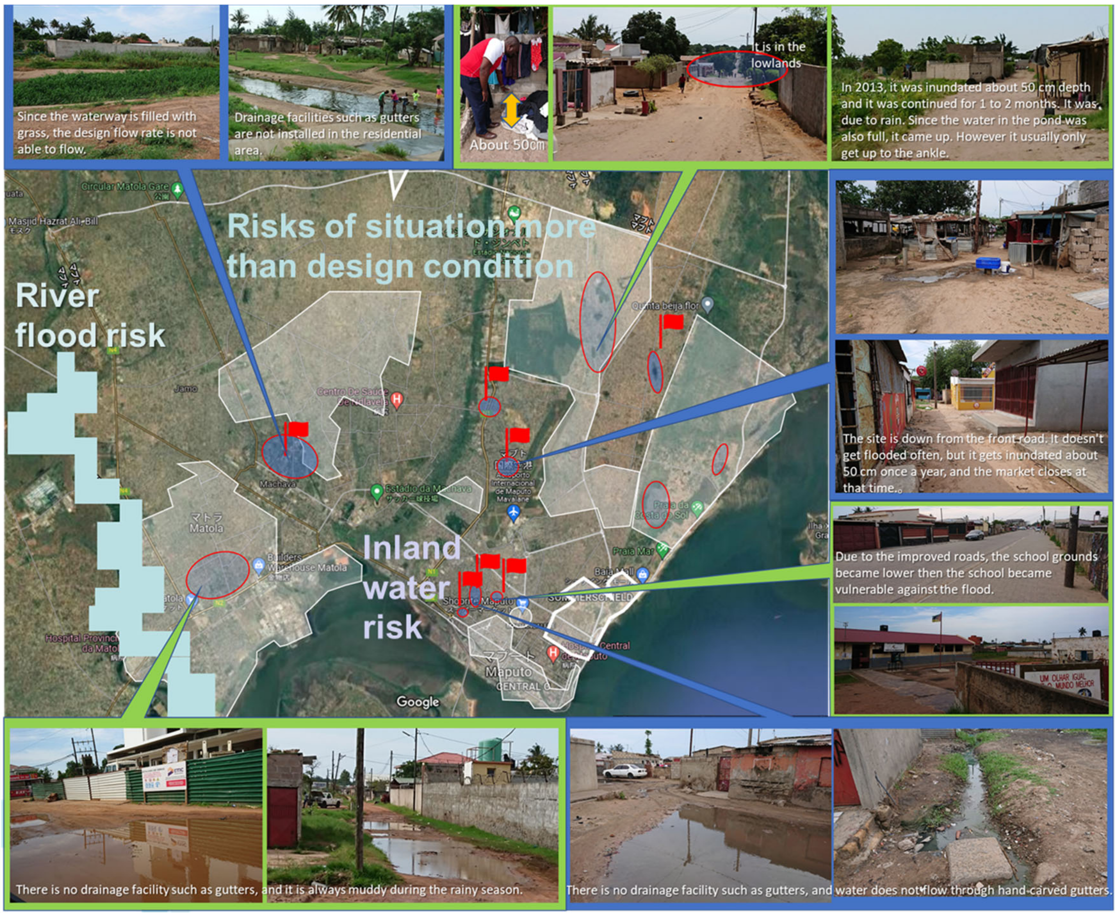


Figure 3-24 Flooding Situation in Maputo Metropolitan Area

Source: JICA research team

In addition, specific examples of problematic development situations include the following situations.

Figure 3-25 Land use status (2021) and land use plan (2008)

Source: JICA Study Team

Relatively large-scale construction is underway in an area (along the Infulene River) that is designated as an agricultural production area in the land use plan. If development continues at this rate, the effective river channel during floods will be dwarfed, and even if damage is not occurring now, the possibility of other areas being impacted by flood due to such development will increase in the future. (Sites such as the one circled in red in the figure may be filled, but may affect existing residential areas and downstream areas on the other side.)

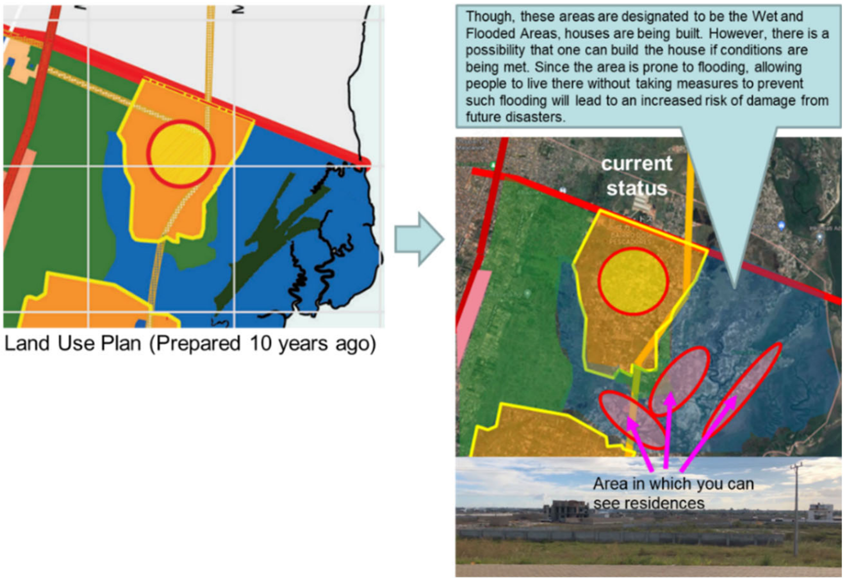


Figure 3-26 Land use status (2021) and land use plan (2008)

Source: JICA Study Team

As shown in the figure above, housing has already been built in the wetlands and flood vulnerable areas (blue) outside of the urban expansion area (orange), and it is necessary to manage land use regulations based on the plan to prevent uncontrolled development in these areas.

【Issue of the urban planning in Maputo Metropolitan Area】

From the above, the following points can be identified as urban planning issues for Maputo Municipality and Matola Municipality.

- Although steps have been taken in urban planning based on hazard analysis, they do not envision the disasters that can be expected in the future.
- There are land use regulations tied to land use plans, but they are not binding.
- There is inadequate management capacity to control them, allowing permits to be granted even when they are inappropriate, and allowing construction without permits.
- There are no financial resources to promote relocation for non-illegal residents.
- The following are some of the views on these issues.
- Since the current land use plans are not based on the consideration of future disasters, the JICA-supported input for planning with an eye on future disasters is a new perspective and is significant as a model for Mozambique.
- The current land use plan may be a follow-up development to an area that has already been developed (a situation that exists in Japan as well), but it would be granting rights, and it would be the city's responsibility if it allows the land use despite the known risk of disaster. If development is to be allowed, it is necessary to include a set of measures against the danger.
- Both cities are aware of the fact that they have land use plans in place, but they are not under control, and unless they take action to address this, they will not be able to change the situation where the plans merely follow what has happened.

【Technical assistance of urban planning for Maputo Metropolitan Area】

Based on the above examination, in order to make the Maputo metropolitan area a city that is resilient to disasters and be able to maintain the function of the capital in the event of disaster, technical assistance for formulation of DRR Plan based on JICA 8 Steps and reflect the plan into the structural plan would be proposed.

This proposal will be integrated with the "Project for Formulation of Integrated Water Related Disaster Risk Reduction Master Plan," which will be described later in (9) River Management and Coastal Management.

<Outline of the project>

As the city has developed, vulnerability of the city will be increased due to sprawling of urban area to high-risk area. Therefore, before uncontrolled development occurs, it is important to formulate a development plan that assumes an urban structure that is less vulnerable to damage from disasters.

Therefore, a disaster management plan based on JICA 8 Steps will be formulated and an urban development plan reflecting structural measures will be developed.

<Proposal>

1. Prepare hazard maps (Flood) that reflect possible future situations and study countermeasures.
   - Provide technical inputs for hazard mapping. (INGD)
   - Study countermeasures against hazards. (ARA SUL, Maputo Municipality, Matra Municipality)

2. Reflect the above measures in urban planning (land use plan). (MTA, Maputo Municipality, Matra Municipality)
   - Review the land use plan to reflect the measures considered in 1.
   - Identification of measures for residual risks.
   - Set goals for DRR urban development
   - Preparation of a roadmap for implementation of the plan
   - Identify and sort out issues in implementation
   - Consideration of countermeasure proposals for the issues
   - Examination of priorities

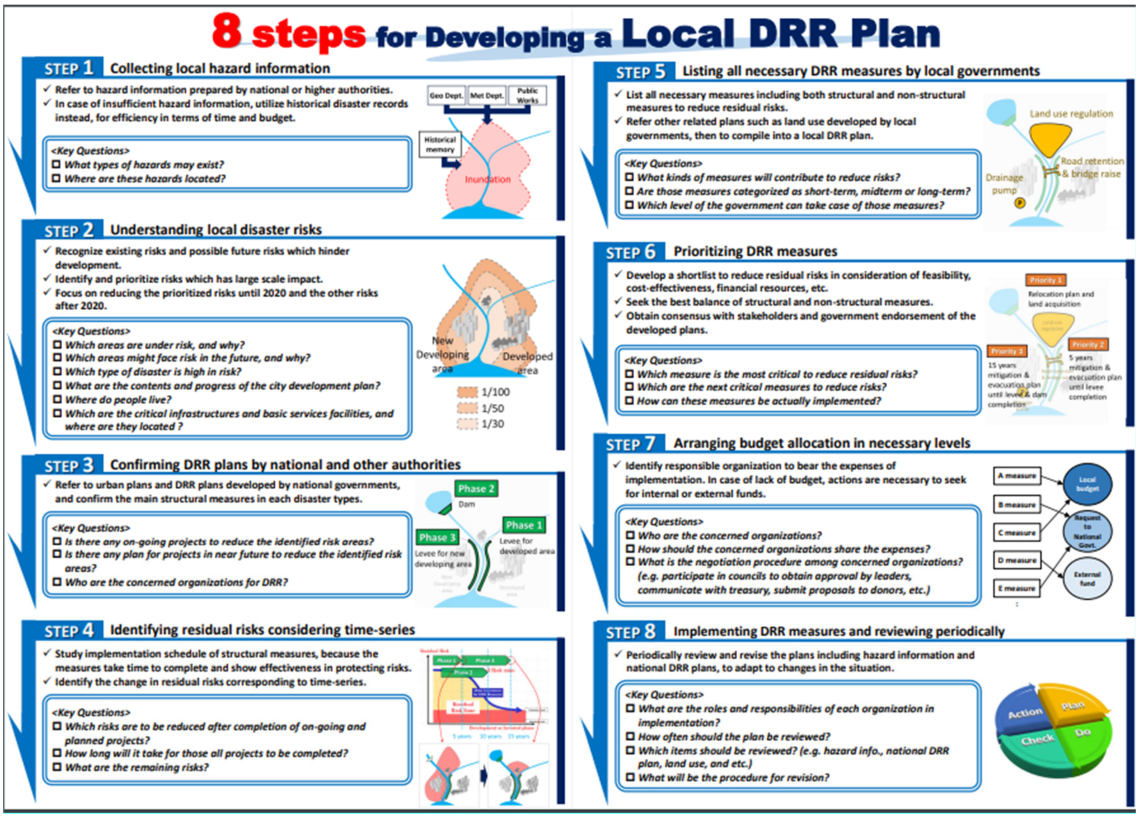


Figure 3-27 (Reference) JICA 8 Steps

Source: JICA, 8Steps Practical Method for Developing Local DRR Strategies/Plans

2) Beira City

Beira city is second largest city in Mozambique and a port city located in central Mozambique. As mentioned above, Beira city is more susceptible to natural disasters than other cities, and in recent years, cyclones have hit the city one after another. The municipality was severely damaged by Cyclone Idai in March 2019, but several cyclones passed through the city before and after that. In the dire need to prepare for cyclones that may come in the next rainy season to minimize losses, disaster risk reduction at various stages of efforts is being made.

Figure 3-28　Cyclone passage and situation after Cyclone Idai

Source: Prepared by JICA research team based on NOAA data.　Photo source: Courtesy of JICA research team

On the other hand, it is not only the city of Beira that is susceptible to natural disasters, but also Sofala Province in the region surrounding Beira. As mentioned above, Mozambique has a weak inter-city infrastructure network, so when Beira and the surrounding areas are affected by the disaster, Beira City will be in a position to serve as a support base for the surrounding areas. Therefore, it is important for Beira itself to be a city that is not easily damaged by the disaster and can maintain its functions as a hub city.

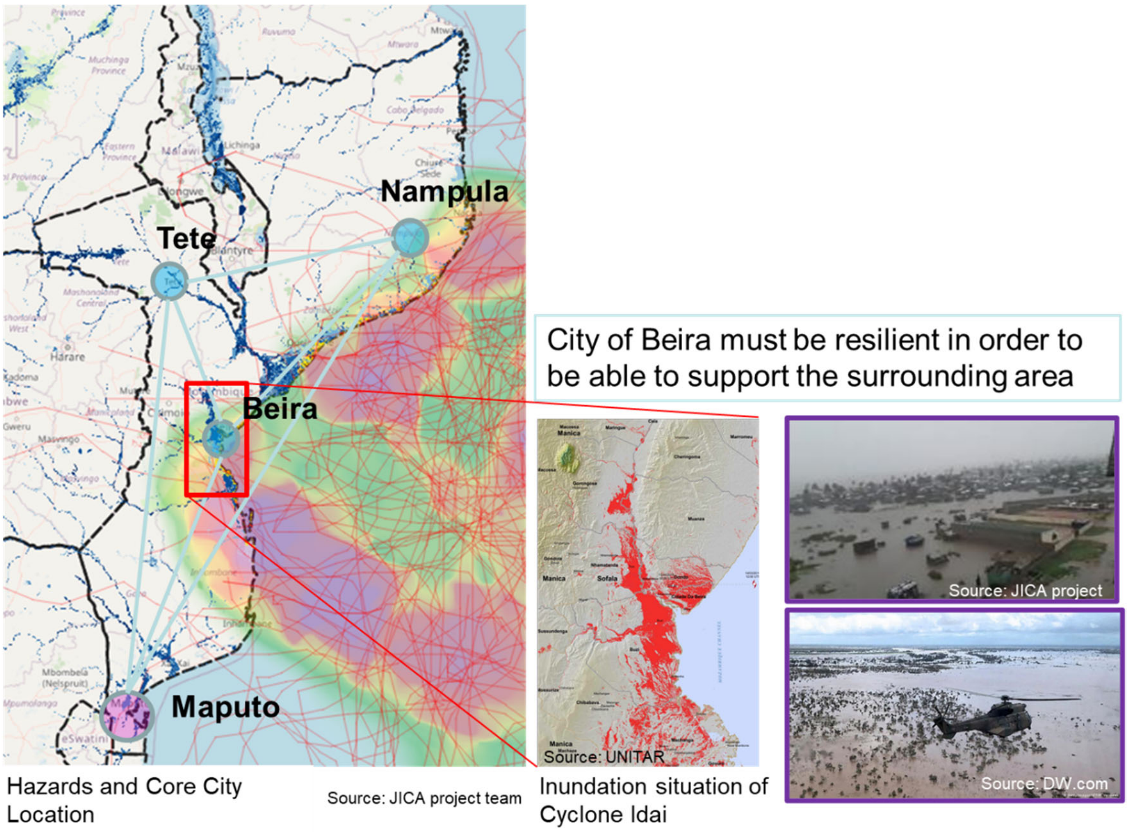


Figure 3-29　Positioning of the Beira Municipality as a support center

Source: Shown in figure

【Base city for Disaster relief】

Currently, with the support not only from JICA but also from donors such as the Dutch government, UN-HABITAT, WB, etc., various disaster risk reduction projects such as seawalls, drainage plans, and water parks are being studied and implemented. In the future, the focus of disaster risk reduction project support will be on the study and implementation of measures for residual risks. (Land use regulations, building regulations, strengthening of disaster risk reduction headquarters functions, disaster risk reduction base facilities, disaster risk reduction base hospitals, measures against outside water, construction of early warning systems, development of evacuation plans for all villages, etc.)

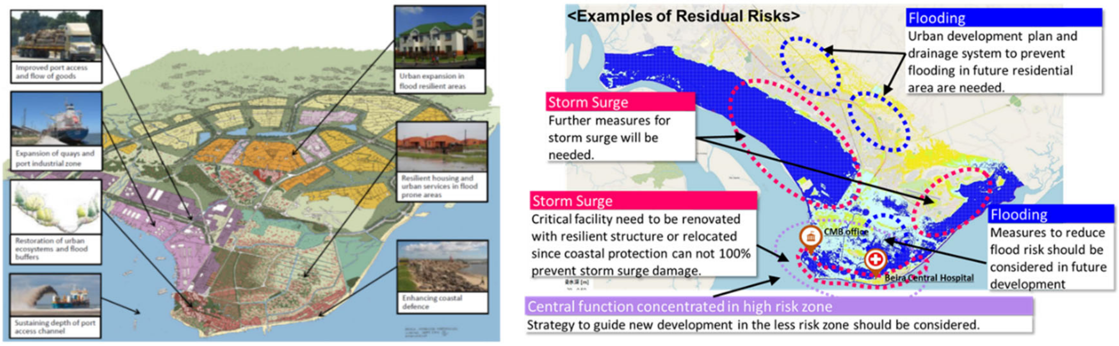


Figure 3-30 Reconstruction plan for the city of Beira and image of residual risk measures

Source: Beira Municipal Recovery and Resilience Plan (left) Prepared by JICA research team (right)

In order for Beira to function as a base city for disaster relief, it is necessary to make Beira itself less vulnerable to disaster. Functions to support neighboring cities include strengthening airports, which will serve as bases for receiving external aid, and logistic centers that will receive aid groups and relief supplies and handle cargo. These centers may be connected by raised roads or roads through higher ground as a logistic network.

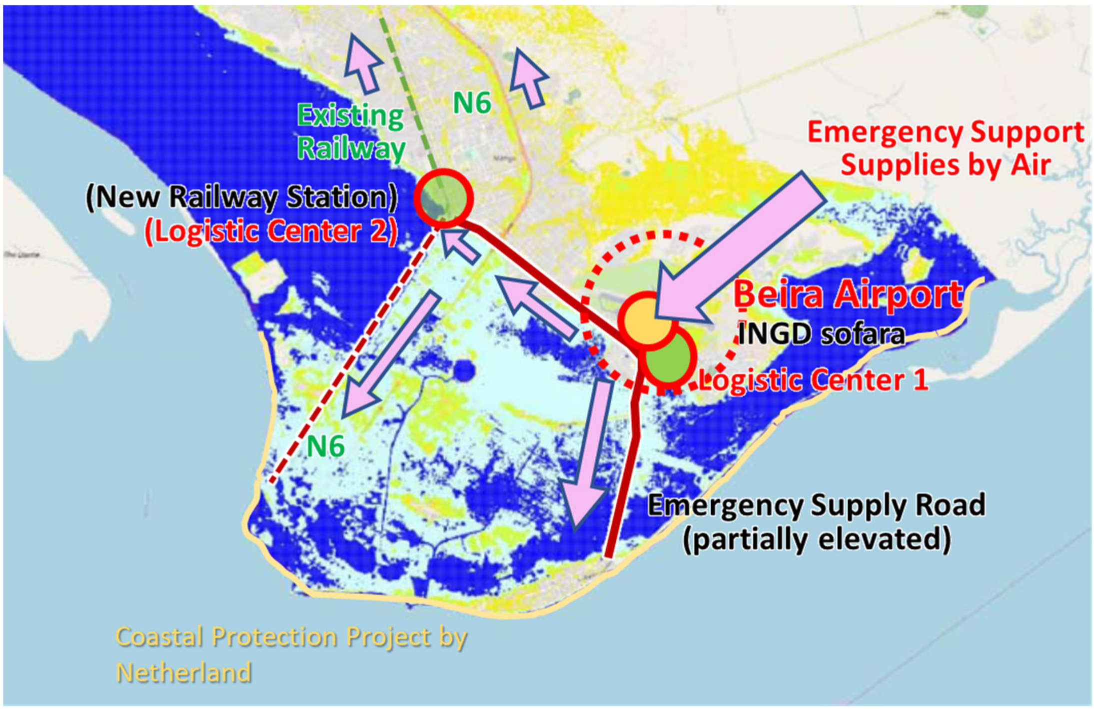


Figure 3-31 Image of enhancement of disaster supporting base city function in Baira Municipality

Source: JICA research team

Since the current structure plan of Beira does not take into account the positioning of the city as a base city for disaster relief, such positioning will be proposed during the "Project on Strengthening Resilience in Cyclone Idai Affected Area", which is being implemented separately. The specific functions, location, scale, and division of roles of each organization will then be positioned in the urban structure plan based on the basic survey and support for master plan formulation.

(2) Transportation

Major roads, railroads, ports, and airports in Mozambique are shown in Figure 3-32. The most significant feature of the country's national transportation infrastructure is that roads and railroads have been developed along international corridors that connects the international ports of Maputo, Beira, and Nacala with neighboring landlocked countries such as Malawi, Zimbabwe, and Zambia to the west, as well as northeastern region of South Africa. These international ports serve as gateways for landlocked countries and are essential transportation infrastructure for imports and exports not only in Mozambique but also in the landlocked countries mentioned above. Although the number of passengers and cargo volume are not large, air traffic is used for long-distance passenger travel, and air traffic is essential for the rapid transportation of emergency relief supplies in the event of a disaster, making airports an important transportation infrastructure.

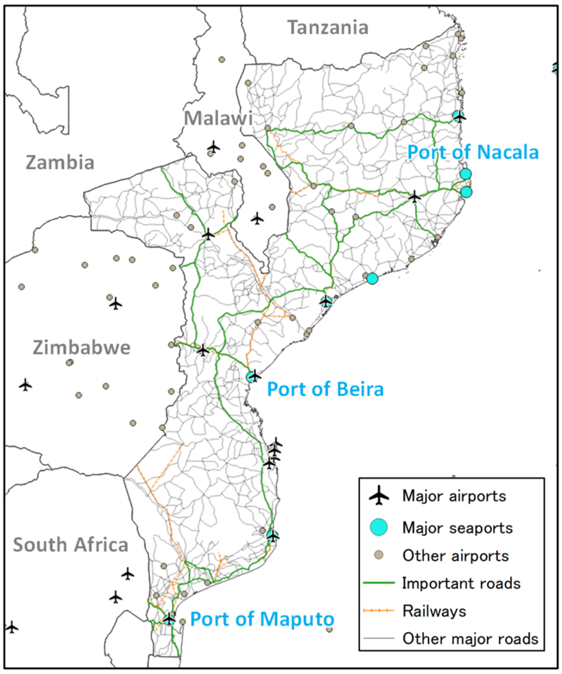


Figure 3-32 Major transportation infrastructure in Mozambique

Source: JICA Study Team

1） Overview of Relevant Organizations and Legal systems

Table 3-17 shows the main relevant institutions, including ministries, that have jurisdiction over the transport and traffic sector in Mozambique.

Table 3-17 Key Institutions in the Transportation Sector in Mozambique

Subsector	Key Institutions
Road	Ministry of Public Works, Housing and Water Resources (Ministério das Obras Públicas, Habitação e Recursos Hídricos), MOPHRH
	National Road Administration (Administração Nacional de Estradas), ANE
Railroads and Ports	Ministry of Transport and Telecommunications (Ministério dos Transportes e Comunicações), MTC
	Mozambique Ports and Railways (Portos e Caminhos de Ferro de Moçambique), CFM
Airport	Ministry of Transport and Telecommunications (Ministério dos Transportes e Comunicações), MTC
	The Airports Company of Mozambique (Aeroportos de Moçambique), ADM

Source: JICA Study Team

a) Road

Roads in Mozambique are under the jurisdiction of the Ministry of Public Works, Housing and Water Resources (MOPHRH), and the National Road Administration (ANE) is in charge of the practice. Mozambique's classified roads are broadly divided into national roads and regional roads, with national roads further divided into primary and secondary roads, and regional roads further divided into tertiary and vicinal roads. These classified roads are planned, implemented, and maintained by ANE. Specifically, ANE is directly in charge of primary roads, while secondary and tertiary roads are managed by the province with the support of the ANE office. Unclassified roads and urban roads that do not fall into the above four categories are managed by the district administration and the municipal council, respectively.

Roads are mainly used for domestic transportation. However, the total road length is 30,616 km, and its pavement coverage is only about 30% (Source: Statistical Yearbook 2019 – Mozambique, National Statistic Institute, 2020). According to AfDB data (Country Results Brief 2018 Mozambique), Mozambique shows low maintenance rate per population and per land area even among African countries (45th and 46th out of 54 countries, respectively). The current status of roads in Mozambique is shown in Table 3-18.

Table 3-18 Current status of roads in Mozambique

Province	Road network (km)						
	Classified roads	Paved	Non Paved	Main roads	Secondary roads	Tertiary roads	Vicinal
Total	30,616	8,268	22,348	6,349	4,885	12,669	6,713
Niassa	3,974	693	3,281	839	347	1,822	966
Cabo Delgado	2,972	828	2,144	477	365	1,708	422
Nampula	3,893	890	3,093	954	166	1,942	921
Zambézia	4,557	1,114	3,443	1,051	722	1,792	992
Tete	2,970	961	2,009	540	1,229	788	413
Manica	2,467	709	1,758	709	561	843	354
Sofala	2,470	748	1,722	513	336	986	635
Inhambane	2,880	705	2,175	558	266	1,154	902
Gaza	2,711	889	1,822	280	752	1,101	578
Maputo	1,632	731	901	428	141	533	530

Source: Statistical Yearbook 2019 – Mozambique, National Statistic Institute, 2020

National roads in the central and northern regions are vulnerable to attacks by guerrilla groups and Islamic insurgents, respectively, and the main north-south road (paved) connecting Palma with Mocimboa da Praia in Cabo Delgado, which has been occupied by armed militants since August 2020, is unavailable. The transportation network is widely fragmented in the north.

As mentioned above, Mozambique's national transportation infrastructure has been developed along international corridors, of which the three most important are the Maputo Corridor, Beira Corridor, and Nacala Corridor (see Figure 3-33). The Maputo Corridor connects the Port of Maputo with the northeastern region of South Africa and Eswatini and is regarded as one of the most successful developments of economic corridor in the entire African continent. The Beira Corridor is an international corridor that connects the Port of Beira with Zimbabwe, and recent improvements to National Road N6 have improved convenience and mobility. However, due to the damage caused by Cyclone Idai, some national road sections were damaged, which had a major impact on the surrounding areas using the Port of Beira and on Zimbabwe. The Nacala Corridor is an international corridor that connects the natural deep-water port of Nacala with the inland province of Tete in Mozambique, as well as with the landlocked countries of Malawi and Zambia. Due to the prolonged civil war, the development of the project has been relatively slow, but with the support of international aid agencies such as AfDB and JICA, the project is currently underway.

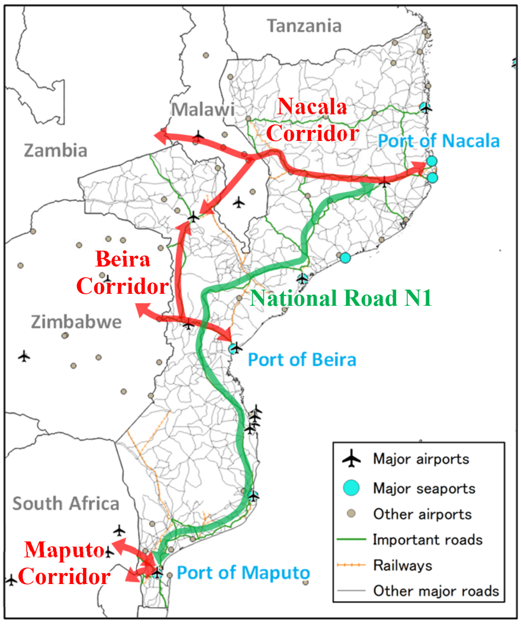


Figure 3-33 Three main international corridors and National Road N1 in Mozambique

Source: JICA Study Team

On the other hand, the only major road that connects these international corridors with each other is National Road N1, which traverses north-south through Mozambique. However, compared to the three east-west international corridors, it has not been properly maintained, and due to the aging of road structures such as pavements and bridges, it is not fully fulfilling its role of connecting the long north-south nation into one.

The road network has been gradually improved through donor support and concessions. Most of them are donor-supported, and concessions are limited to a few toll-road sections. As a result, road rehabilitation and new routes have greatly improved north-south travel by road.

b) Railroad

Like roads, Mozambique's railroads are built around international corridors, which is an important infrastructure not only within the country but also by neighboring countries such as South Africa, Zimbabwe, Malawi, Zambia, and Eswatini. In particular, Tete Province is connected by rail to the Ports of Beira and Nacala for the export of coal from Tete Province, the largest coal-producing region in Mozambique. The Ministry of Transport and Telecommunications (MTC) is the ministry responsible for railroads in Mozambique, and the Mozambique Ports and Railways (CFM) is in charge of its operations.

Mozambique's railroad system consists of four independent routes: Nacala, Beira, Maputo and Zambezia. Each of them was built independently because they were designed to export coal from inland Mozambique and to connect Mozambique's international ports with inland countries. Of the four routes mentioned above, the Zambezia route (connecting the port of Quelimane) in the literature review is still under construction. Three routes in northern Mozambique connecting the Port of Nacala are operated by CDN and CLN under concession. Location, annual transportation capacity, and recent transportation results for each route are shown in Figure 3-34 and Table 3-19.

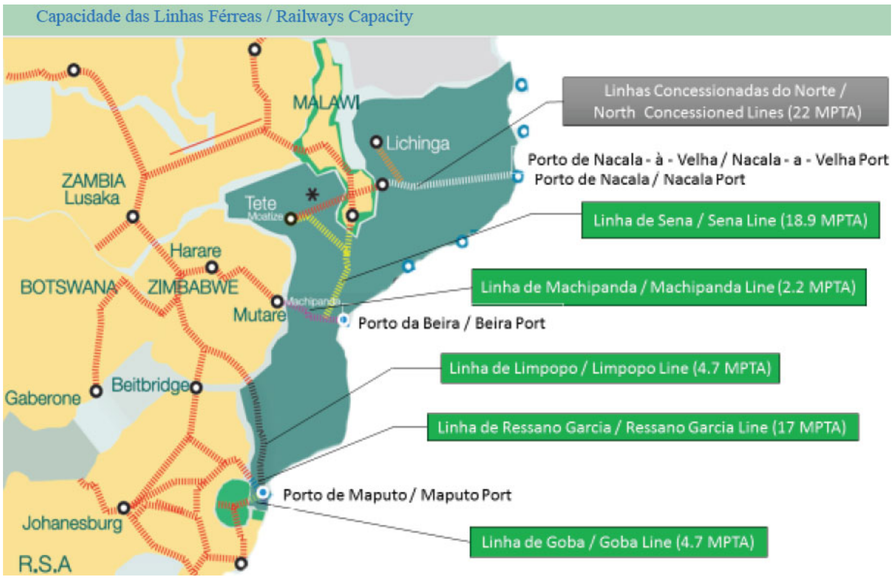


Figure 3-34 Railroad routes and annual transportation capacity in Mozambique (2019)

Source: Annual Statistical Information 2019, CFM.

Table 3-19 Mozambique's railroad lines and transport performance (2019)

Line	Extension (km)	Line Capacity (MPTA, Million Tons per Annum)	Rail Freight Transport (103 Net Tons)	Passenger Transport (person)
North Region				
Nacala – Cuamba	533	22	9,276.4	565,422
Cuamba – Lichinga	262			
Cuamba – Entre Lagos	77			
Central Region				
Machipanda	318	2.2	231.1	1,509,883
Sena	357	18.9	2,181.0	
South Region				
Ressano Garcia	88	17	7,515.0	3,236,582
Goba	74	4.7	959.9	669,279
Limpopo	522	4.7	412.7	1,452,072

Source: Annual Statistical Information 2019, CFM

There is no information found on the number of train services on the northern railroad lines in Mozambique, but in the central region, there is one round trip passenger train service per week on each line. In the southern region, passenger trains run back and forth almost every day. The frequency of freight train operations could not be found. CFM is trying to modernize its facilities to improve safety and cargo capacity, but it is not making much progress due to lack of financial resources and technical know-how.

Due to the relatively good condition of these rail infrastructures, there has been a growing interest in recent years in the private sector for their use. However, the railroad infrastructure is underutilized due to the lack of locomotives and rolling stocks. Once this issue is resolved and the railroad lines are expanded, the country's growth potential is expected to expand further.

c) Port

As with the railroads, the Ministry of Transport and Telecommunications (MTC) is responsible for ports in Mozambique, and the Mozambique Ports and Railways (CFM) is responsible for port operations. Since the early 1990s, the government of Mozambique and CFM have been promoting the development and operation of railroads and ports through PPPs (concessions), and currently 22 private companies are engaged in the development and operation of railroads and ports or related projects. Fifteen of these companies are responsible for railroad and port operations, while the remaining seven are responsible for tourism, railway-related equipment, access roads, and resource development. Figure 3-35 shows the location of major ports and their annual transportation capacities, and Table 3-20 and Table 3-21 shows the transportation results and major operating companies (concessionaires) of each major port.

Figure 3-35 Major ports and annual transportation capacity in Mozambique

Source: Annual Statistical Information 2019, CFM.

Table 3-20 Annual Transport Capacity and Performance of Ports in Mozambique (2019)

Port	Port Capacity (MPTA – million tons per annum)	Freight Transport (thousand net tons)
Maputo	33.0	21,065.9
Beira	16.5	11,055.9
Nacala	3.0	2,747.6
Nacala-a-Velha	22.0	8,611.1
Topuito	2.0	1,026.0
Quelimane	0.7	33.3
Pemba	0.7	251.4
Mocimboa da Praia	-	20.4

Source: Annual Statistical Information 2019, CFM

Table 3-21 List of major operators (concessionaires) of ports in Mozambique

North Region	
CDN - Northern Development Corridor	Concessionaire for the exploitation and management of the Northern Railway and the Port of Nacala.
CLN - Nacala Corridor Logistics	Concessionaire for the construction, operation, management, rehabilitation, maintenance and commercial operation of the Nacala-a-Velha branch-line as well as the port infrastructure of the Nacala Coal Terminal and the Moatize-Malawi railway.
PCD - Ports of Cabo Delgado	Concessionaire for the construction, operation and exploration of specific oil and gas terminals at the ports of Pemba and Palma.
Center Region	
CdM - Cornelder de Moçambique	Its mission is the operation and management of general cargo and containers terminals and multipurpose at the port of Beira.
CQ - Cornelder Quelimane	Concessionaire for the development, operation and management of the Port of Quelimane.
Macuse - Thai Moçambique Logística	Concessionaire for the construction and operation of the Port of Macuse.
NCTB - New Coal Terminal Beira	For construction and operation of the Coal Terminal at the port of Beira (Quay 13).
South Region	
MPDC - Maputo Port Development Company	Concessionaire for the Development and Operation of the Port of Maputo. **Subconcessions:** • DPWM - Dubai Ports World Maputo (operation of the containers terminal) • STAM – Maputo Sugar Terminal Company (operation of the sugar terminal); • TCM – Matola Coal Terminal (operation of the Matola Coal Terminal). • Automobile Terminal; • Molasses Terminal • Citrus Terminal • Granite Terminal • Scrap Terminal • Bulk Liquids Terminal
TCM - Cabotage Terminal of Maputo	Concessionaire responsible for the management and development of the Maputo Cabotage Terminal.
BVH - Bela Vista Holding	Concessionaire for the construction and operation of the Port of Techobanine

Source: CFM website (https://www.cfm.co.mz)

The Port of Maputo is divided into two districts: the Maputo Cargo Terminal and the Matola Bulk Terminal. The Maputo cargo terminal includes terminals for marine products, coastal shipping, general cargo, coal, fruits, sugar, containers and steel and sugar liquid tanks. The Matola Bulk Terminal handles coal, oil, grain, aluminum, and other commodities.

The Port of Beira was developed in the 1980s and 1990s with foreign aid totaling $500 million and 76 projects in total and is known as one of the most modern ports on the African continent with canal dredging, a modern container/oil terminal, and the Beira-Machipanda railroad. The Port of Beira consists of a liquid bulk terminal, a container terminal, and a general terminal.

The Port of Nacala is the largest natural deep-water port in eastern Africa. Currently, it has a general cargo terminal, eight warehouses, and a container terminal. According to JICA data (The Project for Supporting the Promotion of Nacala Corridor Development Final Report, JICA, March 2018), the development of the Nacala Corridor and the upgrading of the Nacala Port are expected to increase cargo handling by more than 10 times the current volume in the next 15 years.

In addition to the risk of sea level rise due to climate change, these major ports are directly affected by cyclones, heavy rains, storm surge, and strong winds, which have become more frequent in recent years, making it essential to check the status of their response to increasingly prominent natural disasters. However, the Mozambican government does not have a comprehensive national policy on port development, nor does it have a specific legal framework for the development or operation of ports.

d) Airport

The ministry in charge of civil airports in Mozambique is the Ministry of Transport and Telecommunications (MTC). However, the airports are operated by The Airports Company of Mozambique (ADM). The country has a land area of 799 thousand km^2 (source: homepage of Ministry of Foreign Affairs of Japan), which is about twice the size of Japan, and because of the poor road condition, international and domestic airports in some regions are important transportation infrastructure.

There are 21 civilian airports in Mozambique. Mozambique Airlines (LAM) dominated scheduled domestic flights until 2017, when it was joined by two other companies. There are international airports (Maputo, Beira, Inhambane, Nampula, Pemba, Tete, and Vilankulo) in major cities including Maputo, the capital city, and major provincial cities, and international flights to Angola, Ethiopia, Kenya, Qatar, Turkey, Portugal, and South Africa. Oil, gas, minerals, and tourism are key sectors for private charter flights, creating potential demand for both passenger and cargo air transportation. However, the current state of airport facilities and air traffic services is not keeping pace with this demand. The aviation demand has increased rapidly over the past few years, but due to the insufficient budget and, consequently, the limited investment, appropriate maintenance and upgrade of various facilities has not been conducted. For example, air traffic control and communication systems of Beira International Airport, at which the Flight Information Center (FIC) for the Beira Flight Information Region (FIR) is located, are deteriorated, and arrival passengers of international and domestic flights use one baggage claim area (one carousal) together, which do not meet the standards recommended by International Civil Aviation Organization (ICAO). Table 3-22 shows the transportation performance of Maputo, Beira and Nampula airports in 2019.

Table 3-22 Transport Performance of Maputo, Beira and Nampula Airports (2019)

Description	Maputo airport *	Beira Airport	Nampula Airport
Freight transport	11,477 ton	1,906 ton	1,558 ton
Loaded goods	5 ton	365 ton	871 ton
Unloaded goods	7 ton	1,540 ton	687 ton
Passengers transport	1,104 x 10^3	261 x 10^3	236 x 10^3
Shipped	548 x 10^3	106 x 10^3	97 x 10^3
Landed	550 x 10^3	116 x 10^3	94 x 10^3
In transit	5 x 10^3	39 x 10^3	46 x 10^3

* The presented data are those expressed in the referred document. It is recognized, however, that freight transport values may not be correct, since the sum of loaded and unloaded goods values does not correspond to the referred total.

Source: Transport and Communications Statistics 2019

2) Overview of Related Plans and Development Status

a) Road

The Mozambique Road Fund (RF) and ANE are developing a Road Sector Strategy under the guidance of the MOPHRH. It also prepares the Economic and Social Plan Integrated Road Sector Program (RES/PRISE) every year, which publishes the road and bridge maintenance and management plan for that year. Figure 3-36 shows the status of road development by ANE as of October 2021, obtained from ANE.

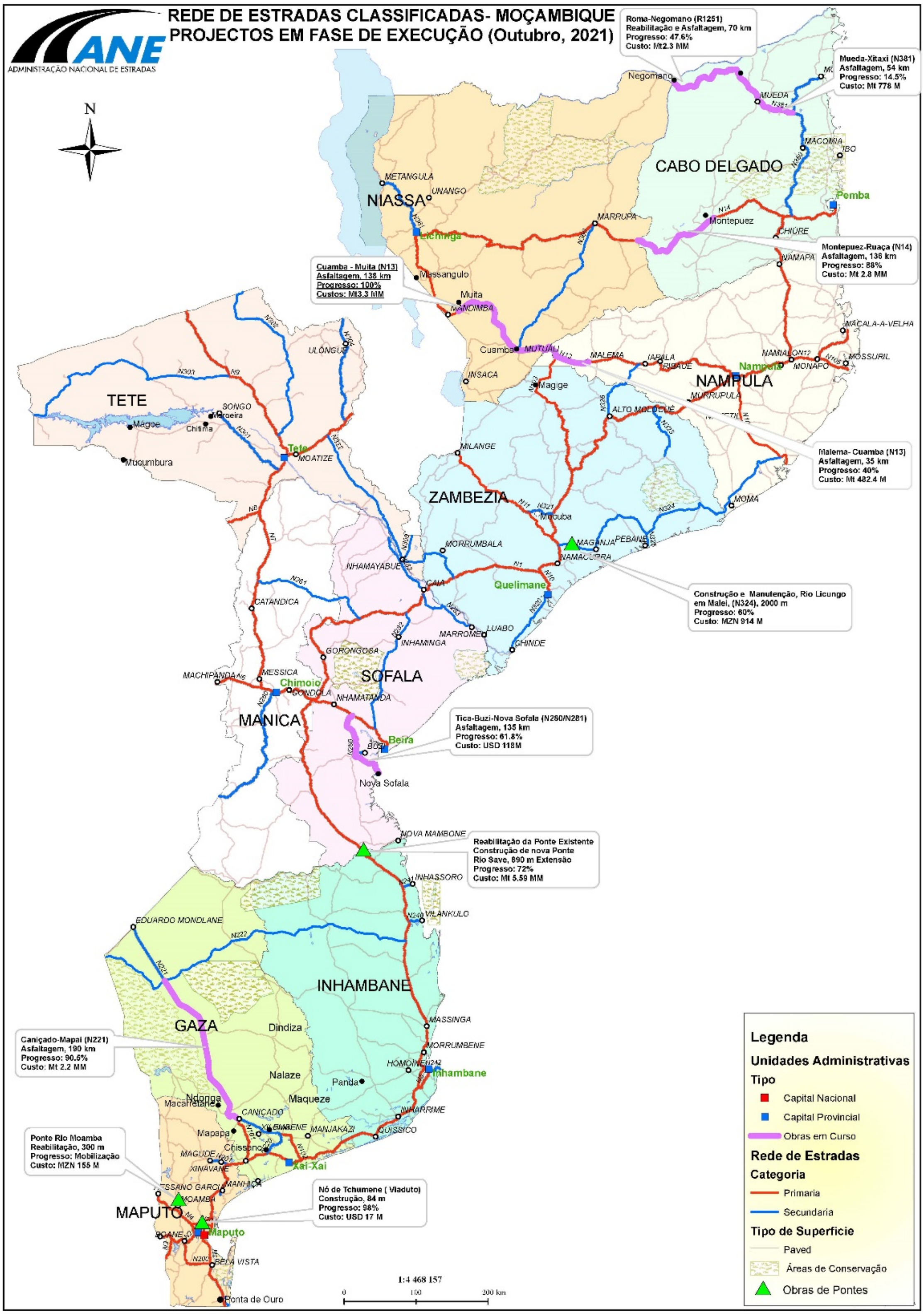


Figure 3-36 Status of ongoing road projects by ANE (as of October 2021)

Source: Materials provided by ANE

Figure 3-37 shows the spatial structure of the Nacala corridor region in 2035 as recommended by PEDEC-Nacala in JICA document (The Project for Supporting the Promotion of Nacala Corridor Development Final Report, JICA, March 2018). According to the same document, the corridor structure is a 2,000 km international corridor connecting Port of Nacala to Lusaka, Zambia via Lilongwe, Malawi. The effect of improved access is expected to spread to other parts of Mozambique, enhancing people's mobility and promoting development along the route.

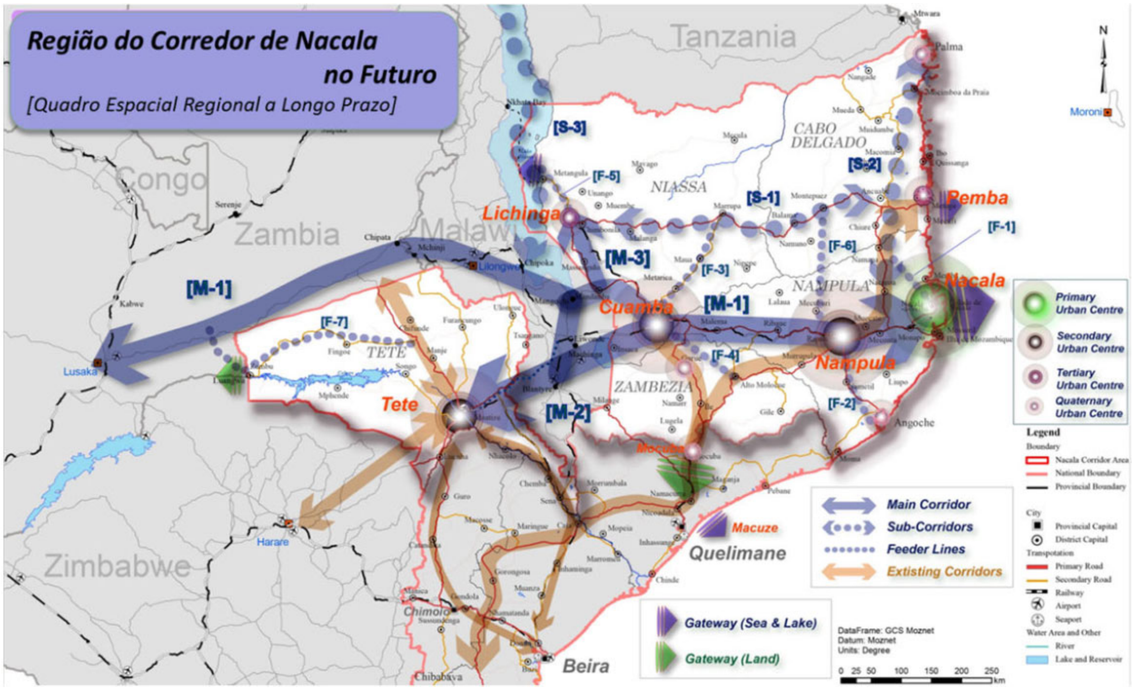


Figure 3-37 Comprehensive Development Strategy for the Nacala Corridor Region and Sectoral and Regional Approaches

Source: The Project for Supporting the Promotion of Nacala Corridor Development Final Report, JICA, March 2018.

On the other hand, international aid agencies such as the EU and AfDB have also recognized the importance of Mozambique's road network and are providing support, including financial assistance. According to AfDB data (Country Results Brief 2018 Mozambique), between 2007 and 2017, AfDB funded projects to build or upgrade a total of 811 km of road sections in Mozambique.

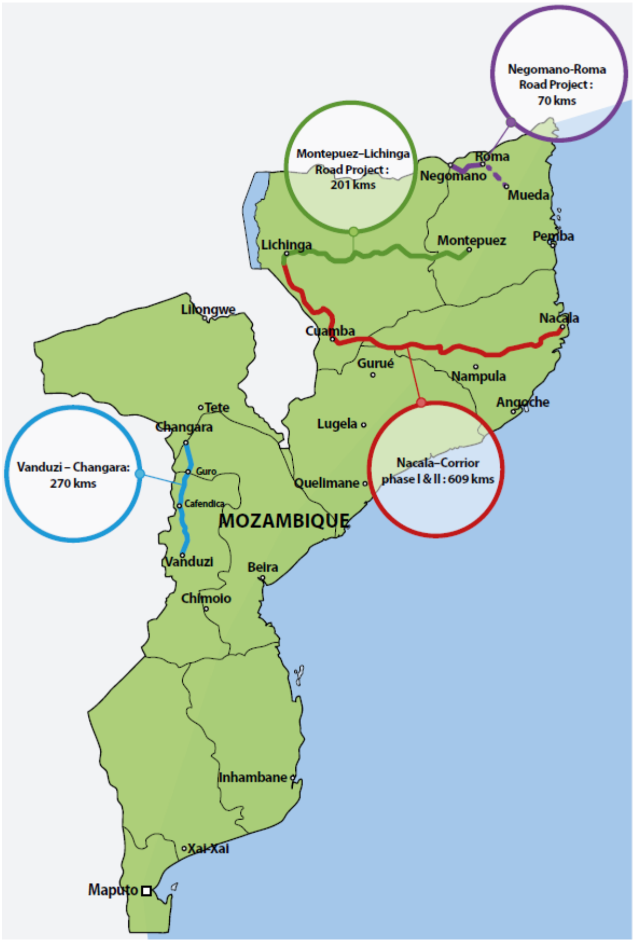


Figure 3-38　AfDB funded sections for road maintenance in Mozambique, 2007-2017

Source: Country Results Brief 2018 Mozambique, AfDB

A diagram of the planned transportation infrastructure development for Mozambique in another AfDB document (Mozambique Country Strategy Paper 2018-2022) is shown in Figure 3-39. Of the AfDB-aided road projects presented in this document, the one that is considered to be currently under implementation is the Mueda - Negomano Road Construction Project Phase 1. This funding was approved in 2016 and the project is to be completed by 2022.

Figure 3-39 Strategy for the Development of Transport and Traffic Infrastructure in Mozambique (developed by AfDB)

Source: Mozambique Country Strategy Paper 2018-2022, AfDB, June 2018.

The European Union (EU) is currently implementing the Tripartite Transport & Transit Facilitation Programme (TTTFP) for the Eastern and Southern Africa region. The TTTFP is a road project funded by the EU to connect COMESA, EAC, and SADC member states by international corridors (road) (island countries such as Madagascar and the Comoros are not covered). Figure 3-40 and Figure 3-41 show the target roads in TTTFP and in Mozambique. The Beira Corridor in the TTTFP includes not only the Beira-Machipanda road (National Road N6) connecting Zimbabwe, but also the routes that branch off from that road to Tete Province and Malawi, as well as the route from Harare, Zimbabwe to Malawi through Tete Province.

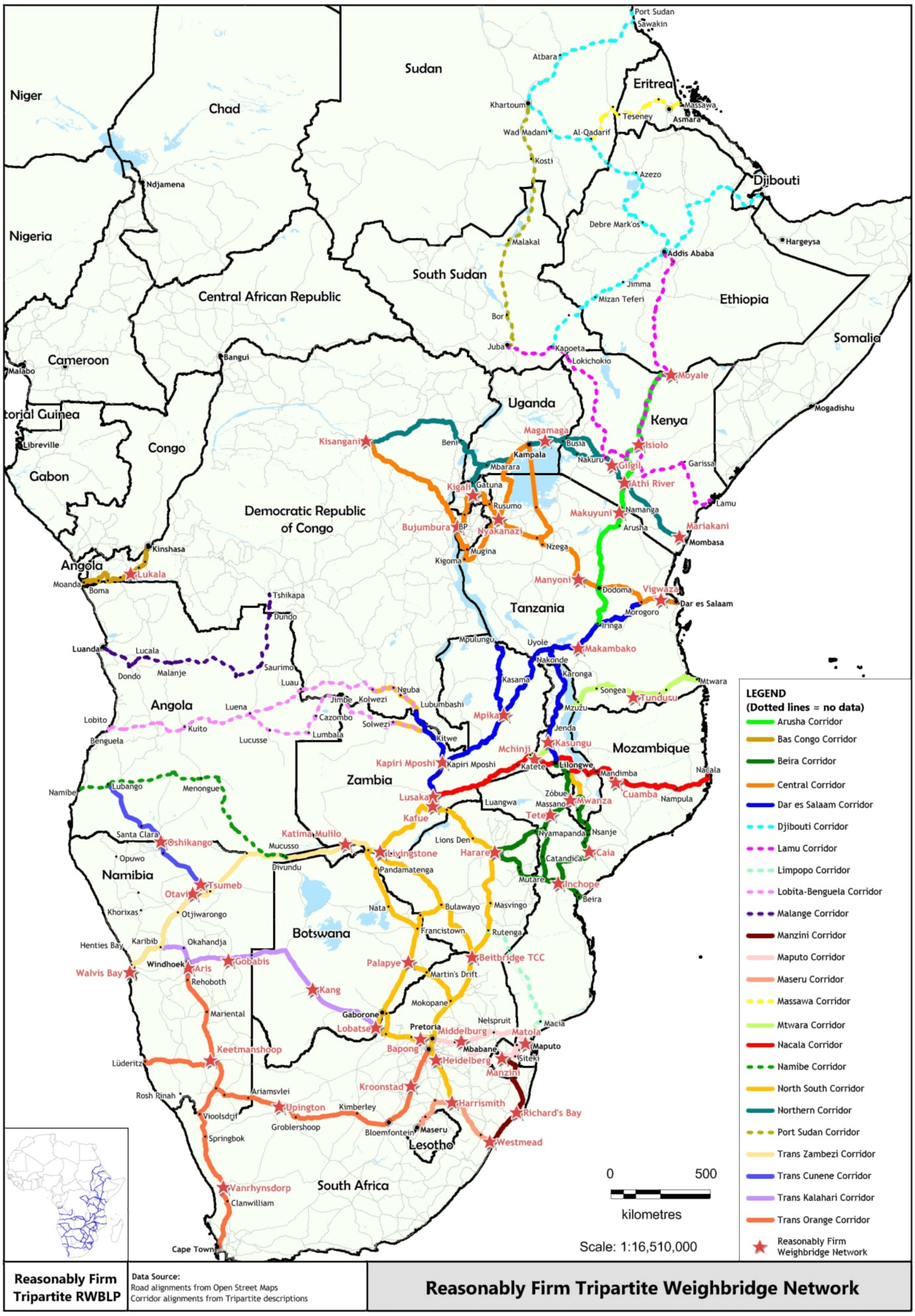


Figure 3-40 Roads covered by TTTFP (overall)

Source: TTTFP website (https://tttfp.org/corridors-overview/)

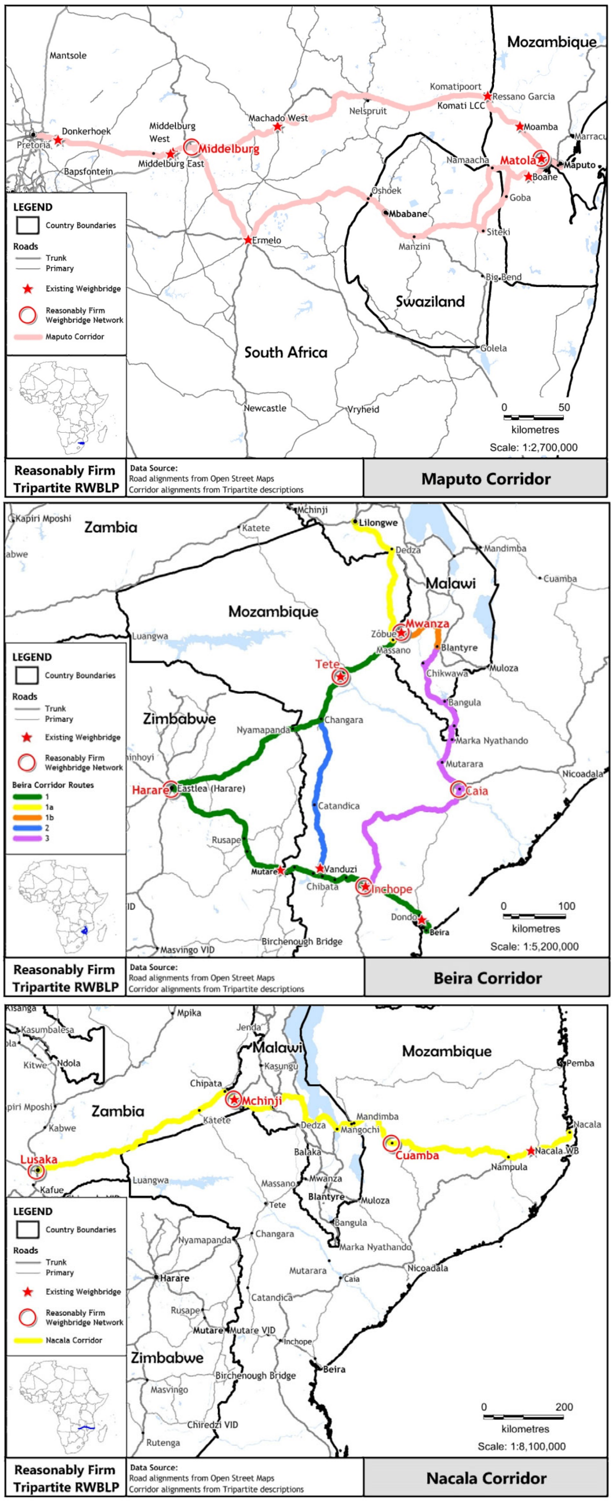


Figure 3-41 Roads covered by TTTFP (in Mozambique)

Source: TTTFP website[17]

[17] https://tttfp.org/corridors-overview/

b) Railroad

According to the AfDB document published in 2018 (Mozambique Country Strategy Paper 2018-2022, AfDB, June 2018), AfDB's ongoing (as of November 2017) support for Mozambique's railroad development is for the Nacala railroad and port project. It was one of the largest projects being undertaken in Africa at the time, with the AfDB bearing US$300 million of the US$5 billion project cost for the construction of a 912 km railroad from Tete Province through Malawi to the port of Nacala. The aid was approved in 2015 and will fund rail and port projects for which the CDN and CLN are responsible.

c) Port

As mentioned above, the AfDB is currently funding the Nacala rail and port project. JICA is also supporting the development of the Port of Nacala as part of this project. Phase 1 of the Nacala Port Development Project (loan agreement amounting to 7.889 billion yen) has been completed, and Phase 2 (loan agreement amounting to 29.235 billion yen) is currently being implemented (source: JICA website).

d) Airport

Beira International Airport (hereinafter referred to as "Beira Airport") was damaged by Cyclone Idai and Cyclone Eloise in 2019 and 2021, which damaged the passenger terminal, cargo terminal, hangars, warehouses, aviation lights and other aviation facilities, perimeter fences on the airport grounds, etc. The repairment is being planned. In addition, since Beira Airport has only one baggage claim, there are security issues such as the mixing of international and domestic arriving passengers in the baggage claim, and service issues such as no restroom in the departure gate area. Furthermore, the aging of the air traffic control systems has been pointed out as a problem. Based on the above, ADM has conducted a study on the renovation of Beira Airport and requested that the project be started as soon as possible, but due to the problem of securing financial resources, the project has not been able to proceed.

(a) Cargo Terminal

(b) Hangar

(c) Perimeter fence

Figure 3-42　Damage to Beira Airport facilities caused by Cyclone Idai, etc.

Source: JICA Study Team (photo taken on October 29, 2021)

3) Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

The risk of sediment disasters, floods, and storm surges in Mozambique is illustrated in Figure 3-43.

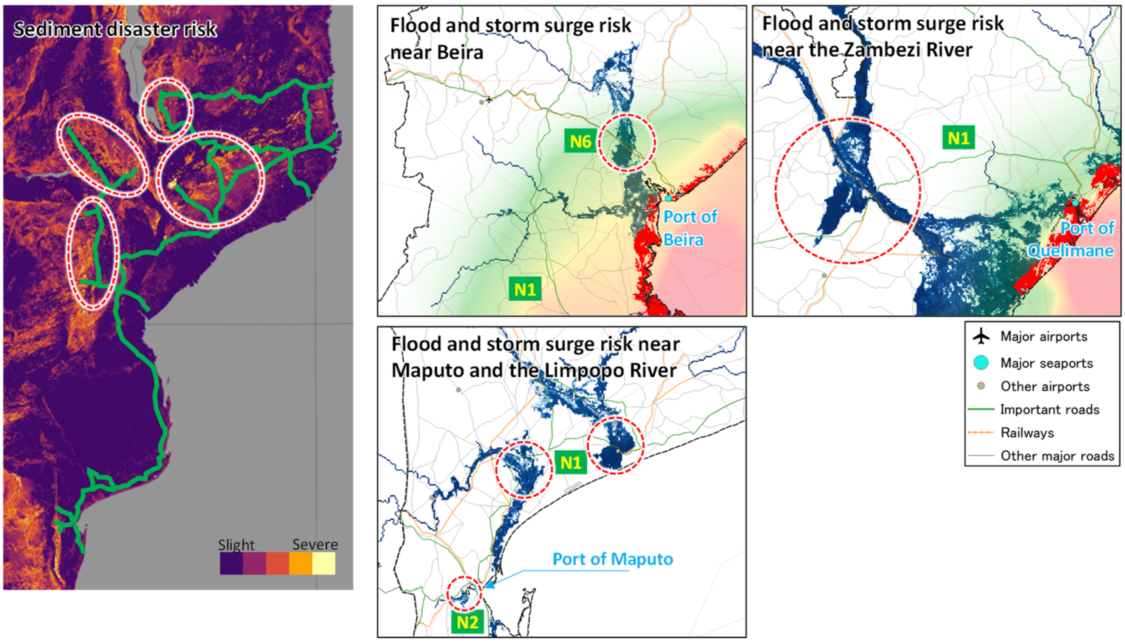


Figure 3-43 Risk of Sediment Disasters, Floods, and Storm Surges in Mozambique

Source: JICA Study Team

The critical transportation infrastructures with high risk of damage are as follows.

Table 3-23 Critical Transportation Infrastructure for Disaster Management in Mozambique (Desktop Survey Results)

subsector	Critical infrastructure for disaster prevention	High-risk disaster
road	National Roads N1 and N6	Floods, sediment disasters
	National Roads N7, N9, N11, N13, N14, and N103	Sediment disasters
	National Roads N2 and N322	Flood
Railroad	Goba Line, Ressano Garcia Line	Flood
	Machipanda Line, Sena Line	Floods, sediment disasters
	Nacala-Cuamba Line, Cuamba-Lichinga Line, Cuamba-Entre Lagos Line	Sediment disasters
Port	Port of Beira, Port of Quelimane	Storm surge, cyclone
Airport	Beira Airport	Cyclone

Source: JICA Study Team

The Mozambique field survey conducted in October-November 2021 included interview with ANE, CFM, and Beira Airport to confirm the actual disaster occurrence. The contents are as follows.

a) Road

- No damage to important roads due to sediment disaster has been reported.
- The section of National Road N1 that crosses the Zambezi River does not require any further investment, as the bridge has already been replaced and the road raised.
- Other national roads along the Zambezi River have indeed been damaged by river flooding, but ANE considers that there is no urgent need to improve them, since they are less important and have low traffic volume. In addition, there is a railroad nearby that is not subject to much flood damage, so if emergency transportation is needed, the railroad can be used.
- The section of National Road N1 that crosses the Incomati River and the Limpopo River has been damaged by flooding, including the loss of bridges. In the event of damage, emergency measures are being taken, such as building temporary bridges in two to five days to allow vehicular traffic. As a countermeasure to this problem, the Moamba - Chókwè road is being considered to be developed and used as an alternative route. A new bridge is also planned for that section.
- National Roads N1 and N4 in the Greater Maputo Area are important road infrastructures, and National Road N4, in particular, is a very important road as the Maputo Corridor, but when it is disrupted due to a disaster or accident, there is no alternative route. We do have a plan to develop an alternative route.

b) Railroad

- No damage to railroads due to sediment disaster has been reported. However, train operation is affected by inundation at some sections which results in the service suspension, and damages to the railroad infrastructure due to the inundation are mainly erosion. In 2020, there were railroad sections washed out by floods at Machipanda Line, Sena Line, and Limpopo Line.
- In particular, the area near the Pungwe River near Beira is subject to widespread flooding every year due to its topography. The railroads have been raised and bridges have been constructed, but in the rainy season, heavy rains and cyclones inevitably cause flooding damage, and operations are suspended until restoration work is completed.

c) Port

- A cyclone damaged port facilities and warehouses in the Port of Beira. It is recognized that some measures are needed to maintain aging and inappropriate facilities. Due to the shallow water depth of the Port of Beira, dredging operations are periodically carried out by Chinese companies.
- The Port of Nacala has not suffered any damage from storm surges and is somewhat resilient to disasters due to the expansion project underway with the cooperation of JICA. However, damage from cyclones and strong winds has occurred.

d) Airport

- Beira airport is frequently damaged by cyclones. By Cyclone Idai and Cyclone Eloise, the roofs of the cargo terminals and hangars were blown off and have not yet been restored. The passenger terminal was also damaged and is still leaking during rainfall. Other damages like aviation lights, aviation guidance signage, and the perimeter fence of the airport site were blown away by the strong wind. In the event of the cyclone, air traffic control was not possible, since the window glass of the air traffic control room was broken, and waterproof sheets should have been put down on the air traffic control equipment to prevent them from being damaged by rainwater.

4) Consideration of Disaster Risk Reduction Measures

a) Formation of Emergency Logistic Hubs in Beira City

The purpose of this project is to ensure an efficient and reliable network for the transportation of emergency supplies for relief and recovery in the event of natural disasters such as floods in Beira and its surrounding areas. As mentioned earlier, the city of Beira is prone to natural disasters such as cyclones, heavy rains, and flooding due to storm surges, and recovery efforts are still underway from the damage caused by Cyclone Idai in 2019. At the time, National Road N6 and the Port of Beira were damaged, making it difficult to transport emergency relief supplies by road and port immediately after the disaster. However, the Beira Airport, which is located at a higher land than the surrounding areas, and the railroad, which is raised, suffered less damage and played a major role in transporting emergency relief supplies. This project is to take advantage of the railroad and airport facilities in Beira and connect them by road to ensure emergency transportation routes. Specifically, the following measures can be considered.

This project strengthens the function of Beira Airport as the primary disaster risk reduction hub for the rapid transportation of emergency relief supplies from overseas and other regions. In addition, a new railroad cargo station is to be built on an existing railroad section that has a low risk of flooding and is located close to the downtown area of Beira City, to be used as a secondary disaster risk reduction hub. Furthermore, the roads connecting these disaster prevention centers will be strengthened, and the respective disaster prevention centers and coastal roads will be connected by road to form a ring road in Beira City (raised if necessary).

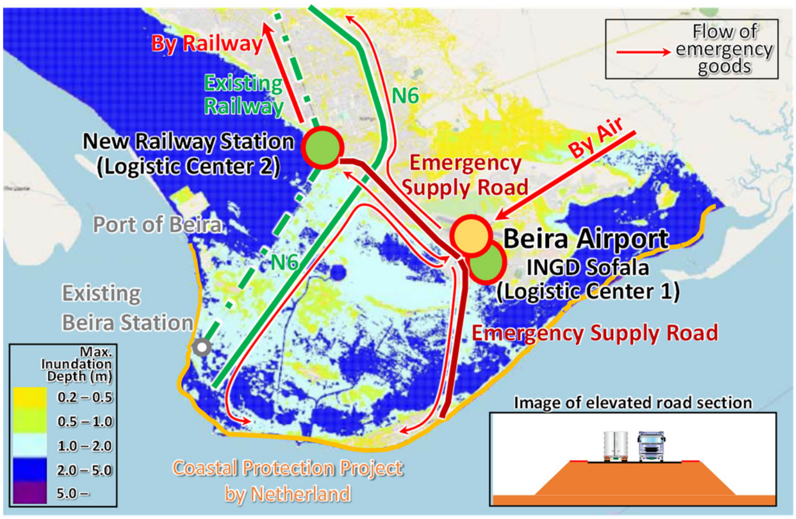


Figure 3-44　Image of the Beira Logistics Hub

Source: JICA Study Team

Table 3-24　Overview of the formation of the Logistics Hub in Beira

component	Overview
Making Beira Airport a disaster risk reduction hub	The existing facilities at Beira Airport will be maximized to create a disaster risk reduction hub.
Construction of a new cargo station and making it a disaster risk reduction hub	A new cargo station will be built. At this time, it is not envisioned that the site will be used during normal times, and minimal maintenance will be carried out for use during emergencies such as the occurrence of a disaster, with priority given to securing space that can be used as a general cargo handling yard. In addition, facilities that can be used as evacuation centers and facilities to accommodate disaster victims will be developed, and dedicated space for emergency operation staff will be secured.
Improvement of the road between the disaster risk reduction hubs	The existing 4.6km road between Beira Airport and the new railroad cargo station will be strengthened to enable the transportation of goods not only between the two disaster risk reduction centers in the event of a disaster, but also to the city of Beira and its surroundings.
Improvement of a road between Beira Airport and the coastal road	The existing 5.2km road from Beira Airport to the coast will be improved, and the section with high risk of flooding will be raised to form a ring road in Beira City, together with National Road N6, the Coastal Road, and the roads between the first and second disaster risk reduction hubs, to form an effective emergency transportation road network in times of emergency.

Source: JICA Study Team

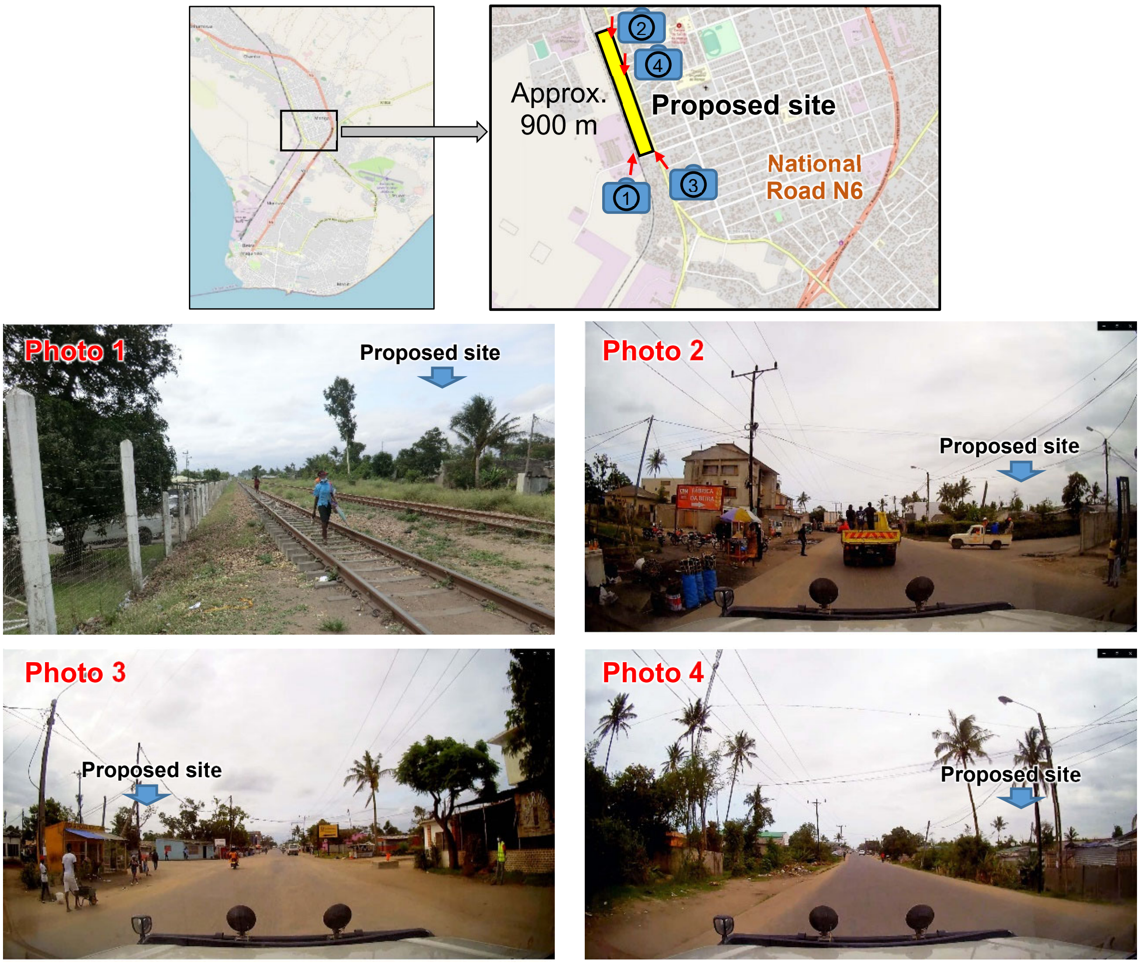


Figure 3-45 Proposed Site for a Railroad Cargo Station as a Logistics Hub in Beira.

Source: JICA Study Team (Map data: OpenStreetMap)

Figure 3-45 shows a proposed site for the railroad cargo station. Although the existing Beira Station was not inundated in the event of Cyclone Idai, the existing station and the nearby road section of the National Road N6 can be inundated if a cyclone of the same scale and a storm surge occur simultaneously, which makes the railroad transport difficult for the emergency relief supplies to be transported from Beira Airport to other areas around Beira City. The proposed site is located at a relatively safe area even in the extreme case. The site is currently used as residential area with mainly low-rise houses. Land ownership is not allowed to individuals in Mozambique, but compensation for resettlement can be an issue.

Railway facilities to be installed at the railroad cargo station should be studied and determined by discussion with C/P. However, it is considered that a cargo handling and a track for turning back for the case that the existing Beira Station is inundated are necessary

It is also considerable to directly connect the existing railroad and Beira Airport by constructing a railroad branch line. However, it requires much larger area for land acquisition and has another issue how to cross the National Road N6 (The road between the proposed site and Beira Airport crosses N6 by flyover). Thus, it is considered that the construction of the railroad branch line for emergency use is not so economically beneficial compared to the construction cost.

b) Functional Enhancement to Beira Airport

In this project, the functions of Beira Airport will be strengthened in order to make it a disaster risk reduction hub in the Beira Logistics Hub Initiative. Beira Airport is an international airport located in the city of Beira, the capital of Sofala Province. It is a small regional airport with an average annual number of arrivals and departures of about 8,000, an average annual number of passengers of about 200,000, and an average annual cargo handling volume of about 700 tons, including mail, during 2015-2018. Due to the recovery from the disaster caused by Cyclone Idai, the number of takeoffs and landings, passengers, and cargo volume are all increasing in 2019, especially cargo volume, which is 2.6 times higher than the previous year, while in 2020, there is a significant decrease due to the COVID-19 pandemic, but it is considered temporary.

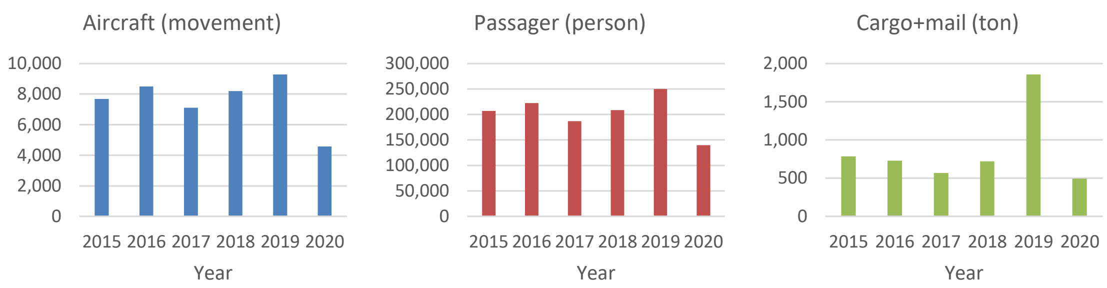


Figure 3-46 Usage of Beira Airport (2015-2020)

Source: JICA Study Team

Although it is a small regional airport, Beira Airport is an important airport for aviation demand not only from the regional hub city of Beira but also from the province of Sofala. It is considered vital as a hub for transporting emergency supplies when natural disasters occur in Beira city and its surrounding area. In fact, during the massive flooding caused by Cyclone Idai in March 2019, emergency supplies were transported mainly from Beira Airport, and foreign aid teams were stationed at Beira Airport while conducting emergency activities. In addition, while the city of Beira was experiencing delays in the restoration of power supply, Beira Airport has operated a backup power supply and opened up space for the general public to recharge their cell phones, an example of how the airport has served as a disaster risk reduction center. In the event of a disaster, aviation accident, or fire in the vicinity of the airport, Mozambique's airports, including Beira Airport, are required to work with other organizations to ensure safety in the vicinity of the airport and to protect people and assets, in accordance with the Memorandum of Understanding on Emergency Response signed between ADM and INGC (April 18, 2018), and it is supposed to provide space for aviation experts, INGC experts, and relief supplies. However, due to the lack of financial resources, only the minimum measures necessary for air traffic control and airport operations were implemented to address the damage to airport facilities caused by Cyclone Idai and Cyclone Eloise, and some facilities are still being restored. In addition, insufficient and outdated aviation and airport facilities that do not meet ICAO standards pose not only aviation safety, security, and service problems but also the risk of further decrease of profitability due to a decrease in the aircraft movements, passengers, and cargo handling caused by reduced flights by aircraft operators. In this situation, appropriate airport function cannot be expected even in ordinary cases, and emergency transport through Beira Airport cannot be ensured in the event of a disaster. Therefore, to utilize Beira Airport as a disaster risk reduction hub, there is a strong need to strengthen the degraded airport functions. The following is a summary of what was confirmed during the site visit to Beira Airport.

Table 3-25 Current Status and Assessment of Facilities and Equipment at Beira Airport

Facilities and equipment	current state	evaluation
Passenger Terminal Building	The roof was damaged by the cyclone and leaks occur during rainfall. All departures and arrivals are on the first floor. There are offices, meeting rooms, cafeteria, etc. on the second floor, but some spaces are not in use. There is only one baggage claim. No restroom in the departure gate area.	The estimated area of one floor is 8,115 m^2, which is currently matching the demand when evaluated at an intensity of 16 m^2/person based on 250,000 annual passengers (2019). However, if demand increases, it will be necessary to utilize the space on the second floor and expand the terminal building. Separating international and domestic passengers by having more than one baggage claim area is necessary from the perspective of security and service.
Cargo Terminal Building	The roof was damaged by the cyclone, and all but a few spaces, including offices, are unusable (some are being renovated and used by private companies).	The approximate area is 4,250 m^2, which is larger than necessary because airports that handle around 1,000 tons per year have an area of 1,000 to 1,500 m^2.
Runway and Aircraft Parking	There are three runways, but only runway 12/30 (2,400m x 45m) is currently available for use. Condition of the 12/30 runway and tarmac is good. After the Cyclone Idai occurred, there were times when the aircraft were parked on the taxiway due to insufficient capacity of the tarmac.	Takeoffs and landings of large aircraft such as B747s are difficult (requiring reduced payloads or transshipment at Maputo airport). The site for the 12/30 runway expansion has been secured but needs to be considered from an economic perspective. As of October 2021, the capacity of the parking area is sufficient for 5 to 8 flights per day, but it is necessary to consider the post-disaster situation.
Rescue Fire Fighting (RFF) Vehicles	As of October 2021, there are two aging RFF vehicles that are 12 years old. They break down frequently, but parts are difficult to procure, so Beira Airport is hoping for redundancy through the purchase of new vehicles.	According to AIP (Aeronautical Information Publication), Beira Airport is RFF Category 6 (but Beira Airport explains it is Category 7), which requires a minimum of two RFF vehicles. ICAO requires regular preventive maintenance, but the current state of the RFF vehicles indicates that proper maintenance is not being done. It is not likely that the airport function will be restricted immediately after the current RFF vehicle's break down. However, if the number of RFF vehicles is lower than the required number by ICAO standards, it will be difficult even for medium-sized aircraft (e.g., B737) to take off and land because the RFF category will be lowered, and airlines will be concerned about maintaining the service, which will lead to the risk of reduced flights and passengers.
Fire Station Building	There was no watchtower, but it is now under construction. The capacity of the water tank for firefighting is 10,000 liters, and Beira Airport wishes to increase the capacity to 20,000 liters.	The ICAO standard calls for reaching an accident site within three minutes. Assuming a dispatch at 60 km/h, from the current location of the fire department building it can be reached within three minutes.

Facilities and equipment	current state	evaluation
Approach lighting system	Beira Airport wishes to repair its aging entry lights.	At the site visit, it was considered the light was being used without particular problems.
Perimeter fence	Fence at airport site damaged by Cyclone Idai	There is a private house right next to the damaged fence, which poses a security issue since it is possible to freely enter the airport site (airside).

Source: JICA Study Team

Based on the above considerations, it is considered that the enhancement of airport functions such as passenger terminals should be re-examined after confirming and carefully examining future changes in demand, but the following items are judged to be in need of renovation even under current demand.

- Refurbishment of cargo terminals, etc.: Cargo handling volume has not necessarily decreased due to cyclone damage. However, it needs to be restored and made usable in order to function as an emergency logistics hub, and it can also be used as a space to house evacuees and disaster victims in the event of a disaster, making it highly valuable for renovation. Hangars and warehouses, including the cargo terminal, whose roofs have been blown off and are difficult to use, have not suffered any structural damage, so the remaining structures are deemed to be usable.
- Firefighting vehicles: If RFF vehicles, which are heavily aged due to inadequate maintenance and break down, it is difficult to repair them in a short period of time due to the difficulty in procuring parts. In that case, not only would there be a safety issue of not being able to respond to air accidents, but also the airport revenue would decrease due to the reduced number of flights serving Beira Airport. Furthermore, lowered RFF category of Beira Airport would limit the size of aircraft that can land and take off, (even medium-sized aircrafts such as Boeing 737 cannot land and take off), making it impossible to meet the current passenger and cargo demand, which would further worsen revenues.

As shown in Table 3-25, there are facilities such as perimeter fences that need to be restored but do not require a large budget. Also, RFF vehicles are supposed to be usable longer than the age of those vehicles at Beira Airport with appropriate maintenance works. From these, it is concerned that the situation could be repeated even those facilities are restored and upgraded. It is considered that vulnerable financial condition of ADM exists in the background. Financial conditions of ADM in the past 5 years are shown in Figure 3-47. Earnings before taxes show negative values except for the year of 2017 in which the amount of expenditure for amortization was decreased due to currency exchange rate. The deficit in 2018 was compensated by the Government of Mozambique, but the net incomes for 2019 and 2020 were negative even though the government supported ADM financially. The financial condition of ADM, especially Beira Airport, might be improved in the future, because there is a development plan at Beira Airport by private sector. However, the financial effect from the development is currently unclear.

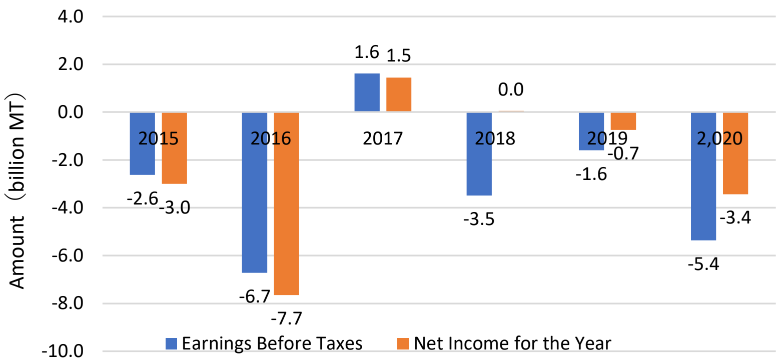


Figure 3-47 Financial Condition of ADM (2015-2020)

Source: Prepared by JICA Study Team based on information provided by Beira Airport

c) Enhancement of Air Traffic Control Systems at Beira Airport

This project aims to improve the safety of aircraft flying over Mozambique as well as those arriving and departing from Beira Airport by renovating and upgrading aging air traffic control equipment and installing new equipment in order to expand the air traffic control system at Beira Airport. The Beira Area Control Center (ACC) located at Beira Airport controls all aircrafts flying at high altitudes in Mozambique together with the Maputo ACC, and particularly those passing through the Beira Flight Information Region (FIR), which includes not only the airspace of Mozambique but also the airspace over the ocean near Mozambique. In details, flights at the high altitudes at the south of Parallel 22 are allocated to Maputo ACC, and those at the north of Parallel 22 are allocated to Beira ACC, while those flying over the ocean in Beira FIR are allocated to Beira Flight Information Center (FIC). Among major airports in Mozambique, only Maputo Airport, Inhambane Airport, and Vilankulo Airport are located at the south of Parallel 22. It means that the flights not controlled by Beira ACC are the flights between these three airports and some international flights between Maputo and several cities out of Mozambique, e.g., Johannesburg, South Africa, that do not fly over the north of Mozambique from Parallel 22. Thus, it is no exaggeration to say that Beira Airport is responsible for the safety of most aircrafts flying over Mozambique.

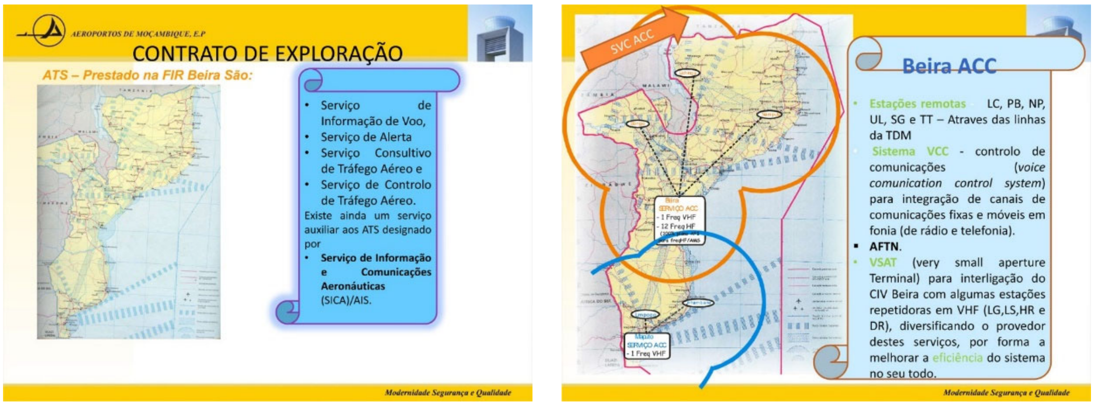


Figure 3-48 Beira FIR and Beira ACC ranges

Source: Materials provided by Beira Airport.

However, according to the information obtained from the interviews with Beira Airport, many of the systems required for air traffic control, including the control of aircraft arriving at and departing from Beira Airport, are overdue for an update and aging. Currently they appear to control the air traffic with the minimum equipment. If the air traffic control system at Beira Airport were to fail, aircraft passing through the Beira FIR would be forced to divert to the surrounding RIRs to avoid the Beira FIR, and aircraft departing from or arriving in Mozambique would be forced to divert or cancel their flights. This situation is also a hindrance to the development of the Beira Airport as a disaster risk reduction hub in the Beira Logistics Hub Initiative, as indicated in the previous section. There are also risks on the economic side, including a decrease in revenues from the use of navigation aids and airport charges due to a decrease in the number of aircrafts flying over the Beira FIR and serving the Beira Airport.

The following table shows the implementation status of the major air traffic control systems at Beira Airport. Although the airport meteorological Doppler radar is not an air traffic control system, we propose its retrofitting together as a facility for safe air traffic control.

Table 3-26 Air Traffic Control Systems at Beira Airport

System	Status
Voice Communication Control System [VCCS]	· Model: SITTI MULTFONO M600S/77.971 · Year of installation: 2009 · Condition: obsolete · Necessity: upgrading required, as the existing VCCS is analogue system and does not comply with the current needs for ATM Integration to IP environment
VHF (Very High Frequency) Communication System	· Model: T6T & T6R · Year of installation: 1988 · Condition: obsolete · Necessity: upgrading NOT required, as this system will be replaced by digital radios * Current Plan For ACC VHF coverage, including local and remote stations, 6 digital transmitters and 6 digital receivers; for TWR and APP, 4 digital transceivers and 2 back-up mobile transceivers with power autonomy (internal batteries)
HF (High Frequency) Communication System	· Model: INVELCO · Year of installation: 2021 · Condition: As of Dec. 29, 2021, the operation started, but only one receiver is installed, the system does not comply with the related ICAO standard (6 receivers required) · Necessity: to comply with the ICAO standard and ensure the redundancy, additional devices required including one 1 KW transmitter, 7 receivers (2 for redundancy), one coupler, and other interfaces
ATS (Air Traffic Service) Message Handling System [AMHS]	· Condition: not installed · Necessity: installation NOT required, as an AMHS will be installed in Maputo and connected to Beira Airport in 2022
Automatic Dependent Surveillance – Broadcast [ADS-B]	· Model: INTELCAN · Year of installation: 2016 · Condition: in service · Necessity: software upgrading required
Very Small Aperture Terminal [VSAT]	· Model: PolarSat · Year of installation: - · Condition: installation completed (operation will start in 2022 after approval) · Necessity: further investment NOT required
Aeronautical Fixed Telecommunication Network [AFTN]	· Model: COPPERCHASE · Year of installation: 2008 · Condition: out of service since December 2017 · Necessity: investment NOT required, as this system will be replaced by AMHS as mentioned above
VHF Omnidirectional Range with a Distance Measuring Equipment [VOR/DME]	· Model: 512 D/721 THOMSON · Year of installation: 1993 · Condition: in service but obsolete · Necessity: replacement required
Multichannel Voice Recorder	· Model: - · Year of installation: 2007 · Condition: in service but obsolete · Necessity: replacement required

System	Status
Centralized maintenance Management System	・Condition: not installed ・Necessity: ADM desires the installation for the modernization of the maintenance service
Airport Doppler Radar	・Model: not investigated (installed by Government of Germany) ・Year of installation: 2007 ・Condition: out of service due to malfunction ・Necessity: repairment or replacement required to ensure the safety of landing and take-off by the prompt detection of downbursts
Flight Object Administration Center System [FACE]	・Condition: not installed
Integrated Control Advice Processing System [ICAP]	• Condition: not installed
Trajectorized En-route Traffic Data Processing System [TEPS]	• Condition: not installed
Trajectorized Airport Traffic Data Processing System [TAPS]	• Condition: not installed
Trajectorized Oceanic Traffic Data Processing System [TOPS]	• Condition: not installed
ATC Data Exchange System [ADEX]	• Condition: not installed
Trajectorized Enhanced Aviation Management System [TEAM]	• Condition: not installed
Terminal Radar Alphanumeric Display System [TRAD]	• Condition: not installed

Source: JICA Study Team

d) Project to Strengthen Road Operations and Planning for Emergencies in the Greater Maputo Area

It is considered that the main arterial roads in the Greater Maputo Area are relatively well maintained, including the international corridor. In recent years, the Ring Road has been constructed with the support of China (as of October 2021, toll booths and other facilities are still under construction), and the bridges on National Roads N2 and N4 that cross the Matola River, the largest river in the Greater Maputo Area with a risk of flooding, were not found to have any structural risks such as aging.

Figure 3-49　Important bridges over the Matola River (left: Route 2, right: Route 4)

Source: JICA Study Team

However, since other roads are often unpaved and have very poor condition to travel, there are no alternative routes that can be used by large trucks when the main arterial roads cannot be used not only due to the occurrence of a large-scale disaster, but also due to heavy rains or accidents. In addition, there are likely to be areas that are difficult to access in the event of flooding or heavy rainfall, which may hinder the transportation of emergency relief supplies and rescue activities. In particular, National Road N4 is an important logistics route that connects the Port of Maputo with neighboring countries such as South Africa as the Maputo Corridor, but there is no detour route, especially for large vehicles, in case the route is closed due to a disaster or accident. In addition, the section of National Road N1 passing through Maputo City has not been improved and is frequently flooded. Julius Nyerere Avenue (Avenida Julius Nyerere) can be considered as an alternative route, but it has a section with a very bad pavement condition which even on a normal day gives problems to passing vehicles. These road sections are bottlenecks in terms of traffic capacity and are considered to be one of the reasons why traffic demand is concentrated on National Road N1, which is a major issue even under normal conditions. While these national roads, major roads, and central city areas are paved, most residential areas have unpaved roads, which can cause delays in rescue and recovery activities in the event of a disaster or accident.

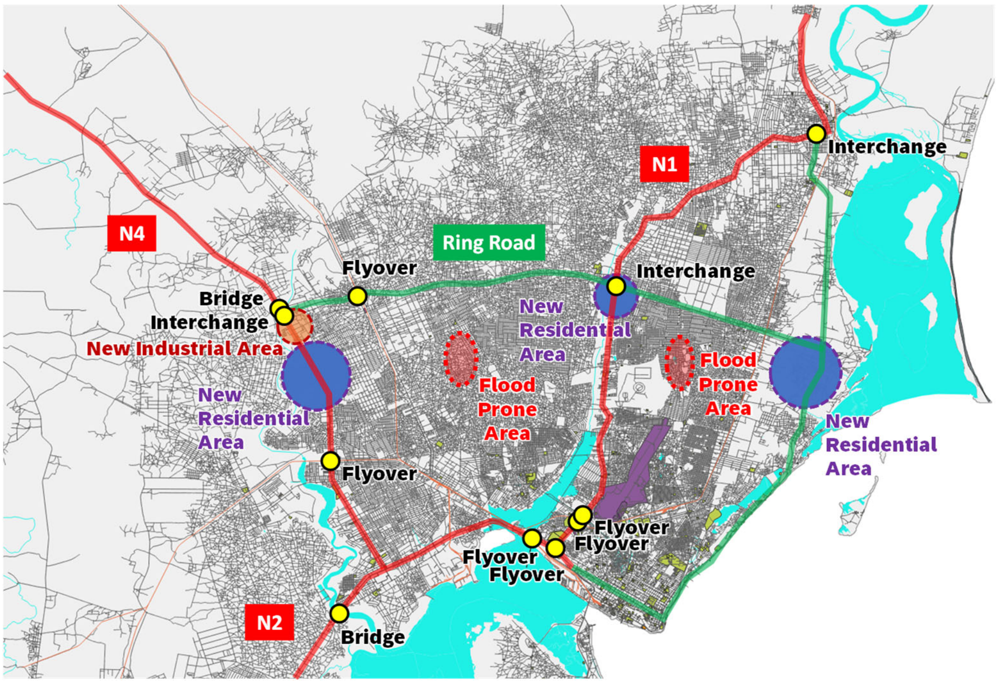


Figure 3-50 Main arterial roads and major road structures in the Greater Maputo Area

Source: JICA Study Team


Figure 3-51 Unpaved roads in the Greater Maputo Area
(Left: residential area, Right: Julius Nyerere Street)

Source: JICA Study Team

Therefore, as a disaster risk reduction measure for the transportation infrastructure in the Greater Maputo Area, and as a traffic measure during normal times, the development of alternative routes is proposed in this project from the perspective of ensuring redundancy and congestion control on major arterial roads, and the study of priority sections for road development is also proposed from the perspective of disaster risk reduction. For these measures, it is assumed that existing roads will be used as the alternative routes, involving pavement, widening, intersection improvements to facilitate right and left turns by large vehicles, traffic safety measures, and other measures to allow passage of large vehicles. When considering priority sections for road maintenance, the travel time required to reach hospitals, government offices, and other facilities that could serve as disaster risk reduction centers in the event of a disaster should be taken into account, and the selection of priority sections for paving should be based not only on traffic volume and political decisions, but also on disaster risk reduction.

(3) Power

1) Overview of Relevant Organizations and Legal systems

In Mozambique, the National Electricity and Energy Authority and the National Renewable Energy Authority of the Ministry of Energy oversee the legal system and policies for electricity supply, while the EDM, under its supervision, develops and operates vertically integrated generation, transmission, and distribution. Rural electrification, which is not grid-connected, is managed by FUNAE, which is subordinate to the Ministry of Energy.

The main power sources in Mozambique are large dams in the Zambezi River basin and thermal power near cities. According to the EDM annual report, Mozambique's power generation will be 3,782 GWh in 2020, with generation increasing from 873 GWh in 2019 to 906 GWh in 2020, a growth of 4 percent.

The grid is divided between north and south, with Zambezi River hydropower transmitted to South Africa once via direct current transmission, while the south imports power from the South African grid. There is no central feeder station in the country, and each facility receives commands from operators in South Africa and Zimbabwe.

The grid code in Mozambique is the N-1 standard. This means that even if one of the transmission lines or power plants fails, there should be enough capacity and operation to ensure that the power supply is not disrupted. However, Mozambique's electrification is still incomplete and demand is increasing, and it is believed that the country is prioritizing electrification and meeting increased demand rather than providing backup.

Overall, the three provinces in which Mozambique's four largest cities are located (Maputo, Matola, Beira, and Nampula) are characterized by aging transmission infrastructure, slow consumer growth, unstable generation, and extreme weather conditions that result in power outages and poor power quality.

EDM has reduced the duration of power outages in the four cities by 15-20% in recent years, with the exception of Beira, which increased by 8% in 2019, likely due to infrastructure outages caused by Cyclone Idai. On the other hand, electricity tariffs do not reflect actual costs due to political reasons, increasing EDM debt and making reliable, quality, and affordable services difficult. Also, because of overloaded substations and distribution lines, the densely populated areas of Matola and Maputo experience more outages than Beira and Nampula. Capacity for tariff collection, operation monitoring, and maintenance needs to be increased in these areas.

2) Overview of Related Plans and Development Status

A JICA-supported national-level electricity master plan was updated in 2018. Rural electrification that is not connected to the national grid is supported by the World Bank. Improvement of power distribution networks in cities is also being supported by the Bank on a case-by-case basis. There are also plans for international interconnection and power supply development by the Southern African Power Pool (SAPP), which has been designated as a priority project; GW-class hydropower and medium-scale coal development is a SAPP priority project, and there are many plans for hydropower and gas and coal-fired power development on the Zambezi River.
Other than hydropower, planned RE installations are around 100-200 MW. The North-South Interconnection, the Zambezi River Hydro Export Line, and the Malawi Line are also SAPP priority projects, and the North-South Interconnection is expected to be realized in 2024. After the interconnection, the operation of the grid will need to be changed (currently Zimbabwe and South Africa are adjusting the load), so organization and capacity building are in progress.

The demand for electricity is increasing by more than 10% per year, so the grid needs to be strengthened and expanded constantly, but increasing the cost of electricity is a prerequisite for continued investment. Improvements to the power transmission and distribution network are underway, and although the grid code is N-1, the priority is to respond to increased demand and the promotion of electrification. The goal is to achieve 50% electrification by 2011 and 100% by 2013. All provincial capitals have been electrified in 15 years. EDM, which deals with grid electricity here, and FUNAE, which promotes rural electrification, are separate organizations. For off-grid electrification, the policy has been changed to actively adopt PV/small hydropower instead of DEG, which was previously planned.

The EDM has also emphasized the need to connect renewable energy to the national grid and also develop off-grid systems in its strategic plan for 2018-2028. The plan envisions an energy demand of about 8,000 MW (10 times the current demand). In order to meet the increased demand, a significant increase in installed capacity with a variety of power sources is projected. (On the other hand, investment in power transmission and distribution networks is very important in the country.

PV capacity has increased from 1 MW in 2011 to 15 MW in 2017 (Energy Eight Edition, 2020 - Global Legal Group), but its contribution to the overall supply is still quite small, especially considering the country's high solar radiation potential. Currently, two solar power plants, Mocuba and Metoro, with 41 MW each, are under construction. As for wind power, EDM and others have initiated feasibility studies for three wind farms, Namaacha, Manhiça, and Cahora Bassa, each with 30 MW.

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

According to Mozambique Cyclone Idai - Post Disaster Needs Assessment, various power infrastructures were in operation in the affected areas. Hydroelectric power plants, transmission lines, primary and secondary substations, distribution lines, transformers, and stand-alone solar power systems in the affected areas were damaged. The number of affected customers is estimated at 570,000, and the development of a new power grid had to be temporarily halted for restoration.

In the meantime, EDM worked to restore power services quickly, immediately diagnosing the damage, developing plans and work procedures, organizing and sending in teams and materials, and mobilizing in-house engineers and local contractors. 9 generators with capacities ranging from 22 KVA to 200 KVA were assigned to Beira. Two weeks after the cyclone, the EDM was able to restore electricity in the main part of Beira, but medical facilities in other areas such as Dombey were also without power.

The Post-disaster Assessment made recommendations for building DRR and resilience in this area, including changes in the technical specifications of the power grid. Specifically, it recommended: i) use of self-supporting transmission towers; ii) use of concrete distribution poles, which are less susceptible to flooding than wooden ones; iii) strengthening of pole foundations, including use of good quality land near the Beira road; iv) shortening the spans between poles; iii) raising the platforms of new substations by 1-2 meters above the ground; iv) increasing the height of existing substations by 1-2 meters above the ground; and v) increasing the number of poles. meters above the ground, and iv) providing additional flood protection to existing substations. The use of stay wires is inappropriate as flood debris can get trapped in the stay wires and apply damaging forces to the poles. These should be included in the technical specifications for future construction orders.

In addition, a 2020-2021 Contingency Plan has been developed by the government. With respect to the energy sector, the activities to be undertaken under this plan include: availability of emergency generators in all provincial capitals; strengthening of logistics for transport, fuel and reserve supplies in all regions; constant monitoring of the behavior of the power grid, especially in river crossing areas; and It is defined as ensuring a minimum supply of materials for emergency interventions, especially in remote areas prone to weather.

<hazard map>

As for landslides, the risk of landslides in Maputo, Beira and Nacala is low, but Songo, where the backbone power supply is located, and the transmission line from Songo to South Africa are in close proximity to areas with landslide risk, so it is necessary to check if there are any problems and make appropriate civil engineering designs for new facilities.

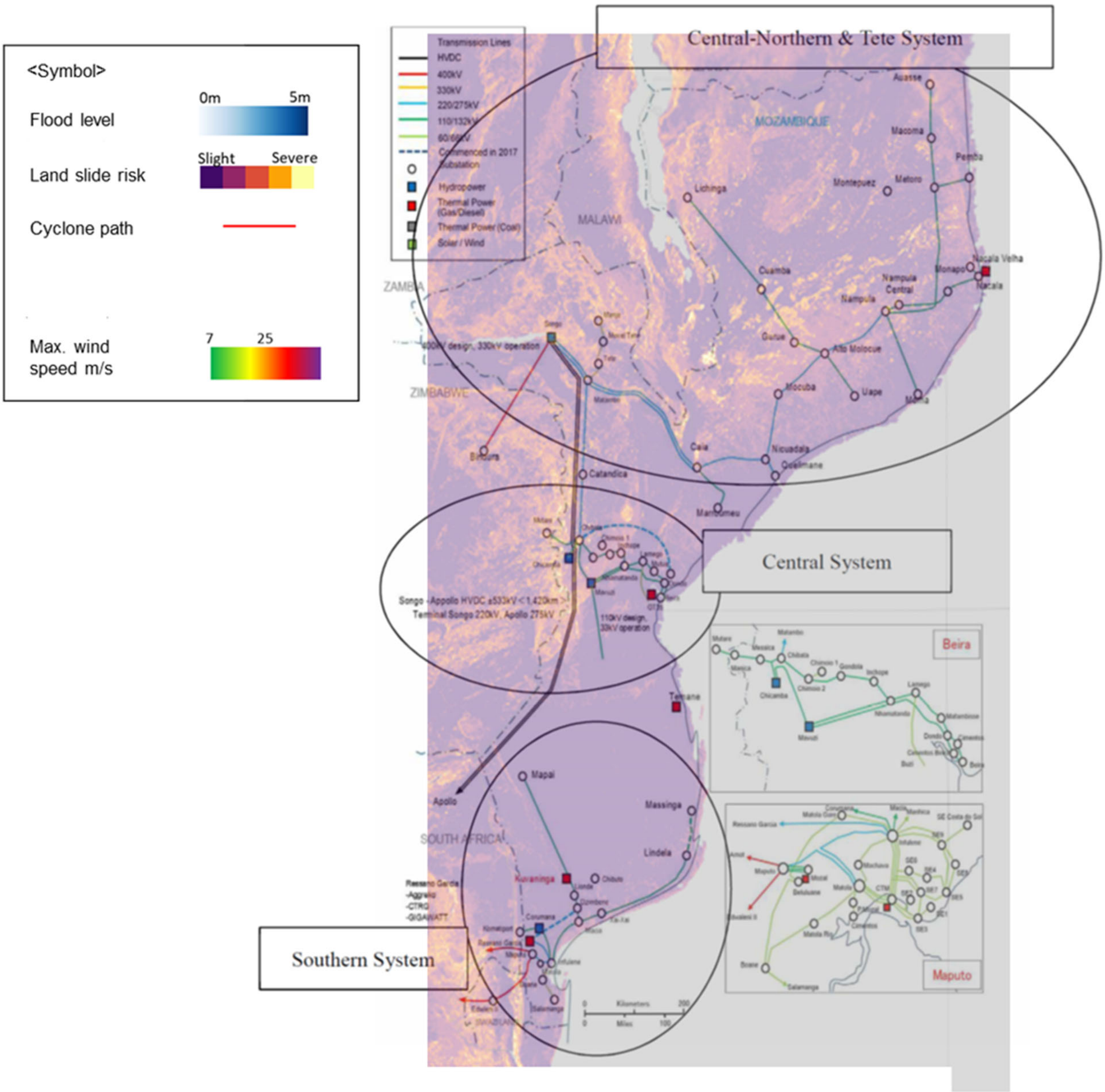


Figure 3-52 Mozambique Power Facilities Map and Landslide Risk Map

Source: Prepared by the study team based on Integrated Master Plan Mozambique Power System Development Final Report (2018, JICA).

On the other hand, there are few backbone power plants and systems that are exposed to the risk of floods and cyclones, but some of them straddle inundation zones. The critical substation in Maputo is close to the flood zone and needs to be checked for problems and if new substation is built, appropriate standards and design should be adopted.

Beira is at risk of cyclone/flooding and needs to be checked for problems and appropriate standards and design adopted for any new construction.

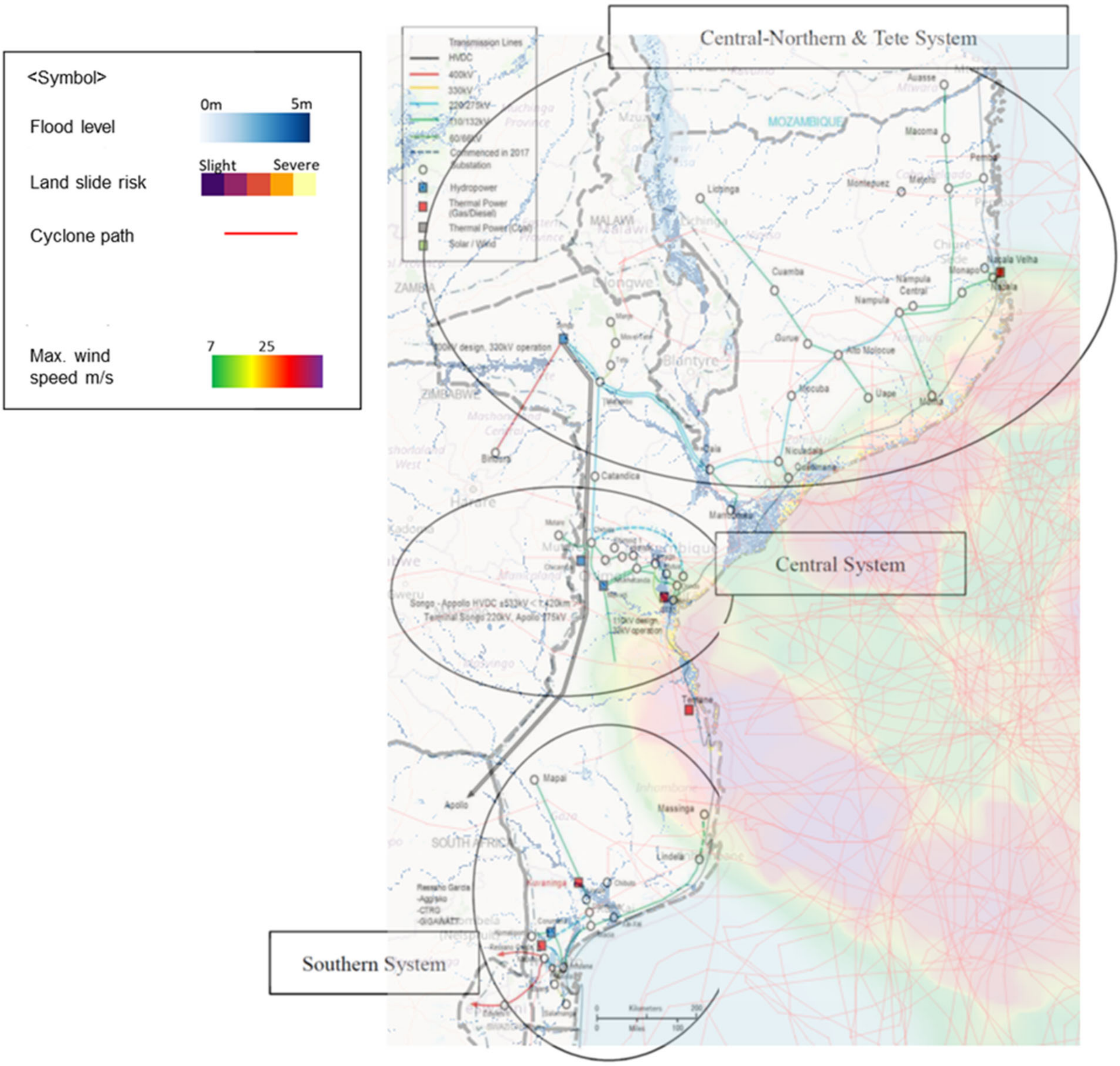


Figure 3-53 Mozambique Power Facilities Map and Flood and Cyclone Risk Map

Source: Prepared by the study team based on Integrated Master Plan Mozambique Power System Development Final Report (2018, JICA).

4） Consideration of Disaster Risk Reduction Measures

The challenges facing Mozambique's power sector include large-scale power development, large-scale transmission development, strengthening of urban distribution networks, and rural electrification. It is not easy to formulate beneficial projects while avoiding duplication as various players, including those supported by JICA, work on master planning and large-scale development.

(4) Water and Sanitation

1） Overview of Relevant Organizations and Legal systems

The water and sanitation related laws and regulations in Mozambique are as follows.

- Water Law (Lei n.º 16/1991 : Lei de Águas)
- National Policy of Water (Resolução n.º 42/2016 : Política Nacional de Águas)
- Decree for QGD (Decreto n.º 72/1998)
- Decree for FIPAG (Decreto n.º 73/1998)
- Decree for CRA (Decreto n.º 74/1998)
- Regulation on Public Water Distribution and Wastewater Drainage Systems (Decreto n.º 30/2003)
- Regulation of Building Water Supply and Wastewater Drainage Systems (Decreto n.º 13/2004)
- Regulation on the Quality of Water for Human Consumption (Diploma Ministerial n.º 180/2004)

Ministry of Public Works, Housing and Water Resources (Ministério das Obras Públicas, Habitação e Recursos Hídricos, MOPHRH) is in charge of the entire governance of water in Mozambique. In the ministry, National Directorate of Water and Sanitation (Direcção Nacional de Abastecimento de Água e Saneamento, DNAAS) is in charge of water, sanitation and hygiene (WASH), and National Directorate of Water Resources Management (Direcção Nacional de Gestão de Recursos Hídricos DNGRH) is in charge of water resources management.

The water administration has organizations in charge of each layer of operations and specific sectors. In addition to the two directorates mentioned above, the WASH related organizations at the central level include the Water Regulatory Authority (Autoridade Reguladora de Água (AURA), formerly Conselho de Regulação do Abastecimento de Água (CRA)), which is the regulator of the water sector; the Water Supply Investment and Assets Fund (Fundo de Investimento e Património do Abastecimento de Água (FIPAG)), which is responsible for the water supply of large cities such as Maputo and Beira; and the Water and Sanitation Infrastructure Management (Administração de Infra-Estruturas de Água e Saneamento (AIAS), which is responsible for sewerage in large cities and WASH service in small cities and towns. At the state level, the Secretary of State carries out the work of the DNAAS in the state. For water resources and river management, five regional water agencies (Administrações Regionais de Águas (ARAs)) carry out DNGRH tasks in their respective districts, such as collection of hydrological information in the districts, dam, river and groundwater management, water utilization, and collection of water consumption. AURA, FIPAG, AIAS and ARAs are defined as external organizations.

Water suppliers including FIPAG submit applications for water use to ARAs, but amount of water use is managed by the suppliers, and only groundwater pumping is recorded by ARAs.

2） Overview of Related Plans and Development Status

The Government of Mozambique, based on its Five-Year Government Program 2020-2024 (Programa Quinquenal do Governo 2020-2024 (PQG)), has established infrastructure development targets to be achieved by 2024, using 2019 as a baseline. The main indicators are to increase the percentage of the population with access to safe water from 52% to 70% in rural areas and from 83% to 90% in urban areas, and to increase the percentage of the population with access to adequate sanitation services from 32% to 55% in rural areas and from 56% to 80% in urban areas.

In addition, the Government of Mozambique has developed the National Rural Water Supply and Sanitation Program 2010-2015 (Programa Nacional de Abastecimento de Água e Saneamento Rural, "PRONASAR", 2010-2015), which is a specific measure for the water and sanitation sector, especially in rural areas. PRONASAR set a target of achieving the national water supply rate (70% in 2015), but fell short of the target at 55% (2019) (DNAAS). The Government of Mozambique and international donors reviewed the program, and the revised PRONASAR, which covers the period from 2019 to 2030, aims to achieve the water sector target set in the SDGs. By 2030, the goal is to ensure sustainable and safe access to water supply and sanitation for rural populations nationwide, and in the medium term (by 2024), to ensure safe water supply for 80% of rural populations and access to sanitation for 75%.

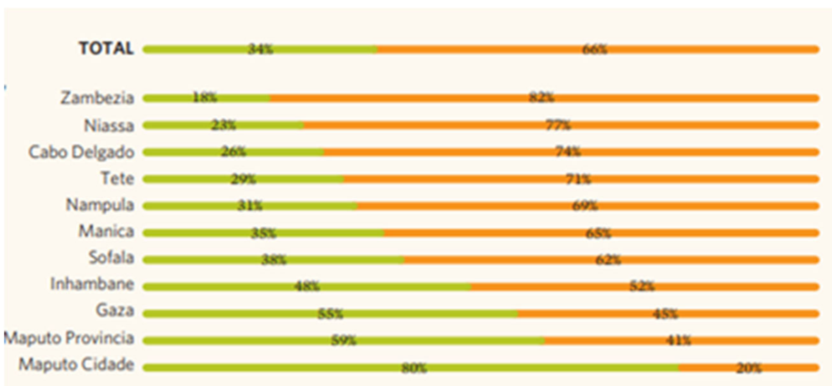


Figure 3-54 Access to piped water by province in Mozambique (%)

Source: FinScope Consumer 2019 Survey

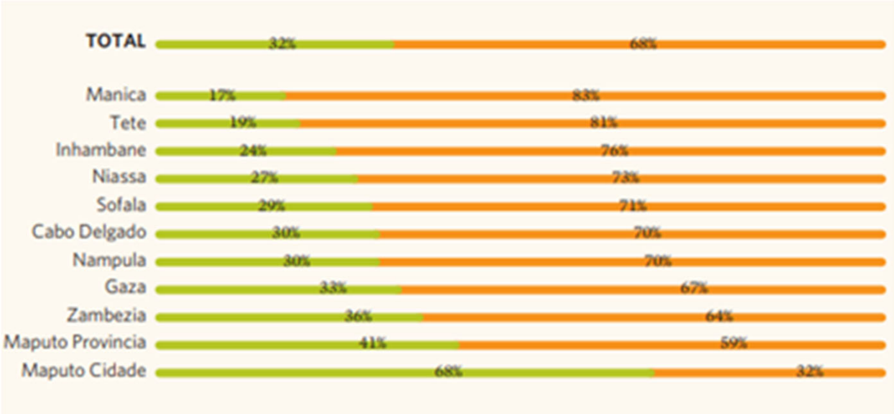


Figure 3-55 Access to sanitation in Mozambique (%)

Source: FinScope Consumer 2019 Survey

The plans related to WASH sector in Mozambique are as follows.

- Five-Year Government Program 2020-2024 (Programa Quinquenal do Governo 2020-2024 (PQG))
- National Rural Water Supply and Sanitation Program 2010-2015 (Programa Nacional de Abastecimento de Água e Saneamento Rural 2010-2015 (PRONASAR))
- Water for Life Program (Programa Água para a Vida (PRAVIDA))
- National Strategy for Water and Urban Sanitation 2011-2025 (Estratégia Nacional de Água e Saneamento Urbano 2011-2025)
- Water Sector Action Plan for the implementation of the Sustainable Development Goals 2015-2030 (Plano de Acção do Sector da Águas para implementação dos Objectivos de Desenvolvimento Sustentável 2015-2030)
- National Strategy for Water and Urban Sanitation 2011-2025 (Estratégia Nacional de Água e Saneamento Urbano 2011-2025)

The Government of Mozambique has been working to improve access to water supply and sanitation services in rural areas under PRONASAR, and JICA has supported this through the "Project for promotion of sustainability in water supply, hygiene and rural sanitation in Niassa Province" and others. JICA has also been studying support measures in the WASH sector in the support for the formulation of the Nacala Corridor Development Plan, and conducting information collection surveys with AIAS as a counterpart.

- Preparatory study report for the emergency water supply program to face climate change in the Republic of Mozambique (JICA, 2009)
- Improvement project of sustainable water and sanitation in Zambezia Province (JICA,

2011)

- Data collection survey on water and sanitation sector in Nacala corridor (JICA, 2012)
- The project for Nacala corridor economic development strategies in the Republic of Mozambique : PEDEC-Nacala (JICA, 2015)
- Project for promotion of sustainability in water supply, hygiene and rural sanitation in Niassa Province, Republic of Mozambique (JICA, 2017)
- Project for promotion of sustainable water supply system and hygiene in Niassa Province, Republic of Mozambique (JICA, ongoing from 2021)

The programmes for WASH sector implemented by the international donors are as follows. Rehabilitation and expansion of urban and rural water supply and sanitation facilities, reduction of non-revenue water rates (NRW), improvement of sanitation, and related research, technical cooperation and institutional capacity building.

- PRONASAR in Nampula and Zambezia Provinces (AfDB, 2010-2017, € 6 million)
- Support for revision of PRONASAR (Common Fund (UK Department for International Development (DFID), UNICEF, Government of Australia, and Government of Switzerland))
- AIAS Phase II (Government of the Netherlands, 2017-2021, € 9.65 million)
- Institutional Support FIPAG (Government of the Netherlands, 2016-2022, € 17.5 million)
- IWRM (Government of the Netherlands, 2019-2025, € 18.5 million)
- Blue Deal (Government of the Netherlands, 2019-2022)
- Urban Sanitation Project (World Bank, I 2019-2024, US$ 115 million; II 2024-2028 and III 2029-2033, US$ 200 million)
- Access to Water, Sanitation and Maintenance Services (Agence Française de Développement (AFD), 2017-2020)

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

a) Organization related to water and sanitation

Disasters of particular concern in Mozambique in terms of water and sanitation infrastructure are flooding, wind damage and drought. In order to minimize the damage to water and sewerage systems in the event of a disaster, to restore them as soon as possible and to maintain a minimum level of functionality, it is important to design resilient facilities against wind damage caused by cyclones, as well as the perspective of locating facilities in areas with low risk of flooding.

On 22 October and 2 November 2021, we interviewed the water supply engineer of DNAAS about the implementation system of water supply and sanitation services and the status of laws and regulations.

The location of the water supply and sewerage facilities will be selected in accordance with the urban planning of the municipality where they are to be located and in an appropriate engineering location. The construction will be in accordance with the structural regulations of MOPHRH. The regulations for the construction of water and sewage works include the Regulation on Public Water Distribution and Wastewater Drainage Systems (Decreto n.º 30/2003), which set out water quality standards, and the Regulation of Building Water Supply and Wastewater Drainage Systems (Decreto n.º 13/2004), which set out standards for pipelines and pumping facilities, but there are no regulations for water treatment plants or distribution reservoirs.

DNAAS, with the support of the Government of the Netherlands, is reviewing the Decreto n.º 30/2003. The main points of the review are drought measures, the standard number of people using public taps, and the location of water supply systems in line with the increase in the number of households wishing to connect to water supply.

In addition, on 21 October 2021, we interviewed the engineers in charge of water resources management at ARA-Sul about the use of drinking water and the construction of structures in the river area.

Water suppliers make an application to ARAs for the use of drinking water from water resources managed by each ARAs. Surface water consumption is not measured, but groundwater consumption is recorded by ARAs. The installation of water and sanitation structures in a river area is in accordance with the structural regulations of MOPHRH.

b) Cyclone damage to urban areas

Disaster damage estimates in the water and sanitation sector are carried out by FIPAG and AIAS, with the National Disaster Management Institute (Instituto Nacional de Gestão e Redução do Risco de Desastres, "INGD") and international donors also playing an important role. Emergency damage estimates are limited to the area accessible by road, and there is a need for more specialised, accurate and immediate damage estimates for rural areas. Cyclone Idai caused significant damage to water supply facilities, mainly in Sofala Province. The pump station in Mutua, Beira (A green pin in Figure 3-56) is only operating at 50% of its pre-disaster capacity. (Mozambique Cyclone Idai Post Disaster Needs Assessment, 2019)

The sewage system of Beira City was also damaged by Cyclone Idai. (Figure 3-57)

On 26 and 29 October 2021, interviews were held with the engineers in charge of drainage channel and sewage system of the Autonomous Sanitation Service of Beira (Serviço Autónomo de Saneamento da Beira, “SASB”), which is responsible for the construction, maintenance and operation of the sewerage, sanitation and drainage system in Beira, to discuss the damage caused by the cyclone and future challenges. As leaks from cracks in pipes caused by ageing and blockages and backflow of pipes due to sand inflow have been a problem, a large amount of sand flowed into the wastewater treatment plant (Estação de Tratamento de Águas Residuais, "ETAR") during the "Idai" attack. (Figure 3-58) ETAR has a capacity of 7,500 m3/day, but after the disaster, its capacity is only 100 m3/day, and most of the wastewater is discharged into the sea. As the EU carried out a survey of the damage in 2019-2020, SASB will consider to restore plan of it once a report has been compiled.

As pumping stations have drainage systems in operation and water storage tanks around the building, no damage to the mechanicaland electrical equipment has been caused by flooding.

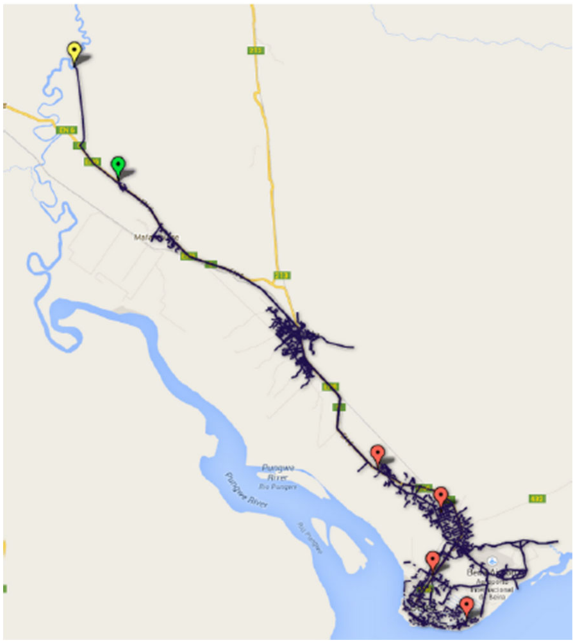


Figure 3-56 Map of water supply pipeline, pump station, intake and water treatment plant in Beira City

Sources: Beira Urban Water Master Plan (Beira City Council, 2014)

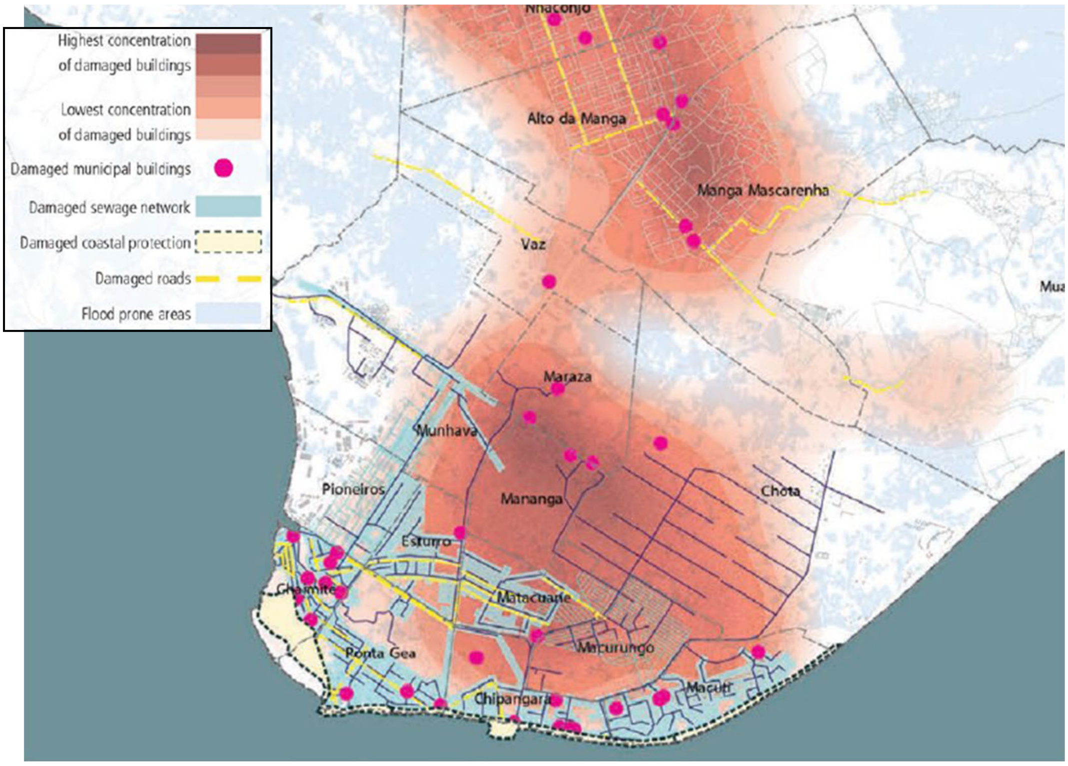


Figure 3-57 Sewage system in Beira City damaged by Cyclone Idai

Sources: Based on “Beira Municipal Recovery and Resilience Plan” (Beira City Council, 2019)

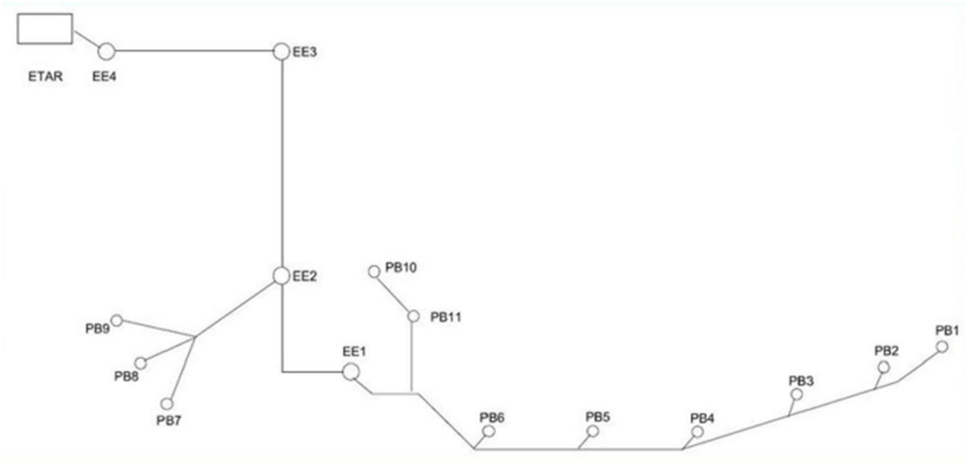


Figure 3-58 Diagram of the sewage system in Beira

Source: Beira Municipal Recovery and Resilience Plan (Beira City Council, 2019)

c) Cyclone damage to urban areas

Damages of water and sanitation sector by natural disasters in recent years are as following.

Table 3-27 Cyclone damages in water and sanitation sector

Year	Affected Areas	Summary
Feb. 2021 Cyclone Eloise	Sofala, Manica, Zambezia, Gaza, Inhambane	- Affetced population to access to water in rural: 30,000 - An estimated 40 wells and boreholes were damaged or destroyed in the rural areas. - Sofala alone had 304 water points affected. (International Federation of Red Cross and Red Crescent Societies, the Emergency Plan of Action (EPoA), 2021)
Apr. 2019 Cyclone Idai	Sofala	- Decreasing of capacity of water supply pump facilities and a waste water treatment plant in Beira (interview to SASB) - Affetced population to access to water in the nation: 211,000 - Number of damaged sanitation facilities: 118,600 in urban and 71,450 in rural (UNDP, 2019) - Recovery need in water and sanitation sector: US$ 106.2 million (UNDP, 2019)

Source: JICA Study Team

4) Consideration of Disaster Risk Reduction Measures

The main disaster prevention measures for water supply and sewerage facilities are: appropriate facility layout; securing drinking water during disaster periods in setting reservoir capacities; flood protection of facilities (especially mechanical and electrical equipment) and drainage infrastructure; improving organisational disaster response capacity; and securing back-up facilities through improved management. By clearly defining specific disaster prevention measures in design guidelines by the national government, it is possible to raise awareness of disaster prevention and prevent differences in disaster prevention considerations between individual projects.

However, the development of guidelines is a time-consuming process and Mozambique urgently needs to improve access to and service delivery of water supply and sanitation. Therefore, the implementation of the above DRR measures in grant aid for WASH sector could promote the resilience of water supply and sanitation systems to disasters.

In the case of droughts, it is necessary to promote the improvement of water supply systems and management capacity of groundwater sources, which are relatively unaffected by droughts, and it would be effective to continue the support that has been provided in Zambezia and Niassa provinces.

(5) Telecommunication

1) Overview of Relevant Organizations and Legal systems

a) Market Overview

Mozambique has the lowest telecoms index among sub-Saharan African countries, with less than one landline phone per 100 people and relatively low cell phone penetration (Eaglestone Securities, 2014). Due to the civil war, the country's major infrastructure was not developed and there was no investment for a long time. After the peace agreement with the Mozambique Liberation Front in 1992, the government began to partially liberalize the ICT sector. However, the communication infrastructure is mainly limited to urban areas, and its services are mainly provided by mobile communication (see the figure below). The mobile communication network mainly covers cities and villages, highways and economic corridors, and coastal tourist areas.

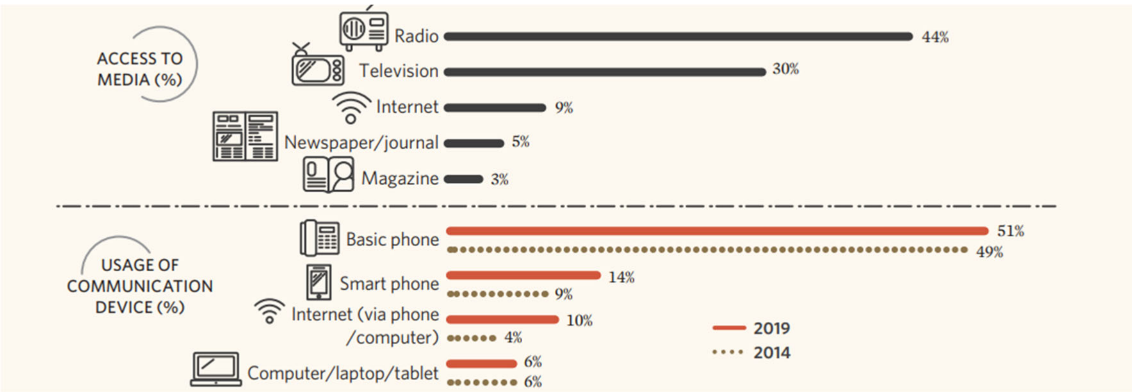


Figure 3-59 Access and usage of communication media in past month (%)

Source: FinScope Consumer 2019 Survey

Mozambique's fixed-line telephone penetration rate is less than 2% of all households, which remains the lowest level in the sub-Saharan region. Despite the corporate efforts of fixed-line operators, the number of fixed-line subscribers continues to decline, falling by 12% in 2019 compared to 2018, mainly due to a decline in contract subscribers. Internet subscribers via landlines followed the same trend, decreasing by 18% in the third quarter of 2019 compared to the previous quarter (INMC, 2019).

On the other hand, the mobile communications market continues to grow at an average annual growth rate of 26%, which is more than 65% population coverage. According to the Communications Regulation Report 2019 (INMC, 2019), the number of service subscribers declined between 2015 and 2017, with a slight decrease (2%) in 2018 and 2019, but that in 2019 remained about the same (14,074,248 people). The predominant communication methods in Mozambique are 2G and 3G networks, according to 2019 data.

Regarding fiber optic networks, some urban areas in Mozambique are served by commercial service providers that have invested in fiber optic networks, but this is limited to densely populated areas in the major urban centers.

Mozambique's telecommunications network is well-served by international connections in urban areas and, in general, there does not appear to be any concerns about pricing or availability of international connections. However, accessing international connections through backhaul service providers can be costly. On the other hand, in rural areas, factors such as poor network quality, lack of standardized network specifications, high cost of connecting to the backbone network, unequal spectrum charging mechanisms, and a wide range of economic factors have led to a lack of infrastructure sharing, backbone networks are duplicated, and investment in telecommunication networks to provide voice and broadband services is stagnant.

Although the International Telecommunication Union (ITU) dataset, which is the main source of data for telecommunications infrastructure (TII), was not available for this study because of its fee, the components of TII in 2020 were examined through the E-Government Survey 2020 (UN, 2020). The E-Government Index (EDGI), Online Service Index (OSI), and Human Capital Index (HCI) for Mozambique were as follows.

Table 3-28 Telecommunication Infrastructure Indicators for Mozambique (2020)

E-Government Development Index	0.3564*
Online Service Index	0.5176
Human Capital Index	0.4222
Telecommunication Infrastructure Index	0.1293
Mobile cellular telephone subscriptions per 100 inhabitants	47.72
Percentage of individuals using the internet (%)	10
Fixed (wired) broadband subscriptions per 100 inhabitants	0.24
Active mobile broadband subscriptions per 100 inhabitants	15.07

Source: E-Government Survey 2020 (UN, 2020)

Mozambique's EGDI is moderate (163rd out of 193), with a moderate OSI value and a very low TII value (0.5176 and 0.1293, respectively), reflecting the country's continued struggle to restore its telecommunications infrastructure after natural disaster damage.

b) Basic Policy

Since 2002, Mozambique has opened up its telecommunications market and moved to a market based on open and free competition. In particular, competition in the mobile communication service sector has led to remarkable growth in the quality of voice communication, and broadband services are now expanding rapidly. The Mozambican government encourages and promotes competition, especially in the segments of infrastructure networks, access networks, and international telephony. Although all segments of the telecom market are fairly opened to new entrants, the actual level of competition varies slightly from segment to segment.

The Mozambican government is also encouraging more operators to enter the market, offer services, and compete on the national network. In Mozambique, fair competition in the telecommunications infrastructure market covers not only the provision of telecommunications network services, but also ensuring interconnectivity among carriers, sharing of infrastructure among carriers, and use of public roads.

c) Related Laws

Mozambique is a country that is frequently hit by natural disasters, so it needs to have a resilient telecommunications infrastructure and the ability to respond quickly in the event of a disaster. Considering such characteristics, key guidelines for reducing or responding to disaster risks are provided in the Law of Telecommunications in Mozambique (Law No. 4/2016, of 3 June). The following is a list of strategies, policies, and initiatives that have been developed by the Government of Mozambique regarding the telecommunications sector.

[1] Law No. 4/2016, of 3 June, which approves the Telecommunications Law;

[2] Resolution No. 54/2006, of 28 December, which approves the Telecommunications Strategy;

[3] Resolution No. 47/2017, of 27 October, which approves the National Broadband Strategy;

[4] Decree No. 32/2001, of 6 November, which defines the Organization and Functioning of the National Institute of Communications of Mozambique (the "Organic Statute of INCM");

[5] Resolution No. 17/2018, which approves the Information Society Policy;

[6] Resolution No. 47/2017, which approves the National Broadband Strategy;

[7] Resolution No. 52/2019, which approves the Strategic Plan for Information Society;

[8] Resolution No. 28/2000, of 12 December, which approves the Information and Communications Technology (ICT) Policy;

[9] Decree No. 37/2009, of 13 August, which approves the Regulation of Telecommunication

and Radio Communications Homologation;

[10] Decree No. 62/2010, of 27 December, which approves the Regulation of Passive Telecommunications Infrastructures Sharing and other Network Resource (the "Regulation of Infrastructure Sharing");

[11] Decree No. 6/2011, of 3 May, which approves the Regulation of Public Telecommunications Services Quality;

[12] Decree No. 26/2017, of 30 June, which approves the Regulation for the Licensing and Registration Regime, and Scarce Resource for the Provision of Telecommunications Services for Public Use and Establishment and Use of Public Telecommunications Networks.

The Telecommunications Law (Law No. 4/2016, of 3 June, [1]) applies to individuals and legal entities authorized to set up, manage, and operate telecommunication networks. The law defines a general framework for the telecommunications sector to open up the credit market and ensure that telecommunication networks converge through competition. In addition, the Telecommunications Law has been amended in the past to further modernize and strengthen licensing regulations in response to the normative framework for fair competition and new developments in the sector. The supervisory authority will intervene only when necessary to promote and enforce these regulations.

A supplement to the Telecommunications Law, Resolution No. 54/2006, of 28 December, which approves the Telecommunications Strategy ([2]), defines the Telecommunications Law and describes how to implement its principles. The objective of the Telecommunications Strategy and the amendments to the Telecommunications Act is to promote competition within the sector by creating an appropriate legal environment. It aims to properly respond to constant technological advances and shakeouts and align the country with global telecommunication trends and best practices.

d) Supervisory authority

The supervising ministry for the telecommunication sector is The Ministry of Transport and Telecommunications (MTC), which is responsible for monitoring the telecommunication sector. MTC focused on various projects such as digital migration, e-government, and cyber security.

The telecommunications regulator is the Mozambique National Communications Institute (INCM), established in 1992. The INCM is an independent body under the control and supervision of the MTC. The main responsibilities of the INCM are licensing, spectrum management, license number management, tariff and telecommunication quality regulation. In order to enhance disaster resilience, telecommunication infrastructures need to be brought into compliance with international standards. Therefore, as part of the Global Partnership for Disaster Resilient Infrastructure, INCM has started discussions with the telecommunication operators mentioned below for standardization in telecommunication sector.

e) Main Operators

Operators in Mozambique's telecommunications and broadcasting sectors are as follows:

Mobile Operator

i.) Moçambique Telecom（state-owned, also known as Tmcel）[18]

ii.) Vodacom（private）[19]

iii.) Movitel（private）[20]

In terms of market size, as of 2019, Vodacom has the highest subscriber base with 49%, accounting for almost half of the subscribers in the domestic market, followed by Movitel with 28% and Tmcel with 23% (INMC, 2019). As previously mentioned, the mainstream communication systems in Mozambique are 2G and 3G networks, according to 2019 data. For the 2G network, Movitel has the widest coverage at the district and administrative unit level, but Tmcel has higher performance at some particular points. However, for 3G networks, Movitel covers more points in all administrative districts (INMC, 2019). The following figure shows the service area map of each mobile carrier.

[18] http://www.mcel.co.mz/

[19] https://vm.co.mz/

[20] https://movitel.co.mz/

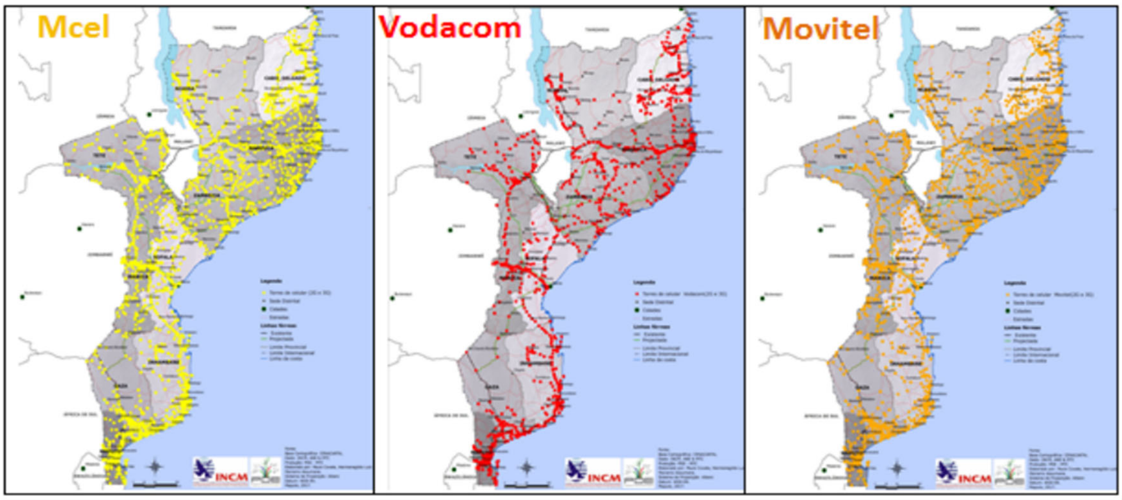


Figure 3-60 Coverage map for each mobile carrier

Source: INCM, 2017

Fixed-line Operators

i.) Telecom-Tmcel (state-owned)[21]

ii.) TDM (Telecomunicações de Moçambique, state-owned)[22]

Telecom-Tmcel became the only operator to offer fixed and mobile communication services in Mozambique. To promote competition, increase market size, and improve performance and service quality, Tmcel invested about US$23 million in telecommunication equipment in 2019 (INMC, 2019). Telecomunicações de Moçambique (TDM) is also a telecommunications and internet service provider in Mozambique, while MoçambiqueCelular (Mcel) and TeleecomunicaçõesdeMoçambique (TDM) were merged in 2018 in order to improve the cost-effectiveness of the state-owned enterprise.

Digital TV

The digital television market in Mozambique has been analyzed for the first time in the Communications Regulation Report 2019 (INMC, 2019). There are four companies in the market: Digital Satellite Television (DSTV), GoTV, ZAP, and TVCabo, with the latter providing access to ZAP and DSTV channels. These companies offer 191 national TV channels, 62 radio channels, and 41 HDMI channels. In terms of subscribers, by the end of 2019, this market will have about

[21] http://www.mcel.co.mz/

[22] http://www.tdm.mz/

1,955,841 active subscribers nationwide, with TvCabo leading the pack (62%), followed by ZAP (24%), GoTV (9%), and DSTV (4%).

2） Overview of Related Plans and Development Status

In Mozambique, the rapid expansion of broadband Internet access continues, with about 15% of the total population having access to the Internet.

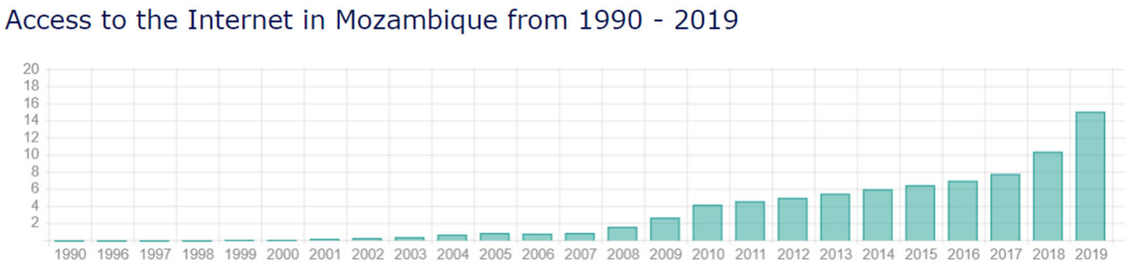


Figure 3-61 Percentage of population with access to the Internet (1990-2019)3-1

Source: EorldData.info[23]

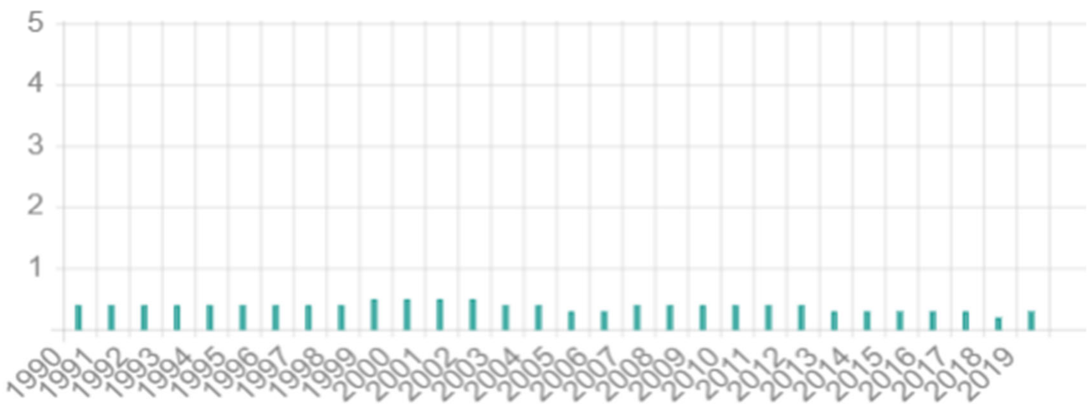


Figure 3-62 Fixed-line Subscriber Population Ratio3-2

Source: EorldData.info

[23]https://www.worlddata.info/africa/mozambique/telecommunication.php

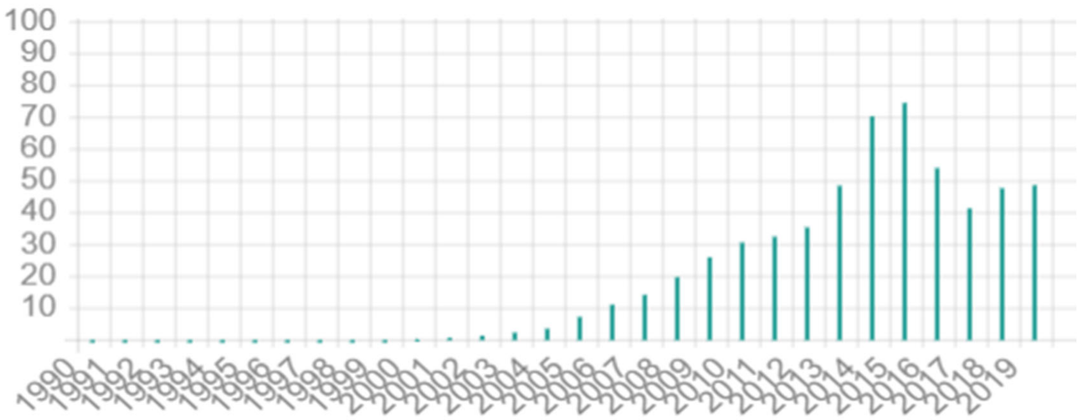


Figure 3-63 Percentage of population with mobile line subscriptions

Source: EorldData.info

Table3-29 Key indicators for Mozambique's telecommunications sector (ITU Estimation, 2017) [24]

indicator	Mozambique	Africa average	World average
Number of fixed-line subscribers (per 100 population)	0.3	0.9	13.0
Number of mobile subscribers (per 100 population)	40.0	74.4	103.6
Number of mobile broadband subscribers (per 100 population)	25.7	24.8	61.9
3G population coverage (%)	40.0	62.7	87.9
LTE/WiMAX population coverage (%)	0.0	28.4	76.3
Internet access population rate (%)	20.8	22.1	48.6
Percentage of households with PCs (%)	7.1	8.9	47.1
Percentage of households with Internet access (%)	10.8	19.4	54.7
Average Internet bandwidth per user (kbps)	1.2	11.2	76.6
Number of mobile broadband subscribers (per 100 population)	0.1	0.6	13.6

Source: ITU

As a result of the growing international globalization of the economy and the emergence of new production centers, there is a growing demand for mobility of people and goods, integrated logistics, transportation, and communication services. In this regard, the government of Mozambique is continuing its efforts to build and rebuild the telecommunications infrastructure for access to information and communication technologies. The plan to build/rebuild the telecommunications infrastructure is included in the Government of Mozambique's five-year plan, PQG 2020-2024, along with the following strategic actions:

[24] https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2018/MISR-2018-Vol-2-E.pdf

- To launch 4G (LTE) services in all provinces, covering 50% of local administrative centers.
- To begin promotion and implementation of 5G services in all states
- To launch satellite TV services in 500 rural villages across the country.

According to PQG 2020-2024, the Government of Mozambique has established the expansion of a wide range of telecommunications services and defined a set of indicators based on actual figures for 2019 and targets by 2024 (see table below). Major donors are expected to support the implementation of the project so as to improve these indicators identified in PQG 2020-2024.

Table 3-30 Target indicators for telecommunications services

Strategic Objectives	**indicator**	**2019 (base year)**	**2024 (target value)**	**responsible body**
Improving and enhancing communication services	Quality indicators for national government networks (call success rate, %)	95%.	99.8	MTC
	Quality indicators for critical areas (call success rate, %)	75%.	98%	
	Quality indicators for metropolitan area networks (data traffic)	0	20	

Source: PQG2020-2024

The latest donor-supported projects by international organizations and companies include the following projects on-going:

- Emergency Telecommunications Cluster (ETC): The ETC does not currently have an active operation in Mozambique;
- World Food Programme (WFP);
- Télécoms Sans Frontières;
- Southern Africa Development Community;
- Emergency.lu ;
- Ericsson Response;
- NetHope;
- Swedish Civil Contingencies Agency.

3) Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Communication infrastructure is one of the most vulnerable infrastructures to natural disasters, and Mozambique, which is frequently hit by natural disasters, requires disaster-resistant communication infrastructure and rapid emergency response. The main guidelines for disaster risk reduction and disaster risk response are stipulated in the Telecommunications Act as following.

- In case of emergency, the government can issue mandatory instructions to network operators, telecommunications service providers, and wireless carriers.
- It is the responsibility of the government to ensure proper coordination of telecommunications networks and services in emergencies, public calamities, crises, and wars.
- Telecommunications operators shall take the necessary measures to ensure the security and integrity of their own network and service operations, and, whenever possible, ensure that alternative means are available in the event of an emergency.
- Telecom operators are required to allow calls to emergency services on their networks free of charge. Telecommunications carriers must also provide the authorities in charge of emergency services with information on the location of the caller.
- Radio communication users shall not make or permit unlawful radio communications, broadcast alarm, emergency, or danger signals, or make false or misleading emergency calls.

However, hazard maps (based on simulations or estimates) for areas affected by natural disasters such as cyclones, tsunamis, and earthquakes in the past do not seem to have been created and could not be found by this survey. We were also unable to confirm the existence of operational guidelines for backup power using UPS (uninterruptible power supply using batteries) or generators (e.g., target values such as enabling 24-hour operation even during commercial power outages).

Restoration of telecommunication infrastructure will take a long time as it will require a large investment. After Cyclones Idai and Kenneth devastated many parts of Mozambique, the Mozambican government asked the World Food Programme (WFP), the global leader of the Emergency Telecommunications Cluster (ETC), to respond to the emergency. In Mozambique, WFP has the most extensive communications network with repeaters throughout the country. In addition to WFP, other large networks include UNDP, UNHCR, and UNICEF.

Table 3-31 Existing emergency communication systems of UN agencies

	WFP	UNICEF	UNHCR	FAO	UNDP	WHO
VHF Frequency	existence	existence	None	existence	existence	None
HF Frequency	existence	existence	existence	existence	existence	existence
Relay station	nation-wide	Maputo city only	Maputo city only	Maputo city only	Maputo city only	None
VSAT (satellite communication)	existence	existence	None	existence	existence	None

Source: WFP

ETC acted quickly as a focal point for humanitarian organizations and worked closely with the authorities to ensure an efficient and coordinated communications response to emergency communications needs. ETC's work in response to both Cyclone Idai and Kenneth is supported by a network of partners and organizations, including emergency.lu, Ericsson Response, Télécoms Sans Frontières, NetHope, and the Swedish Civil Contingencies Agency. Local and global ETC meetings were held on a regular basis to ensure a coordinated response. For example, immediately after the disaster, a cholera outbreak was reported, and by April, more than 4,000 cases had been confirmed. Cyclone Kenneth, which made landfall in northern Mozambique on April 25, just five weeks after Cyclone Idai, became the strongest cyclone to hit Mozambique since records began. In response to this emergency, ETC partners and equipment were deployed.

During the peak of the Cyclone Idai response, ETC provided communication services to humanitarian aid workers at 21 locations, including the Emergency Operations Centre (EOC) in Beira, SOC in Beira, 17 locations in Beira town, Buji, Grudja and Nhamatanda. Communication services were provided to humanitarian workers at 21 locations, including the Beira SOC, 17 locations in Beira town, Buzi, Grudja and Nhamatanda. Also. During the Cyclone Idai response, a cumulative total of more than 1,800 humanitarian aid supporters from 440 organizations registered for ETC's Internet access service.

The main issues reported by the ETC are as follows.

- Delays in importing telecommunication equipment and customs clearance affected the operation of ETC in the field.
- Satellite voice services were unreliable, hampering humanitarian response in the field.
- The national power grid in Beira failed for several weeks after the cyclone

Cyclones Idai and Kenneth destroyed most of the telecommunication infrastructure, including towers, radio stations, fiber-optic lines, and satellite dishes, owned by all telecommunication companies in central and northern Mozambique, and reportedly cut off mobile communications in central and northern areas for three days. This damage was caused by strong winds that reached 62 m/s (224 km/h) in central areas (Manica, Sofala, Tete, Zambézia) and 58 m/s (210 km/h) in northern areas (Nampula, Cabo-Delgado, Niassa). All operators took a very long time to restore their mobile communication networks, and in some places overhead wire fiber optic cables were damaged by falling trees.

This experience reaffirmed the need for a more careful and systematic review of the telecommunications infrastructure to ensure that current standards are compatible with the new generation of future networks. The design, deployment, and implementation of telecommunications infrastructure requires more stronger commitment to compliance with telecommunications infrastructure standards, taking into account how risks and losses will be managed. Telecommunication operators must realize that they will have to spend more to build a more resilient infrastructure.

On the other hand, in locations where disaster risk is expected to remain low in the future and consequently there is no need to invest in disaster, operators will be compensated for losses incurred in other infrastructure located in high-risk disaster areas. Because of the enormous cost of investing in communications infrastructure, it is necessary to go beyond saving lives to mitigate the enormous impact on the infrastructure. In the next 10-20 years, more infrastructure will need to be built than ever before, using new network technologies such as IoT.

At the same time, it is possible to reduce the impact of natural disasters by preparing communities in advance. ETC played an important role in the disaster, but just as important is the disaster preparedness activities. The main backup communication systems in case the network is damaged by a disaster are radios (community radios), warning sirens, bells, and megaphones.

Linha Verde 1458 (Emergency Green Line) is a dedicated hotline for stakeholders with no communication costs and is accessible daily (7 days a week) from 6 a.m. to 9 p.m. The hotline was used by people affected by the disaster to request information and assistance, and to discuss concerns among humanitarian agencies. As part of its accountability to the affected population, it also serves as a vehicle for reporting wrongdoing in humanitarian assistance. In the period August 16 to September 15, 2020 (recovery period from Cyclone Idai), Linha Verde 1458 registered 240 cases in the Central Mozambique region, with an overall feedback rate of 61%.

To commemorate the establishment of the ATU, the Africa Telecommunication Day/ICT is held every year. The ATU Council decides on a theme for the commemoration each year, and African countries plan activities according to that theme. The theme for 2019 was "Use of Technology to Save Lives" (use emergency communications for disaster risk management and reduction). This theme was set due to the devastation caused by Cyclone Idai and Kenneth. On the other hand, this theme is in line with the strategic plans of the government and other relevant agencies, indicating the growing presence of DRR in the telecommunications sector. However, primary (raw) data on Mozambique's telecommunications infrastructure is not generally available, even at the national and lower levels. The main difficulty in obtaining information on the telecommunications sector is due to the reality that some potentially interesting documents are stored in paid databases and/or owned by private companies. It is difficult to investigate the relevance of the telecom sector with respect to DRR through desktop surveys alone due to the limited information accessible.

Finally, human backup means in case the network is damaged by a disaster could not be found during the course of this study.

4） Consideration of Disaster Risk Reduction Measures

According to the INCM-Communications Regulation Report 2019, following Cyclones Idai and Kenneth in 2019, much of the infrastructure in central and northern Mozambique, including towers, radio stations, fiber optics, and satellites, was damaged, and mobile communications were cut off for three days. In the central provinces of Manica, Sofala, Tete, and Zambezia, winds reached 62 m/s, and in the northern provinces of Nampula, Cabo Delgado, and the Niassa group, winds reached 58 m/s.

The table below summarizes the telecommunication facilities that were damaged in each region.

Table 3-32 Number of Base Stations Affected by Cyclone Idai

county	Number of existing base stations			Number of affected base stations		
	Tmcel	**Vodacom**	**Movitel**	**Tmcel**	**Vodacom**	**Movitel**
Sofara	165	313	237	90	235	249
Manica	112	185	224	63	42	-Mr.
Tete.	137	242	228	42	37	-Mr.
Zambezi	144	291	297	56	34	1
Total	558	1031	986	251	348	250

Source: INCM-Communications Regulation Report 2019

Table 3-33 Number of subscribers whose communication was affected by Cyclone Idai

county	Number of subscribers whose communication has been affected		
	Tmcel	**Tmcel**	**Vodacom**
Sofara	212,600	547,609	335,009
Manica	189,921	138,961	444,832
Tete.	102,524	493,382	365,699
Zambezi	143,639	552,979	873,487
Total	648,684	1,732,931	2,019,027

Source: INCM-Communications Regulation Report 2019

Figure 3-64 Tmcel pylon destroyed by Cyclone Idai, Sofala

Source: INCM

Table 3-34 Number of Base Stations Affected by Cyclone Kenneth

county	Number of existing base stations			Number of affected base stations		
	Tmcel	**Vodacom**	**Movitel**	**Tmcel**	**Vodacom**	**Movitel**
Cabo Delgado	121	304	160	19	67	60
Mampula	230	470	415	0	0	0
Total	351	774	575	19	67	60

Source: INCM-Communications Regulation Report 2019

Table 3-35 Number of subscribers whose communications were affected by Cyclone Kenneth

county	Number of subscribers whose communication has been affected		
	Tmcel	**Tmcel**	**Vodacom**
Cabo Delgado	72,804	284,128	570,746
Mampula	0	0	0
Total	72,804	284,128	570,746

Source: INCM-Communications Regulation Report 2019

Figure 3-65   Flood-damaged communication channel, Sofala district

Source: INGC

It took a very long time to restore the mobile networks of all the operators, and in some places, fiber optics were cut by falling trees. The lessons and learned from this reminded us that it is important to not only comply with telecommunication infrastructure standards, but also to anticipate disaster risks and losses in the design, implementation and enforcement of telecommunication infrastructure. When planning communication infrastructure, it is necessary to firstly strengthen resilience to disasters and secondly prepare equipment and personnel for quick recovery. It is said that if operators add 3% to their infrastructure investments in anticipation of disaster risk, they can gain 20% in terms of disaster resilience.

Specific disaster prevention measures can be clarified by adding standards for telecommunications infrastructure to improve the disaster resilience of all businesses. Specifically, it would be effective in the long term to introduce to INCM the disaster prevention guidelines of other countries such as Japan, which are frequently hit by natural disasters, and to formulate disaster prevention guidelines for telecommunications infrastructure.

(6) Education

1) Overview of Relevant Organizations and Legal systems

Education in Mozambique is under the jurisdiction of the central Ministry of Education and Human Development (MINEDH, Ministério de Educação e Desenvolvimento Humano) and the Ministry of Science and Technology Higher and Technical and Professional Education (MCTESTP). MINEDH is responsible for formulating educational policies related to primary and secondary education and social education, and developing and supervising educational systems. The MCTESTP was separated from the Ministry of Education and Human Development when the ministry was reorganized with the new government in 2015, and is responsible for developing policies and strategies for higher and vocational education, as well as various measures to expand opportunities for higher and vocational education (MEXT, 2016).

As a result of the decentralization of power, provincial and district education bureaus have been established in the provinces, with the provincial education bureau having overall jurisdiction over education administration in the province in accordance with the policy of the Ministry of Education and Human Development, while primary and secondary education administration, including promotion of school construction and budgeting, has been delegated to district education bureaus (Ministry of Education, Culture, Sports, Science and Technology, 2016). The school construction is managed by the District Education, Youth, Science and Technology Office (SDEJT, Servicos Distritais da Educação Juventude e Tecnologia).

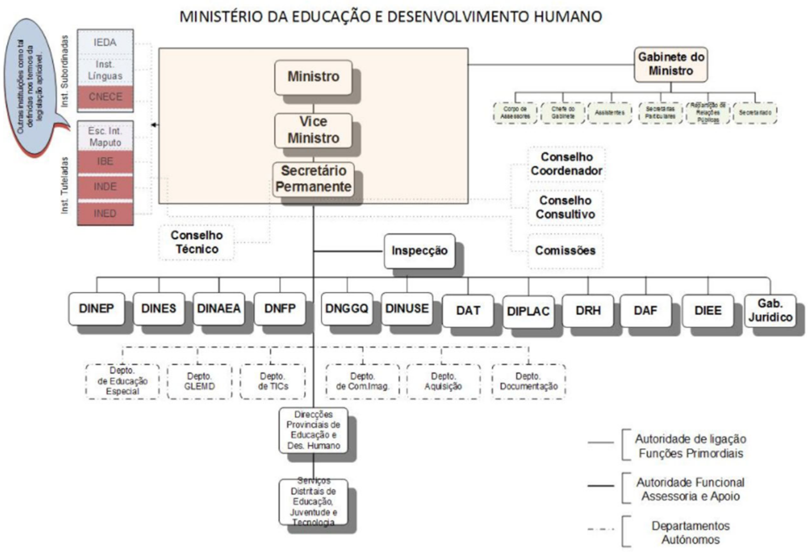


Figure 3-66 Organizational chart of education-related institutions

Source: Retrieved from MINEDH homepage

The National Development Strategy 2015-2035 defines intervention in human resource development as one of the four pillars, and specifies that improvement of basic living conditions requires support and intervention in education, health, housing, water supply and sanitation, and social protection for vulnerable population groups.

The Mozambican government introduced a free primary education policy in 2005, and although the number of students expanded rapidly between 2004 and 2011, the supply of teachers could not keep up with the expansion of students, and a shortage of teachers became an issue. In response to this, based on the Fourth Plan National de Development, the Education Strategic Plan (PEE, 2012-2016, later extended to 2019) promoted quality 7-year primary education and to expand post-primary education opportunities including secondary education, while to raise the quality of teachers by introducing a new teacher training curriculum and extending the period of teacher training up to three years. The PEE 2020-2029 aims to train *"citizens with knowledge, skills, moral, civic and patriotic values capable of contributing to the development of a cohesive society adapted to the constantly changing world"*. Its three priorities are to:

1. Ensure inclusion and equity in access, participation, and retention by securing all children, youth, and adults' access to a full cycle of school readiness, primary and lower secondary education.

2. Ensure the quality of learning by making sure that children, youth, and adults acquire basic literacy, numeracy, and life skills

3. Ensure transparent, participatory, efficient, and effective governance by enhancing the capacities of the Ministry of Education staff to enable education sector planners and managers to practice evidence-based policy and strategy.

The budget allocated to school construction by the SDEJT has been increasing every year, and in 2019, about 70% of the education sector budget was allocated to the construction of new classrooms, while about 60% of the education budget went to improving primary education. There was also an increase in appropriation for literacy and basic education for adults to support work-force generation.

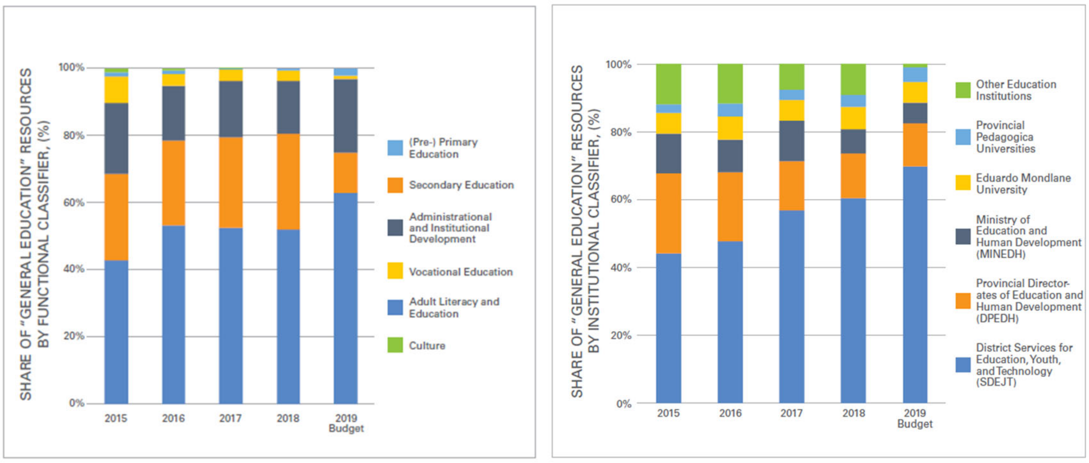


Figure 3-67 SDEJT's allocation of school construction budget

Source: Unicef, Budget Brief: Education Mozambique 2019

Compulsory education and systems in Mozambique are regulated by the National Education System Law (SNE). Complete Primary Education, which was initially set at seven years (Law No. 6/1992), was revised in 2018 (No. 18/2018) to extend the period of free and compulsory education to nine years (six years of primary education and three years of secondary education). The revision also includes development of a continuous education system with six stages; pre-school education, general education (compulsory education), adult education, professional education, teacher training, and higher education. This was done in line with the Southern African Development Community (SADC)'s Protocol on Education and Training and African Union's Continental Education Strategy 2016-2025 recommending the adoption of a 9- or 10-year basic education system and due to the need for equal educational opportunities for citizens of different ages.

Considering past disasters, in October 2021, the Ministry of Human Resources Development and the Ministry of Public Works, Housing and Water Resources jointly developed the "Guidelines on Natural Disaster Recovery, Environmental and Social Safeguards in School Construction" [25]. The guidelines provide zoning map for four types of natural hazards (cyclones/gale force winds, floods/flooding, droughts, and earthquakes) which each evaluated into with four levels depending on the level of external loads on buildings. The guidelines suggest that these forces should be taken into account when selecting a school site and structural designing. It also requires that all parties involved in site selection, damage analysis of existing facilities (in the case of post-disaster or retrofitting), design, and construction be held accountable for the level of technology involved,

[25] Guidelines on Natural Hazard Resilience, Environmental and Social Safeguards for School Buildings,

that construction be responsible for the environment, sanitation, health, and safety of the surrounding community, and that construction materials be inspected. It aims to improve overall quality of educational facilities.

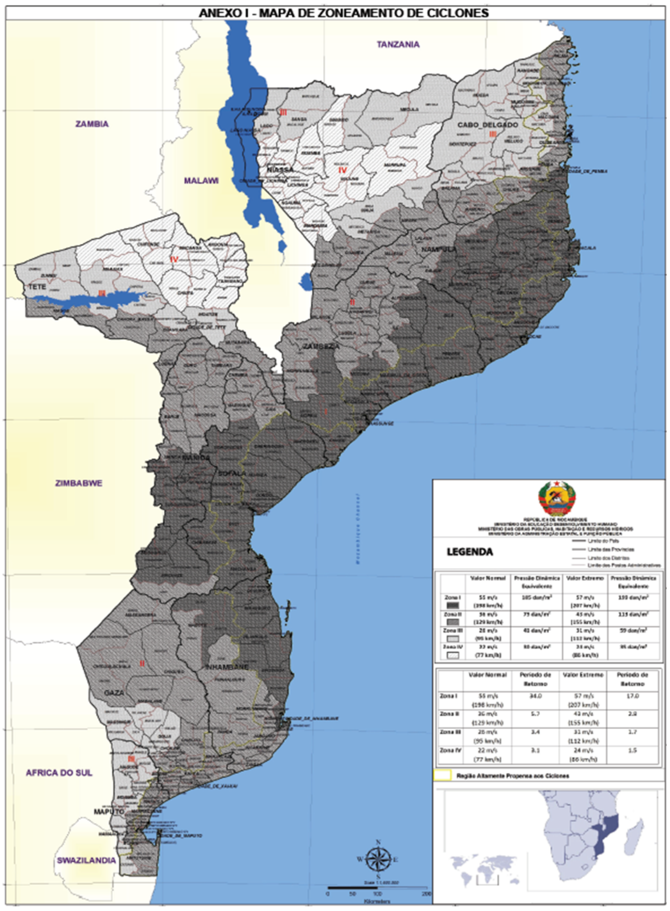


Figure 3-68 Zoning (for cyclones and high winds)

Source: Guidelines on Natural Hazard Resilience, Environmental and Social Safeguards for School Buildings (Diploma Ministerial n.º 122/2021

Table 3-36 Zoning setting values (for cyclone and high wind)

Zone	Intensity Grade (Mercall Scale)	Average values of horizontal seismic acceleration in g computed for 10% probability of excellence in 50 years
I	VIII	0.163 – 0.244g
II	VII	0.040 – 0.163g
III	VI	<0.040g

Source: Guidelines on Natural Hazard Resilience, Environmental and Social Safeguards for School Buildings (Diploma Ministerial n.º 122/2021

2） Overview of Related Plans and Development Status

In the education sector of Mozambique, the Support Fund for the Education Sector (FASE), a trust fund, was established in 2002 in line with the sector-wide approach, with the following three goals

1) Ensure equitable access to education and continuing education for all.
2) Ensure the quality of learning.
3) Ensure open, inclusive, and effective education administration.

Since its establishment, FASE has provided approximately 9% of the national budget for the education sector (approximately USD 800 million) every year, totaling approximately USD 1.5 billion, and reports and shares the results of its activities at the Annual Review Meeting (RAR).[26] Eleven organizations are members of FASE: Germany (chair), Portugal, Canada, France, Finland, Italy, Ireland, EU, World Bank, UNICEF, Global Partnership for Education[27], and ILO, UNESCO, USAID, UNFPA, etc. are also providing support activities in the field of education. In addition, in the implementation of PEE 2020-2029, a new MoU was signed in Maputo in July 2021 between the government of Mozambique and the supporting partner organizations to provide support in the education sector, which will contribute to the FASE.

Poverty Reduction Action Plan 2011-2014 (PARP)[28] published by IMF identifies human and social development, including education, as one of the top priority target for comprehensive economic growth and poverty reduction. Its strategic policies include universal access to primary education for basic academic skills and expanding post-primary educational opportunities for youth and adults to acquire life skills.[29]

[26] Mouzinho Mário et al. 2020, The education sector in Mozambique

[27] Minister for Foreign Affairs of the Republic of Finland HP

[28] The PARP 2011-2014 is the latest version in February, 2022

[29] PARP Progress Report published (IMF 2014) evaluates the accomplishment with two criteria: the net enrolment rate of children aged 6 and the student-teacher ratio; and concluded that the target will be fully achieved or attainable by the end of the planning period.

Table 3-37 International Assistance History

Project Name (Project ID/Code)	Donored by	Commitment USD	Project Cost USD	Status	Period			Abstract
Improving Learning and Empowering Girls in Mozambique (WB-P172657)	WB	160,000,000	299,000,000	Active	2021.3	－	2025.12	・improves learning outcomes during the first three years of primary schooling ・improves girls' retention and transition to upper grades of basic education.
Additional Financing for the Education Sector Support Project (WB-P160959)	WB	59,000,000	59,000,000	Active	2017.6	－	NA	Continuous support for the Education Sector Support Project.
Development of a Safer School Program in Mozambique (Global Program for Safer Schools, GPSS)	WB, Gov. of Japan	1,450,000	－	Closed	2017.1	－	2019.1	・help integrate risk considerations into the resilience of school buildings (finding a balance between constructing new safe school infrastructure and retrofitting of existing schools); ・assessment of existing safe school infrastructure and its exposure to natural hazards ・future education infrastructure needs.
MZ - Emergency Resilient Recovery Project (WB-P156559)	WB	40,000,000	40,000,000	Closed	2015.9	－	2021.11	Restores the functionality of critical infrastructure and to improve the GoM's capacity to respond promptly and effectively to an emergency. (a) resilient infrastructure rehabilitation (dikes, irrigation, water supply, education infrastructure); (b) technical assistance for resilient recovery and vulnerability reduction (implementation of resilient school construction, capacity strengthening for DRM, and study on watershed management); (c) project implementation, monitoring and evaluation for MOPHRH and MINEDH
Mozambique Additional Financing to Education Sector Support Project (WB-P151185)	WB	50,000,000	107,900,000	Active	2015.7	－	NA	Continuous support for the Education Sector Support Project.
Reducing Disaster Risk through Safe and Child Friendly Schools in Hazard Prone Areas of Nampula Zambezia	UNICEF	96,000	－	Closed	2014	－	2015	(a) Carries out post-damage field assessments in more than 20 schools located in hazard prone areas; (b) conducts one provincial training on Safe School Construction and DRR in Schools (c) incorporates Safe and Child Friendly School Standards elaborated by UNICEF worldwide, into the didactical material; (d) conducts the third "Safer School" workshop in Maputo; (e)includes recommendation on safe and child safe schools into schools Council Manual
Developing Guidelines on School Safety and Resilient School Building Codes, Mozambique (Safer Schools Project)	WB	185,735		Closed	2012.8	－	2013.12	This project is an initiative supported by the WB, GFDRR, MINEDH MOPHRH, and MAEFP through INGC who in 2011, mobilized the technical partnership in response to disasters that affected more than 1,000 classrooms in of Maputo, Gaza and Zambezia Provinces, during the end 2011 and early 2012. The project aims to provide guidance on the safety of schools in Mozambique based on the reality of the country and promote construction methods for resistant schools.
MZ- AF to Education Sector Support Project (ESSP II) (WB-P124729)	WB	40,000,000	40,000,000	Active	2012.5	－	NA	Continuous support for the Education Sector Support Project.
MZ-Education Sector Support Program (WB-P125127)	WB	71,000,000	161,000,000	Closed	2011.4	－	2019.12	Trains teachers (pre-service and in-service), improve teaching practices, update the curriculum, increase availability of textbooks, and improve local school management capacity and access to resources were likely to contribute to the objective to improve quality of education, particularly at the primary level.
Mozambique Education Sector Support Program Fast Track Initiative Catalytic Fund (WB-P112052)	WB	－	79,000,000	Closed	2008.8	－	2010.12	Objective: To improve the access, quality and equity of primary and secondary education by supporting the implementation of the Government's Strategic Plan for Education and Culture 2006-2011.
Mozambique - Education IV Project (ITAI ID: 46002-P-MZ-IA0-006)	AfDB	9,662,577	－	Closed	2001	－	2011.5	Background: ESSP activities are expected to help to lowering repetition and drop-out rates and increasing the number of primary graduates seeking secondary education. Objective: Improves access, efficiency and quality of lower secondary and technical/vocational education. (a) helps to decrease repetition and drop-out rates through the use of qualified and effective teachers, appropriate textbooks; (b) helps suitable mechanisms for monitoring the dynamics of the labour market; (c)rehabilitates 6 lower secondary schools and construct 2 new ones; (d) contributes to the streamlining of educational management by strengthening a number of decentralized structures.
Mozambique - Education III Project (ITAI ID:46002-P-MZ-I00-001)	AfDB	11,319,318	－	Closed	1998	－	2008.12	follows-up to two earlier similar projects in the sector. focuses on the primary teacher education to be able to cope with the growing number of schools with a view to improving the quality of basic education, especially in deprived rural areas.
Education Sector Strategic Program (ESSP) (WB-P001786)	WB	71,000,000	72,000,000	Closed	1992.2	－	2006.6	Provides increased and equitable access to higher quality education through improvement in the management of education. (a)improves the quality of education (pre-service teacher and director training and network; curriculum for grades 1-7; teaching materials; classroom assessment); (b) improves access to education and equity (the number of places, improving girls' initiatives, non-formal and special education); (c) strengthens the institutional capacity of the MINEDH; (d) develops a strategy for operating the higher education systems
Mozambique - Education II Project	AfDB	13,838,454		Closed	1992	－		
Education Project (02) (WB-P001776)	WB	53,700,000	67,900,000	Closed	1990.12	－	1998.12	(a) improving the quality and efficiency of primary education (school construction and maintenance capacity, training for pre- and in-service teachers, new initiatives for effective learning (local language instruction, testing, reading materials, extramural programs, and student health interventions)); (b) improving the quality and efficiency of University Eduardo Mondlane; (c) improving Ministry of Education's managment of education sector.
Mozambique - Education I Project (Primary Teachers Training) (ITAI ID: 46002-P-MZ-IAB-001)	AfDB	8,063,030	－	Closed	1989	－	2003.12	(a) Primary Teachers Training Centres PTTC; (b) Development of Teaching Materials; (c) Strengthening the management capacity of the Project Implementation Unit (PIU).
Education Project (01) (WB-P001763)	WB	15,900,000	NA	Closed	1988.5	－	1995.12	Designed within the context of Mozambique7s Economic Rehabilitation Program. (a) improve the quality and efficiency of parimary education in the city of Maputo (improving school facilities, training for school managers and principals, provision of essential school supplies); (b) improving the quality and relevance of financial experts; (c) improving planning and management of education sector.
Education II - Studies (ITAI ID: 46002-P-MZ-IA0-002)	AfDB	916,218	－	Closed	1986	－	1995.12	A pre-investment secondary schools study for the rehabilitation of secondary schools in four prioity districts: Buzi, Nhamatanda, Manica and Gondola.

Source: extracted from WB Website Projects & Operations, AfDB Projects and Operations and UNHabitat Mozambique Projects

Educational facilities in Mozambique have been damaged by cyclones and floods caused by heavy rains every year, and the typical natural disasters shown in the table below alone have damaged an average of about 1,000 classrooms every year since 2012 (excluding Cyclone Idai would be about 650 classrooms).

Table 3-38 History of Natural Disasters in Mozambique

Year	Natural Disasters	Affected Areas	Deaths	Affected Pople	Damaged Houses	Damaged Classrooms	Damaged Health Facilities
2012	Tropical Storm Dando, Fundo, and Irina	Nampula, Zambezia, Inhambane, Gaza, and Maputo Province	44	108,048	28,000	735	31
2013	Inundation caused by heavy rain	Maputo City, Gaza, Zambezia Inhambane, Nampula, Niassa and Cabo Delgado Provinces	—	420,000	20,000	600	3
2015	Inundation caused by heavy rain	Zambézia, Nampula and Niassa	—	160,000	19,600	2,084	5
2017	Cyclone Dineo and following heavy rain	Inharrime, Massinga, Maxixe, Morrumbene, Vilanculos, Panda, Zavala, and Gaza	7	750,000	60,000	2,000	70
2019	Cyclone Idai	Zambezia,Tete, Sofala, Manica,	603	1,850,000	240,000	3,500	62
	Cyclone Kenneth	Cabo Delgado	45	374,000	45,300	480	
2020	Tropical Storm Chalane	Sofala	2	10,930	2,595	169	11
2021	Cyclone Eloise	Sofala, southern Manica, northern Inhambane, Zambezia and eastern Gaza	11	250,000	8,000	400	76

Source: Retrieved from Reliefweb past articles

In 2019, Cyclone Idai affected 3,582 classrooms (of which 2,713 were in Sofala Province), affecting more than 335,100 children's education and more than 7,830 teachers[30]. Due to the occurrence of strong winds of up to 220km/h accompanied by torrential rain, the main damage to buildings concentrated on the roofs and windowpanes. In Beira City, Tete City, Buzi, Mafambisse and Estaquinha, seven schools were used as shelters for 4,987 people evacuated delaying the restoration and resumption of educational functions. Damages caused by Cyclone Idai spurred on the demand for new school infrastructures with disaster mitigation measures, in addition to the 38,000 classrooms which were already in need before the disaster. In light of this, after Cyclone Idai, an Education Cluster was organized under the leadership of DPEDHS (District Education Department), UNICEF and Save the Children, which has been playing a proactive role in coordinating overall efforts to restore the education environment and working with MINEDH to develop the "Education Sector Preparedness, Response and Recovery Strategy for Emergencies (2020-2029)" (3rd draft ver. as of February 2020). The list of affected schools and the availability of support donors has been updated by DPEDHS and shared with the Education Cluster. Disaster risk reduction support for educational facilities has been provided mainly for the reconstruction, repair, and new construction of school facilities, the creation of standard designs for buildings with disaster countermeasures, and the creation of disaster countermeasure manuals for elementary schools.

[30] OCHA MOZAMBIQUE: Cyclone Idai & Floods Situation Report no.22
Some statistics show that 1,372 school facilities and 4,219 classrooms were damaged. (Mozambique Cyclone Idai Post - Disaster Needs Assessment (PDNA)DNA)

In terms of support for disaster education and school management, a disaster response plan (PEBE, Plano de Emergência Básico para a Escola) is being implemented by Unicef and UN-Habitat. This is a manual for schools and school district communities to prepare for natural disasters and to plan the after-response. It has been implemented in Gaza, Nampula, and Zambezia districts as of 2017, WeWorld-GVC implemented in 16 schools within 5 districts from 2020 to 2021[31], Emergency Education Program 2020-2021 funded by Global Partnership for Education implemented in 300 schools. This manual does not assume to use the schools for mid- to long-term evacuation after disasters.

Currently ongoing Project on Strengthening Resilience in Cyclone IDAI-Affected Areas includes establishment of evacuation plan, which individual district follows by timeline action plan and disaster-response drill, which are aimed to minimize human and assets damages by evacuating/removing them in the most efficient manner in prior to the occurrence of natural disasters. In forming the evacuation plan, primary and secondary school buildings are considered as options for evacuation sites, considering its scale, resilience of the building, connection to the local community and forementioned cases of evacuees rushing into the schools. Therefore, it is desirable to improve the PEBE by assuming schools will be required to function as a shelter before, during, and after a disaster.

The Safer Schools Program (2011-2012) has been implemented by MINEDH in cooperation with UN-Habitat as a representative initiative for facility rehabilitation and tangible elements. The project supported the revision of building regulations to strengthen school construction in Mozambique by conducting a survey of schools damaged by natural disasters, preparing hazard maps for all of Mozambique for natural disasters (floods, cyclones, droughts, and earthquakes) and guidelines for the development of facilities for primary education in response to each disaster. In 2017, MINEDH requested US $1.5 million in World Bank technical assistance from UN-Habitat for the reconstruction and renovation of about 1,100 classrooms in central and northern Mozambique. The government of Mozambique has decided to apply the school building standards and designs developed with UN-Habitat for future school construction, as there was no damage to these Safer Schools standard facilities during the aforementioned devastating Cyclone Idai and Cyclone Kenneth disasters in 2019.[32]

[31] https://www.info-cooperazione.it/2021/04/weworld-education-in-emergency-specialist-mozambico/#

[32] 13/10/2019, "UN-Habitat's standards-built schools survived Mozambique's Cyclone Idai", UN-Habitat, Retrieved from URL: https://unhabitat.org/un-habitat%E2%80%99s-standards-built-schools-survived-mozambique%E2%80%99s-cyclone-idai

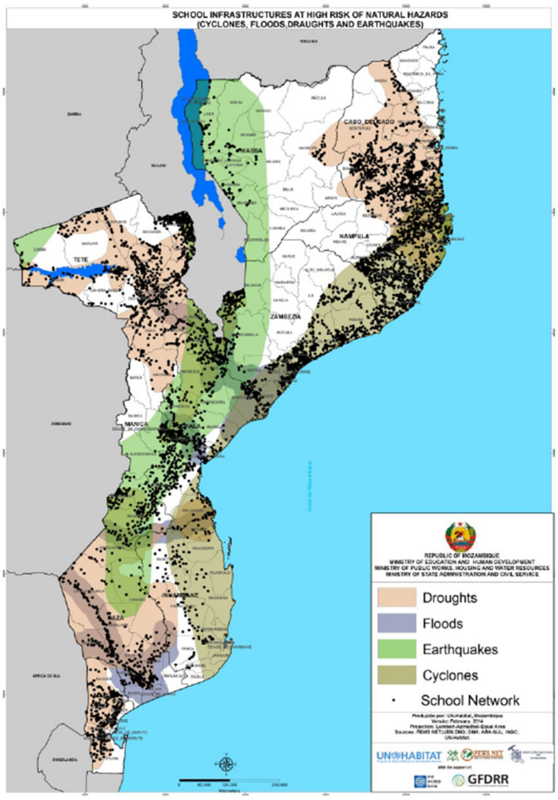


Figure 3-69 Distribution of education-related facilities and hazard map

Source: UN-Habitat, Safer School, 2015

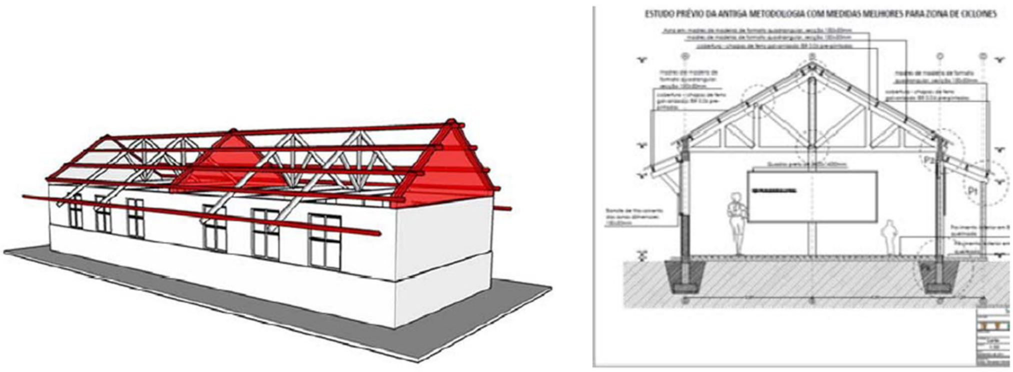


Figure 3-70 Illustration of reinforcement of school facilities

Source: UN-Habitat, Safer School, 2015

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

a) Policy on Managing Educational Facilities in Maputo

The most damaging natural disaster to buildings in Maputo is inland water inundation, which tends to last for several days in some areas even with little rainfall. In addition, most of the existing elementary school were built at a rapid pace in the 1970s and 1980s after the country's independence. Due to the growing population in Maputo, the only sites that were available for building new schools concentrated in lowlands and swamps. As a result, even a small amount of rainfall causes water to accumulate on school grounds, and with poorly functioning water and sewage systems, the schools are forced to close temporarily. What smore, due to the lack of drainage systems, the flood and the closure of schools tends to be prolonged.

Recognizing the vulnerability of the existing school buildings, the Department of Education and Human Resources Development of Maputo City has been rebuilding about two schools every year since 2012, giving priority to those schools that are severely damaged by flooding.

Table 3-39 Top priority list for rebuilding

Nº	Escola	Distrito	Bairro
1	Escola Primária Completa Unidade 24	KaMaxakene	Maxaquene
3	Escola Primária Completa FPLM	KaMaxakene	FPLM
4	Escola Primária Completa Mavalane A	KaMavota	Mavalane A
5	Escola Primária Completa Magoanine B	KaMubukwana	Magoanine B
6	Escola Secundária Unidade 30	KaMubukwana	25 de junho

Source: Courtesy of the Department of Education and Human Resources Development, Maputo City.

Although the Ministry of Education recommends single-story standard model of Safer Schools, for primary and secondary schools, Maputo City has devised its own standard design model of two to three stories, given the shortage of land caused by the accelerating concentration of population. In Maputo's standard model, the entire school site is filled with soil and drainage ditches are built around the school in consideration of the surrounding area. The school building itself was designed to have a U-shape for stability, and the center of the building is used as a plaza for students to relax. The outdoor playground is large enough to accommodate a variety of sports. (From an interview with the Department of Education and Human Resources Development, Maputo City)

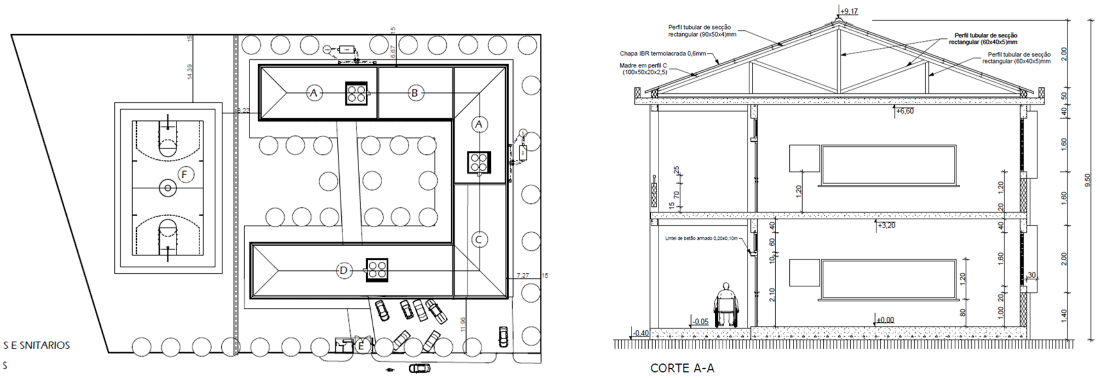


Figure 3-71　Maputo standard model (left: layout, right: cross section)

Source: obtained from Directorate of Education and Human Development in Maputo City

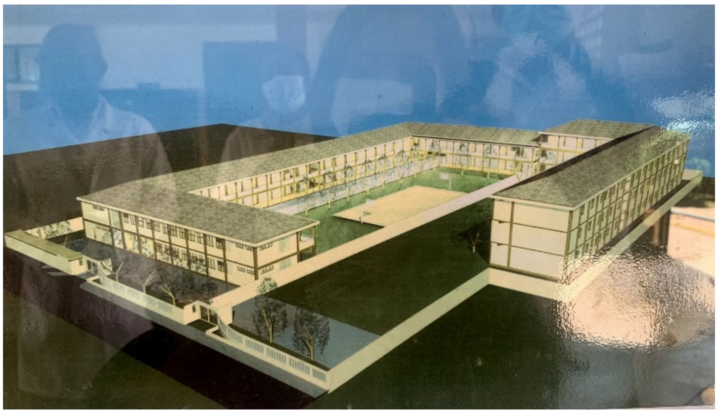


Figure 3-72　Integrated primary and secondary school using Maputo standard model

Source: obtained from Directorate of Education and Human Development in Maputo City

No damage from flooding or other natural disasters has been observed in school buildings that adopted the Maputo standard model since 2012. In addition, there have been no evacuations of nearby residents, and even if they were to evacuate due to flooding, they would do so at the Bairro Center, not at the school. Therefore, as of December 2021, Maputo City does not consider using the schools as evacuation sites. However, the Maputo Standard Model was designed with flood control in mind, and it will be necessary to carefully examine whether the model is designed to withstand multi-decadal rainfall and other natural disasters.

b)　Policy on Managing Educational Facilities in Beira

In Sofala Province, 2,713 schools were affected by Cyclone Idai and another 1,027 schools by Cyclone Eloise. The Beira city has reconstructed and restored 680 schools so far, but due to recurring natural disasters leaving another damage, reconstruction and restoration stay far behind.

The city of Beira has identified 67 schools in particular as being particularly vulnerable to the cyclone, but due to lack of budget and manpower, there is no plan in place to repair and rebuild them (Beira city adopts the Safer School Standard recommended by the Ministry of Education). However, from the survey conducted in the Project on Strengthening Resilience in Cyclone IDAI-Affected Areas, it was found that many donors were considering supporting the affected schools, therefore reconstruction of damaged schools is excluded from proposal list in chapter 4.

When a school is affected by natural disasters, the number of students who drop out of school tends to increase significantly due to a drastic deterioration in the learning environment and the financial difficulties of the family. Therefore, the Beira city has made it a priority to prevent students from dropping out of school through a free school lunch program by UN, provision of 'dignity kits' (feminine hygiene products), and establishment of a psychological support system for students (TOT for teachers). (From an interview with the Department of Education and Human Resources Development, Beira City)

4) Consideration of Disaster Risk Reduction Measures

Maputo City has been rebuilding existing primary and secondary schools at a rate of several schools per year as a countermeasure against damages caused by inland water flooding. In view of the shortage of land due to population concentration, the Maputo standard model (two to three stories) has been adopted, and a priority list of schools that need to be rebuilt has already been considered. At this time, there are no reports of damage to schools that have already been rebuilt, and the MINEDH of Maputo City is not considering further strengthening, so it is difficult to make a case for simply supporting the rebuilding of educational facilities.

In the case of Beira City, due to repeated cyclone damage, there is no prospect of repairing or rebuilding, and the unrepaired condition tends to be prolonged, but since the field survey revealed that various donors are already considering providing assistance, no proposal is considered in this field.

(7) Health Service

1） Overview of Relevant Organizations and Legal systems

Insurance development policy in Mozambique is under the jurisdiction of the Ministry of Health (MISAU, Ministério da Saúde). Due to the promotion of decentralization, provincial health departments and district health directorates (DPSs) have been established in local areas. The provincial health department has considerable independent authority over health care policy.

The main management and implementation agency for health service delivery at the central level is DNAM, while the National Directorate of Public Health (DNSP) manages the SMI, SSR, nutrition, etc in a vertical program. The management and execution of cross-cutting areas and activities related to health care at the central level involves other bureaus of the MOH, such as Department of Administration and Finance (DAF), Directorate of Planning and Cooperation (DPC), and Directorate of Human Resource (DRH), as well as subordinate agencies such as the National Institutes of Health (INS) and Medical Research Center (CMAM). The DPC is responsible for sector-wide orientation and planning, the DNSP for the development of public and community health programs and activities (health promotion and prevention), and the DRH for the strategic orientation of the sector's human resource development and management.

In terms of medical services, the central hospital is at the top, followed by provincial hospitals, district hospitals, health centers and health posts. However, there is a shortage of human resources in health centers and health posts, and residents use hospitals directly. As a result, hospitals have been found to be overwhelmed with primary medical services and unable to provide high-quality medical services, and the referral system (patient referral and transfer system) is not functioning as it should.

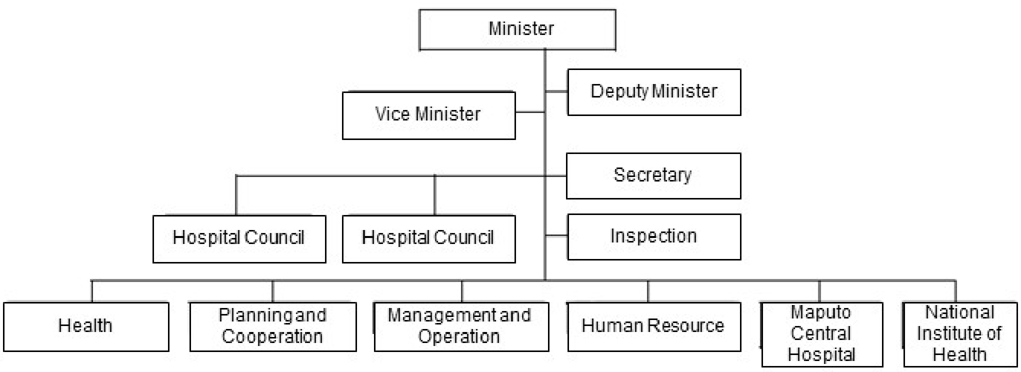


Figure 3-73 Ministry of Health organization chart

Source: JICA, Basic design study report on the project for improvement of the Institute of Health Science of Quelimane in the Republic of Mozambique, 2004

Table 3-40 Establishment standards and services of health facilities

Level	Facility		Standard	Service
Fourth	Central Hospital Specialized Hospital		▪ More than 400 beds ▪ More than 30 doctors ▪ More than 200 staffs	Provides the highest level of medical services and function as the educational hospital for the university
Third	Provincial Hospital		▪ 200-300 beds ▪ 5-10 doctors ▪ 50-80 staffs	Provides the highest level of medical services in the state
Second	Regional Hospital General Hospital		▪ 75-120 beds (surgical and obstetric equipment, various clinical tests, X ray equipment) ▪ 40 basic to mid level staffs per doctor	Provides assistance and referral services to primary facilities and surgeries
First	Health Center (Urban)	3	▪ No bed ▪ 1-3 beginner level staff	Family planning, immunizations, health promotion, outpatient treatment
		2	▪ 2-10 beds ▪ 4-5 beginner/basic level staffs	Family planning, immunizations, health promotion, outpatient treatment, maternal and child health,
		1	▪ 10-40 beds ▪ 10-20 beginner/basic level staffs	Family planning, immunizations, health promotion, outpatient fundamental treatment, maternal and child health,
	District Hospital		▪ 40 beds ▪ 20 beginner/basic/mid-level staffs	Family planning, immunizations, health promotion, outpatient fundamental treatment, maternal and child health,
	Health Center (Rural)	3	▪ No bed ▪ 1-3 beginner level staff	Family planning, immunizations, health promotion, outpatient treatment
		2	▪ 2-10 beds ▪ 4-5 beginner/basic level staffs	Family planning, immunizations, health promotion, outpatient treatment, maternal and child health,
		1	▪ 10-40 beds ▪ 10-20 beginner/basic level staffs	Family planning, immunizations, health promotion, outpatient fundamental treatment, maternal and child health,
	Health Post		▪ 1 beginner level staff	Family planning, immunizations, fundamental treatment

Source: JICA, Basic design study report on the project for improvement of the Institute of Health Science of Quelimane in the Republic of Mozambique, 2004

Table 3-41 Distribution of Health Facilities in Mozambique 1995-1997

Health Facility	Year	Total	Niassa	C.Dlgdo	Nmpula	Zmbezia	Tete	Manica	Sofala	Inhmbn	Gaza	Maputo	C. Mapt
Hospitals	1995	27	1	3	3	3	2	0	4	2	4	2	3
	1996	39	2	4	5	4	3	1	4	3	5	3	5
	1997	43	2	4	6	4	4	1	5	3	5	4	5
Health Centers	1995	240	12	16	45	22	26	15	19	45	11	13	16
	1996	236	13	16	42	22	26	15	16	45	11	14	16
	1997	277	15	43	45	24	30	14	18	47	11	14	16
Health Posts	1995	679	76	63	89	126	49	61	76	21	59	45	14
	1996	727	86	64	104	126	50	61	99	23	60	40	14
	1997	734	90	37	106	138	50	60	98	26	69	43	17

Source: JICA, Report of the Southern African Aid Study Group, Volume 3, Supplement, 2000.

In the healthcare sector, the National Development Strategy 2015-2035 lists support and intervention in human resource development as a pillar of the strategy and the goal of the National Five-Year Plan (2000-2004) of the Government of Mozambique is the economic and social development of the country and the lifting of the people out of poverty. The Action Plan for the Reduction of Absolute Poverty (PARPA) for 2001-2005 recognizes that it is essential to raise the standard of service in the medical system to reduce poverty and sets forth the following policies: 1) Improvement of the primary health care level; 2) Improvement of the health system to overcome endemic diseases; 3) Treatment of HIV/AIDS, 4) Networking of medical facilities; 5) Development of human resources, and 6) Strengthening of activity planning and management in the health sector.

Based on this, the Ministry of Health has formulated the Strategic Plan for Health Sector (PESS) 2001-2019, which aims to improve national health services by (1) Expanding health services; (2) Strengthening individual and community responsibility for health; and (3) Strengthening the administrative and management capacity of the health sector. In 2020, the Minister of Health announced that 49 new provincial hospitals will be built during the current term of office (2020-2024) to improve healthcare services for approximately 7.62 million people.

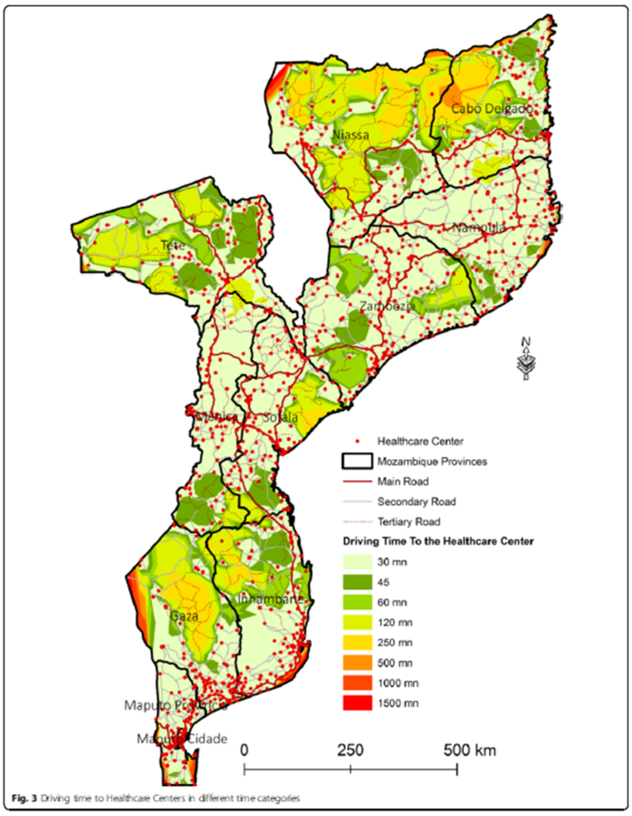


Figure 3-74 Access time to health care center

Source: Geographic accessibility to primary healthcare centers in Mozambique, International Journal for Equity in Health, 2016.

The following laws and regulations have been enacted in the health sector in Mozambique, but the Ministry of Health has not responded at this time as to whether or not there are any regulations or standard designs for boosting the resilience of health care facilities. In addition, in December 2020, UN-Habitat launched "Safer Hospitals: Post-Disaster Reconstruction and Construction Guidelines on Safer and Gender Sensitive Health Facilities in Mozambique" with the financial support of the Canadian government. [33]However, no further information could be confirmed through an internet survey.

- Ministerial Diploma 19/1991: Establishment of the National Institute of Hygiene, the National Institute of Food and Water Sanitation, and the National Institute of Drug Quality Control

[33] United Nations Mozambique HP : https://mozambique.un.org/pt/106899-reconstrucao-de-hospitais-resilientes-e-inclusivos-pos-desastres-em-mocambique

- Law 25/1991: Establishment and Operation of the National Health Service
- Law 3/2006: Establishment and Operation of the Medical Association
- Resolution 73/2007: Regulation on the Rights and Obligations of Patients
- Resolution 16/2008: Regulation on International Medical Insurance
- Ministerial Diploma 45/2009: General Laws for Hospitals
- Law 24/2009: Approval of the Law on Private Medical Practice Management

2) Overview of Related Plans and Development Status

In the health sector, a sector-wide approach is also being taken, and PROSAUDE (Mozambique's Common Fund of Support for the Health Sector) has been established, with USAID as the chair and Canada, EU, UK, Netherlands, Denmark, Germany, Belgium, Ireland, France, Italy, WB, Global Fund, WHO, UNFPA, UNICEF, and GFF as international cooperation partners. Thematic subgroups meet regularly for coordination among governments and donors. As it allows for spending in line with government policy, it helps secure funding for high priority programs such as human resource development for the health sector, and has been used to pay for any shortfalls in the national personnel budget due to increased health personnel. In addition to general financial support, there is also significant individual and direct support per project, and among these, the amount of support specific to HIV/AIDS is particularly large. In the healthcare sector, in addition to PROSAUDE, there is also the Vertical Project Fund, which provides support for specific projects implemented by the government.

The Poverty Reduction Action Plan 2011-2014 published by IMF identifies human and social development, as one of the top priorities for inclusive economic growth and poverty reduction. It lists the promotion of equitable access to health care as a strategic policy, including the expansion of childcare systems, nutrition monitoring for prevention and treatment, professional development to combat HIV/AIDS, promotion of food and hygiene practices, and linkages between communities and health care facilities. [34]

[34] PARP Progress Report published (IMF 2014) evaluates the accomplishment with two criteria: Institutionalized childbirth usage rate, immunization rate of infants under one year of age, and the number of specific medical personnel trained; and concluded that the target will be fully achieved or attainable by the end of the planning period.

Table 3-42 International Assistance History

Project Name	Donored by	Commitment	Status	Starting	Closing
Mozambique - Health II Project	AfDB	7,511,794	Closed	2000	
Mozambique - Beira Corridor Health Project	AfDB	6,424,132	Closed	1996	
Health Study	AfDB	200,718	Closed	1991	
COVID-19 Strategic Preparedness and Response Project	World Bank	115,000,000	Active	2021.6	2024.6
Mozambique Primary Health Care Strengthening Additional Financing	World Bank	90,159,335	Active	2019.2	
Mozambique Primary Health Care Strengthening Program	World Bank	930,000,000	Active	2017.12	2023.12
Social Accountability Knowledge, Skills, Action and Networking	World Bank	700,000	Closed	2013.12	2018.12
Mozambique Nutrition Additional Financing	World Bank	37,000,000	Closed	2013.1	
Health Commodity Security Project	World Bank	39,000,000	Closed	2010.9	2014.6
Health Service Delivery Project	World Bank	44,600,000	Closed	2009.4	2017.12
HIV/AIDS Response Project	World Bank	64,000,000	Closed	2003.3	2011.6
Flood Emergency Recovery Project	World Bank	30,000,000	Closed	2000.4	2001.12
Health Sector Recovery	World Bank	239,100,000	Closed	1995.11	2003.8
Health and Nutrition Project	World Bank		Closed	1989.3	1997.6

Source: Extracted from WB Website Projects & Operations, AfDB Projects and Operations.

Hospitals and other medical facilities have a large number of users such as inpatients, outpatients, visitors, and medical personnel. [35]In addition to general patients, it is necessary to accept patients injured by disasters, victims of Sexual and Gender Based Violence (SGBV), which rapidly increases after disasters, and patients with infectious diseases caused by unsanitary environments. While the need for medical services is high on a daily basis, the demand for such services increases in times of disaster, and medical facilities must still be able to function properly after a disaster. In addition, medical facilities are expensive to build because they handle a lot of precision equipment and require special consideration in the design of the facility itself. Therefore, in order to ensure that their functions are not compromised in the event of a disaster, facilities need to be strengthened, systems need to be established to ensure that medical services reach patients to the maximum extent possible, and all staff need to be trained to respond quickly to disasters.

When Cyclone Idai made landfall in Mozambique, 89 medical buildings were damaged, three collapsed, and two medical training facilities were damaged [36]. Of the 173 facilities under the jurisdiction of MISAU and DPSS in Sofala Province, four were completely destroyed, 63 were

[35] UN Resident Coordinators, Flash Appeal – Cyclone Dineo, 2017

[36] Post Disaster Needs Assessment – Mozambique Cyclone Idai, 2019

partially destroyed [37], and the damaged areas were reported to be mainly in the roofs [38]. In the Beira city, more than 90% of the medical facilities were affected[39], which resulted in confirming 31,107 cases of malaria[40]due to the difficulty in obtaining sanitary water and food and the influx of people to the shelters, highlighting the importance of continued medical services.

In 2000, WHO and the Pan American Health Organization (PAHO) issued "Guidelines for Vulnerability Appraisal and Reduction in The Caribbean," a set of guidelines for disaster preparedness of health care facilities against high winds and earthquakes. This guideline defines the "CEN" criteria that categorizes the priorities of medical services and equipment into three levels for disaster preparedness: Critical, Essential and Non-Essential. Based on these priorities, a checklist of disaster countermeasures and daily maintenance items for medical facilities has been devised for easy use.

Table 3-43 Categorization of CEN

Category	Services	Equipment
Critical: services and equipment that are lifesaving and without which the patient’s life is at risk.	Accident and Emergency Operating Theatres Pharmacy Minimum number of beds	Ventilators Defibrillators Incubators
Essential: services and equipment which are needed to make a diagnosis or provide a unique form of therapy.	Radiodiagnosis Laboratory	X ray Units Patient Monitors Blood Gas Analyzers
Non-Essential: services and equipment which support diagnosis and therapy but for which there may be reasonable alternative equipment or methods available.	Physiotherapy Laundry Central Sterile Supplies Dietary	Diathermy equipment Washing machines Autoclaves

Source: PAHO and WHO, Guidelines for Vulnerability Appraisal and Reduction in The Caribbean, 2000

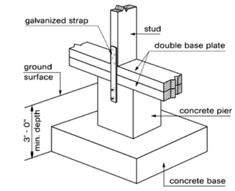
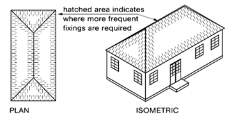
[37] There were many facilities that could not be accessed due to flooding or other reasons during the emergency assessment, and it was not possible to accurately assess the damage to all facilities. Health PDNA_Mozambique IDAI_Damage Loss and Needs tables_Health & Nutrition Sector _12 May 2019 (material provided by DPSS)

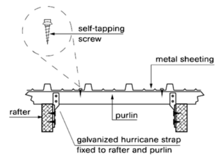
[38] From interviews with DPSs planning officers (February 2020)

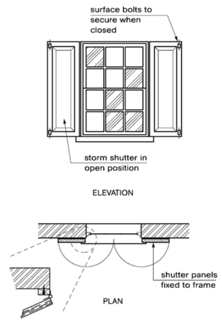
[39] https://www.directrelief.org/2019/12/cyclone-idai-destroyed-their-hospital-these-two-doctors-never-stopped-treating-patients/

[40] OCHA MOZAMBIQUE: Cyclone Idai & Floods Situation Report no.22

Table 3-44   Checklist of Mitigation Measures Against Strong-wind

<table>
<tr><th>Aspect</th><th>Disaster Prevention Measures</th><th>Illustrations</th></tr>
<tr><td>Wall</td><td>- Precast concrete construction: Tensioning with floor and roof
- Concrete block masonry: Ratio of block size to wall thickness specified; ties to floor and roof
- Concrete block masonry: Reinforcement with steel bars, ties to floors and roofs
- Wooden construction: Specification of dimensions of columns, beams, spacing columns and boards, and fixing to reinforced concrete foundation</td><td>
</td></tr>
<tr><td>Roof</td><td>- Concrete
- Light-weight plates (steel plates, aluminum plates, asphalt plates, etc.): Tensioning of roofing materials to purlins and rafters, installation of a waterproof layer, and reinforcement with push edges
- Others (stone, concrete, porcelain tile, etc.): Fixing to baseboards and tile piers
- Tensioning of trusses, rafters, and other roof framing to walls
- Specification of roof slope</td><td>

hip-roof


valley connection</td></tr>
<tr><td>Window</td><td>- Use of laminated glass (strength that will not be destroyed even if a piece of wood of 2 inches x 4 inches comes flying)
- Protection by shutters and storm doors (strong enough not to be destroyed by flying pieces of wood of 2 inches x 4 inches)
- Installation of louvers made of wood or aluminum
- Fixing windows, shutters, and storm doors to the structure</td><td>

Permanently installed shutters</td></tr>
<tr><td>Door</td><td>- Sliding type: Use of laminated glass, protection by shutters and shutters (strength that will not be destroyed even if a piece of wood of 2 inch x 4 inch comes flying), fixing of the frame to the structure, and securing of the rail depth
- Shutter type: Fix the frame to the structure and secure the rail depth.
- Others: Use of wood with appropriate strength, fixing of door and frame</td><td>—</td></tr>
</table>

Source: PAHO and WHO, Guidelines for Vulnerability Appraisal and Reduction in The Caribbean, 2000

However, responses from MISAU regarding whether these guidelines are consistent with the natural disasters expected in Mozambique, and whether they have been referred to and adopted any kind of guidelines like this as the policy or standard design for the health facilities in Mozambique were not obtained.

The content of international assistance and technical cooperation in the health sector is mainly focused on the improvement of medical technology and human resources that contributes to health services. This is aimed at improving the provision of health services that are in chronically short supply, and it is believed that the system is not yet ready to handle emergencies such as natural disasters. Given the potential for hospitals to be used as base of restoration and rehabilitation after disasters, education of disaster risk reduction and after-response are essential.

3) Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

a) Hazard Risk in Maputo city

Although there are no major natural disasters expected in Maputo City, it is known from the research in the field of education that the water does not recede easily even with a small amount of rainfall. The following figure shows the results of overlaying the locations of medical facilities obtained from the desktop survey and the hazard map (100-year probability) for reference, and the table below shows the inundation depth of each medical facility identified.

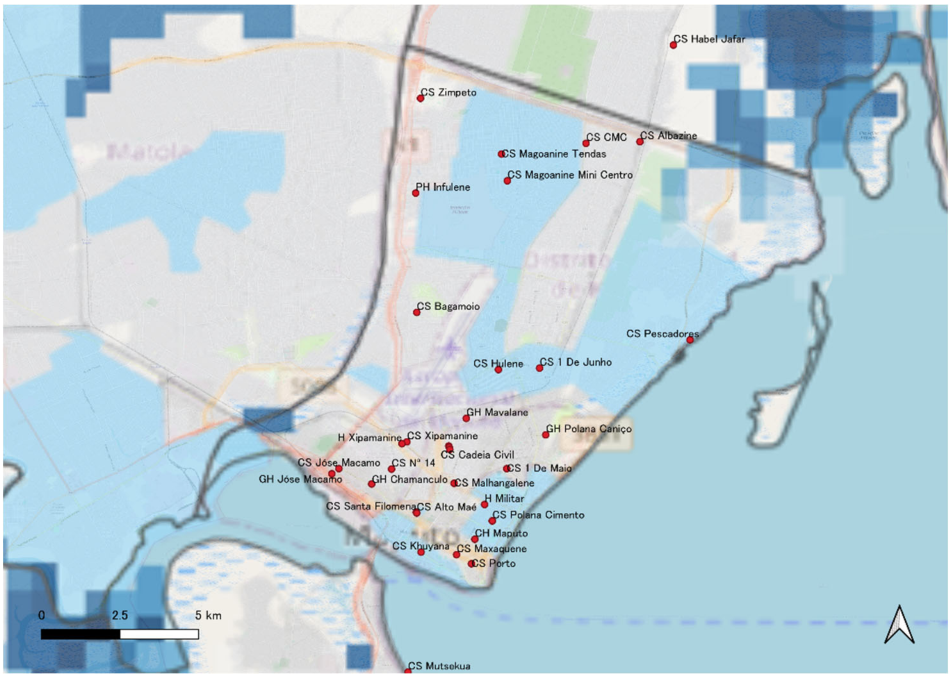


Figure 3-75 Health Facilities and Hazard Risk (100-year probability) in Maputo

Source: Hazard map described in Chapter 2, Background map from Open Street Map, Locations of health facilities plotted by the project team

Table 3-45 Inundation Depth of Each Health Facility in Maputo

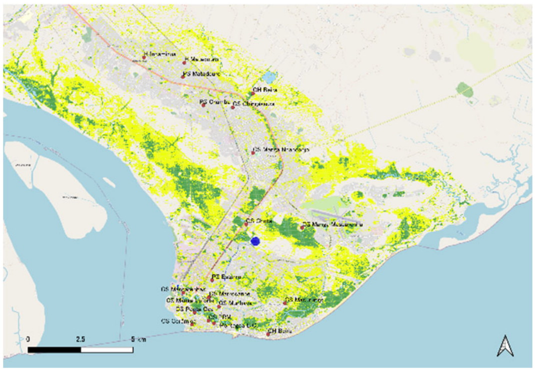
US (Health unit name)	CLASSIFICATION	Inundation	US (Health unit name)	CLASSIFICATION	Inundation
1 De Junho	Centro de Saúde Urbano A	0.0-0.5m	Pescadores	Centro de Saúde Urbano C	0.0-0.5m
1 De Maio	Centro de Saúde Urbano A	0.0-0.5m	Catembe	Centro de Saúde Rural I	—
Albazine	Centro de Saúde Urbano A	—	Inhaca	Centro de Saúde Rural I	—
Alto Maé	Centro de Saúde Urbano A	0.0-0.5m	Incassane	Centro de Saúde Rural II	—
Bagamoio	Centro de Saúde Urbano A	—	Muchina	Centro de Saúde Rural II	—
Benfica	Centro de Saúde Urbano A	—	Mutsekua	Centro de Saúde Rural II	—
J.Macamo	Centro de Saúde Urbano A	—	Santa Filomena	Centro de Saúde	0.0-0.5m
Malhangalene	Centro de Saúde Urbano A	—	Khuyana	Centro de Saúde	0.0-0.5m
Maxaquene	Centro de Saúde Urbano A	0.0-0.5m	CMC	Centro de Saúde	0.0-0.5m
Nº 14	Centro de Saúde Urbano A	—	Catembe	Hospital Central	—
Polana Cimento	Centro de Saúde Urbano A	0.0-0.5m	Infulene	Hospital Psiquiatrico	—
Porto	Centro de Saúde Urbano A	—	Mavalane	Hospital Geral	—
Xipamanine	Centro de Saúde Urbano A	—	J.Macamo	Hospital Geral	—
Zimpeto	Centro de Saúde Urbano A	—	Chamanculo	Hospital Geral	—
Hulene	Centro de Saúde Urbano B	0.0-0.5m	CH Maputo	Hospital Central	0.0-0.5m
Inhagoia	Centro de Saúde Urbano B	—	Hospital Militar	Hospital Militar	0.0-0.5m
Magoanine Mini Centro	Centro de Saúde Urbano B	0.0-0.5m			

Source: JICA Study Team

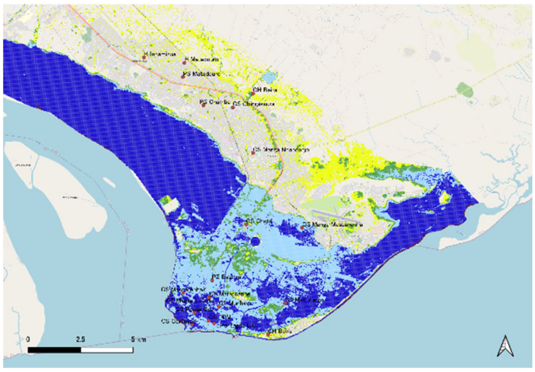
In Maputo, the maximum inundation depth is assumed to be 0.0-0.5 m, which indicates that flood control measures can significantly prevent the shutdown of health facilities.

b) Hazard Risk in Beira city

The hazard risk of Beira City was examined based on the hazard map made in the Project on Strengthening Resilience in Cyclone IDAI-Affected Areas The figure below (a) shows the case of rainfall equivalent to Cyclone Idai (occurrence is about once every 10 years), and (b) shows the case of rainfall equivalent to Cyclone Idai coinciding with spring high tide (occurrence is about once every 200-300 years). The storm surge during Cyclone Idai was about 1.8 m, and the frequency of occurrence in this case is assumed to be about once a year.



(a) Rainfall equivalent to Cyclone Idai (once every 10 years)



(b) Rainfall equivalent to Cyclone Idai + Spring High Tide (once every 200-300 years)

Figure 3-76 Health Facilities and Hazard Risk in Beira

Source: Hazard map described in Chapter 2, Background map from Open Street Map, Locations of health facilities plotted by the project team

Table 3-46 Inundation Depth of Each Health Facility in Beira

US (Health unit name)	CLASSIFICATION	(a) Cyclone Idai Rainfall	(b) Cyclone Idai Rainfall + Spring High Tide
Chamba	Posto de Saúde	-	-
Matadouro	Posto de Saúde	-	0.2-0.5m
Esturro	Posto de Saúde	0.2-0.5m	1.0-2.0m
Ponta Gêa	Centro de Saúde Urbano A	0.2-0.5m	2.0-5.0m
Munhava	Centro de Saúde Urbano A	0.2-0.5m	1.0-2.0m
Chingussura	Centro de Saúde Urbano A	-	-
Manga Nhaconjo	Centro de Saúde Urbano A	-	-
Macurungo	Centro de Saúde Urbano A	0.2-0.5m	1.0-2.0m
Manga Mascarenha	Centro de Saúde Urbano B	-	1.0-2.0m
Chota	Centro de Saúde Urbano C	0.2-0.5m	1.0-2.0m
Manga Loforte	Centro de Saúde Urbano C	0.2-0.5m	1.0-2.0m
Marrocanhe	Centro de Saúde Rural II	0.2-0.5m	2.0-5.0m
Cerâmica	Centro de Saúde Rural II	0.2-0.5m	2.0-5.0m
Mascarenhas	Centro de Saúde	0.2-0.5m	1.0-2.0m
PRM	Centro de Saúde	0.2-0.5m	1.0-2.0m
Matadouro	Hospital	-	-
Inhamizua	Hospital	0.2-0.5m	0.2-0.5m
Ponta Gêa B.O.	Hospital	0.2-0.5m	1.0-2.0m
Beira	Hospital Central	-	0.2-0.5m
Beira	Hospital Geral	0.5-1.0m	0.5-1.0m

Source: JICA Study Team

The estimated inundation depth in case (a) shows that most of the facilities will be flooded up to about 0.2-0.5 m except for inland facilities, indicating the necessity of disaster prevention measures against flooding.

c) Mitigation Measures for Health Facilities

For the consideration of disaster countermeasures applicable for health facilities, major items used in the BCP of general hospitals are evaluated in terms of maintenance of functions and effectiveness against floods and strong winds, as shown in the table below.

Table 3-47 Possible Challenges Caused by Disasters and Considerable Measures

Challenges	**Measures**	**Inundation**				**Strong Wind**
		0.0-0.5m	0.5-1.0m	1.0-2.0m	Over 2.0m	
Infrastructure	Legend ●: Effective Mitigation ▲: Effective in right term —: NA					
Inundation above floor	Right design floor level (Securing line of flow)	●	▲	—	—	—
	Setting Flood Control Line (Water Barrier, sandbag, etc)	●	▲	—	—	—
Inundation within the site	Installing Retention Basin (Surrounding or courtyard)	— (The purpose is to slow down the flooding)				—
Damage in infrastructure	Rehabilitation of roof	—	—	—		●
	Rehabilitation of openings	—	—	—		●
Lifeline	Legend ●: Effective Mitigation ▲: Effective within limit —: NA					
Loss of access to electricity	Fixing electrical facilities higher than the inundation level	●	●	●	●	—
	Securing emergency power generator	●	●	●	●	
Infunction of water	Securing water source by storing in tanks	●	▲	—	—	—
	Securing emergency sewage tanks (underground)	●	▲	—	—	—
Loss of telecommunication to external	Securing satellite communication (which gets hardly damaged by natural disasters)	●	▲	—	—	—
Loss of telecommunication internally	Securing alternative communication (ex. Transceiver)	●	▲	—	—	—
Medical Service	Legend ●: Effective Mitigation ▲: Effective within limit —: NA					
Loss of medical records	Digitalization of medical documents (Utilization of electrical system)	Operational measure (not infrastructural measure)				
	Securing safe place to store such documents	●	▲	—	—	●
Damages to medical equipment	Fixation to wall and floor	●	▲	—	—	●
Lack of medical materials and equipment	Securing emergency stocks	●	▲	—	—	—
Lack of spaces for medical personnel to stay	Securing resting rooms for the medical personnel	●	▲	—	—	●
Infunction of transportation means	Securing alternative means of transportation	Operational measure (not infrastructural measure)				

Source: JICA Study Team

If the inundation level is equal to or below the height of 0.5m, facilities can be prevented from water entering by filling soil and/or water barrier, and even if they allow the water entering, fixing necessary equipment and documents above the flood level can prevent them from losing its functions. Such disaster prevention measures can be applied for both newly constructing and retrofitting.

On the other hand, inundation level more than 0.5 m is difficult to prevent the water entering into the facilities and not practical to install equipment higher than the estimated depth. Hence, it is realistic to premise temporal closure of the health facilities in such situation, and focus on efficient evacuation before and quick restoration after the disaster, which include securing transportation method in the emergency and cooperation systems among the health facilities.

4) Consideration of Disaster Risk Reduction Measures

From the survey in the previous section, it was found that in the health sector focuses on improving the health care service by development of health care workers, and support for strengthening facilities are left on the backburner. This suggests that development of guidelines for the health facility management against natural disasters can be proposed as disaster reduction measures.

In addition, in the interview to MISAU, the officials mentioned a fear that healthcare in primary healthcare are not capable to manage the facilities after reinforcement and the measures end up not functioning in the event of a natural disaster. It is assumed that support for the workers on disaster mitigation and after-response are also an issue, and hence while providing guidelines for facility resiliency, educational support for the workers is strongly recommended.

(8) Agriculture

In Mozambique, the agricultural sector accounts for 70.2 % (2019) of the working population, with agriculture, forestry and fisheries accounting for 26.0% (2019) of total GDP and 12.6% (2018) of exports41. Many of those engaged in agriculture are engaged in low-input, low-productivity subsistence farming, dependent on rain-fed water, with significantly lower incomes. While domestic supplies of staple foods such as cassava and maize are sufficient, most of the rice is imported. There is also a chronic shortage of food, a situation exacerbated by climate change and natural disasters. It is therefore important to increase production and access to markets by improving productivity.

On the other hand, only about 15%, or 5.9 million hectares, of the 41 million hectares of arable land that make up about half of the country's total land area is used42, while the tropical savannah region to the north has a large area of arable land and is considered to have high potential for expanding agricultural production. Bordered by various countries and with its own port, Mozambique has the potential to provide food security for the Southern African region as well as international markets.

1） Overview of Relevant Organizations and Legal systems

a) Related organizations

(i) Ministry of Agriculture and Rural Development / Ministério da Agricultura e Desenvolvimento Rural (MADER)

Established in 2020, MADER directs, plans and ensures the execution of legislation and policies in the areas of agriculture, livestock, agricultural hydraulics, agro-forestry plantations, food security and coordination of rural development. In addition, they are involved in promoting the sustainable management and use of water and developing agricultural infrastructure to improve agricultural productivity.

MADER consists of the following directorates:

- Agriculture Inspection and Rural Development / Inspeção da Agricultura e Desenvolvimento Rural;
- National Directorate of Family Agriculture Development / Direção Nacional de

[41] Employment in agriculture (% of total employment): WB, World Bank Indicator, Agriculture, forestry, and fishing, value added (% of GDP) : Calculation based on World Bank Indicator, Agriculture as % of total exports : World Trade Organization, Trade Profile 2020

[42] FAO, Country profile and Country Fact Sheet

Desenvolvimento Agricultura Familiar;

- National Directorate of Livestock Development / Direção Nacional de Desenvolvimento Pecuário；
- National Directorate of Local Economic Development / Direção Nacional de Desenvolvimento Económico Local;
- National Directorate of Family Farming Assistance / Direção Nacional de Assistência à Agricultura Familiar;
- National Directorate of Promotion of Commercial Agriculture / Direção Nacional de Promoção de Agricultura Comercial;
- National Directorate of Agricultural Health and Biosecurity / Direção Nacional de Sanidade Agro-pecuária e Biossegurança;
- Directorate of Planning and Policies / Direção de Planificação e Políticas;
- Directorate of Cooperation and Markets / Direção de Cooperação e Mercados;
- Directorate of Administration and Human Resources / Direção de Administração e Recursos Humanos;
- Directorate of Agricultural Information and Communication / Direção de Informação e Comunicação Agrária;
- Legal Office / Gabinete Jurídico;
- Office of Social and Environmental Safeguards / Gabinete de Salvaguardas Sociais e Ambientais;
- Office of the Minister / Gabinete do Ministro; and
- Department of Procurement / Departamento de Aquisições.

The directorate relevant to the project is the National Directorate of Family Agriculture Development, which is responsible for planning, implementing and evaluating policies, strategies, and laws related to family farming, and for improving the environment to improve agricultural productivity and promoting production. Besides, MADER has National Directorate of Family Farming Assistance, which coordinates the implementation of actions on cross-cutting issues with special emphasis on natural resource management, climate change, and food and nutritional security in the agricultural sector, and Directorate of Planning and Policies, which formulates proposals for strategic policies, action plans and priorities for the development of commercial agricultural and agro-industrial production, and food security.

During 2011-2012, the Ministry of Land, Environment and Rural Development (MITADER), the predecessor of MADER, conducted a feasibility study on agricultural insurance for four priority crops: pulses, cotton, maize and cashew nuts, developed by Guy Carpenter & Company, LLC in collaboration with the World Bank Group Global Index Insurance Facility (GIIF). Hollard Mozambique, an insurance company, provided agricultural insurance to farmers through agribusiness companies based on the results of the study.

(ii) Agencies related to Ministry of Agriculture and Rural Development

The related agencies under the authority of the minister of MADER are as below.

Table 3-48 Related agencies under the authority of the minister of MADER

Agency	Outline
Mozambique Agricultural Research Institute / Instituto de Investigação Agrária de Moçambique (IIAM)	IIAM is a public institute that conducts research, development, and extension of agricultural technologies in Mozambique. It is mainly involved in disaster management activities by providing important baseline data such as soil maps of the country and information on suitable land for crops. Besides, the necessary data for an early warning system is provided to the Famine Early Warning System Network (FEWS NET) by IIAM.
National Fund for Sustainable Development / Fundo Nacional de Desenvolvimento Sustentável (FDA)	FDA enhance input and product markets to support agricultural production, supports producers by facilitating access to services provided by financial institutions, companies and organizations, and mobilizing other resources, and promotes partnerships between government agencies and other stakeholders in the agricultural sector
National Institute of Irrigation / Instituto Nacional de Irrigação (INIR)	INIR is an institute that plans, develop, use and manage land and water resources for agricultural production. It is responsible for facilitating the rehabilitation, construction, operation, and maintenance of irrigation infrastructure as well as supporting the establishment of water user associations and participating in integrated water resources management plan.
Technical Secretariat for	SETSAN is a government agency mandated to coordinate and

Agency	Outline
Food Security and Nutrition / Secretariado Técnico de Segurança Alimentar e Nutricional (SETSAN)	monitor the implementation of food security and nutrition strategies to provide decision-making based on information that contributes to poverty alleviation and reduction of food insecurity. A working group called Vulnerability Assessment Committee (VAC) has been set in the secretariat and assess to conduct multi-sectoral assessments regularly with the support of relevant ministries and development partners. It plays an important role in proposing countermeasures to reduce the risk of food and nutrition insecurity in the country.
National Fund for Sustainable Development / Fundo Nacional de Desenvolvimento Sustentável (FNDS)	FNDS has set the mission to promote, finance, and manage sustainable development initiatives in rural area of Mozambique, and funds programs for environmental management, adaptation and mitigation to climate change, sustainable forest management, biodiversity conservation, land management, and spatial planning.
Institute of Cotton and Oilseeds of Mozambique / Instituto de Algodão e Oleaginosas de Moçambique (IAOM)	IAOM was established to to promote the production, marketing, processing, and export of oilseeds. The Instituto do Algodão de Moçambique (IAM), the predecessor of IAOM, coordinated a public-private partnership with Hollard and EMOSE (Empresa Mocambicana de Seguros, SA) to contribute extension of agricultural insurance to reduce the impact of drought and other severe weather conditions on farmers' incomes.

Source: JICA Study Team

(iii) Ministry of Public Works, Housing and Water Resources / Ministério das Obras Públicas, Habitação e Recursos Hídrico (MOPHRH)

Water resources management and flood control in Mozambique are implemented by the National Directorate of Water Resources Management (Direcção Nacional de Gestão de Recursos Hídricos, DNGRH) and 5 Regional Water Administration (Administracao Regional de Aguas, ARA) that were established following decentralization, under the umbrella of the MOPHRH. The detail of the MOPHRH is memtioned in (9) River management and coastal management. DNGRH plans and constructs river structures such as weirs and embankements. ARA implement water resources management including rainfall and hydrological data collection and analysis, water rights licensing and collection of water fees.

b) Legal systems

Legislation has been enacted to define the roles of the related organizations mentioned above.

2） Overview of Related Plans and Development Status

a) Related plans

(i) Five-Year Government Program / PROGRAMA QUINQUENAL DO GOVERNO 2020-2024 (PQG)

The program identifies agriculture and rural development as one of the priority scope and sets the following actions, particularly in the areas of agricultural production and market development.

Table 3-49 Actions in Five-Year Government Program

Scope	Actions
Agriculture	i) To assist producers in extension of improved agricultural technologies; ii) To expand the coverage of assistance to farmers by hiring improvement and extension officers; iii) To promote the creation of self-employment for young people through livestock promotion and agricultural production; iv) To supply improved seed to the market based on the production of basic seed for rice, maize, beans, sweet potato, tomato, lettuce and carrot cultivation; v) To promote extension of improved breeds of bulls, goats and chickens; vi) To production and use of certified cotton seed; and vii) To product and distribute cashew tree seedlings.
Rural Development	i) To build the capacity of small producers, associations and rural traders; ii) To build capacity and assist districts in mapping and diagnosing district potentialities and integrating them into the District Strategic Development Plan (PEDD); and iii) To promote and assist the establishment of partnerships between local communities and private sectors in the management and conservation of biodiversity, and contribute to job creation and the development of income-generating activities in rural areas.

Source: JICA Study Team

(ii) National Development Strategy 2015-2035

Agriculture has been identified as a priority area in the National Development Strategy, with strategies to i) improve agricultural productivity and ii) commercialize agricultural and livestock production. The government of Mozambique has set development goals for agriculture area to be achieved by 2035, using yields of maize and rice as indicators. The strategy has suggested flood in irrigated areas and drought in rain-fed agricultural areas as risk factors that hinder the achievement of these goals. Therefore, it has proposed construction of infrastructure (dams and protection dike) to protect irrigated areas, and introduction of alternative irrigation technologies in rain-fed agriculture and agricultural insurance.

(iii) Strategic Plan for Agricultural Sector Development / Plano Estratégico De Desenvolvimento Do Sector Agrário II (PEDSA II 2021 - 2030)

Regarding strategies specialized in the agricultural sector, PESDA II is currently being drafted and will replace the Strategic Plan for Agricultural Sector Development 2011-2020 (Plano Estratégico para o Desenvolvimento do Sector Agrário, PEDSA). It is planned to include climate change measures and disaster management. In addition, the National Agricultural Investment Plan 2014-2018, Extended 2018-2019 (Plano Nacional De Investimento Do Sector Agráriopnisa, PNISA), the investment plan to implement PESDA, will be updated.

(iv) National Irrigation Program / Programa Nacional de Irrigação 2017-2042 (PNI)

The goals of the PNI are to: a) establish national instruments for action, management and support for irrigation development with strategic options; b) establish plans and frameworks for irrigation development and investment in terms of river basin and agricultural development; c) ensure sustainable expansion of irrigated agriculture including rational and efficient use of land and water resources; and d) contribute to the socio-economic development of Mozambique. The specific objectives are to: a) prioritize potential irrigation development areas for future projects; b) map and identify existing irrigation infrastructure; c) identify water availability and needs according to hydrographic basin conditions; d) plan irrigation based on rational and sustainable use of land and water resources; and e) identify the most appropriate institutional capacity building needs for the INIR.

According to PNI, 180,000 ha of land were equipped for irrigation, of which only 90,000 ha are in operation. The prioritization of the hydrographic basins for irrigation indicated that 8 basins are suitable for irrigation: Maputo, Limpopo, Buzi, Zambezi, Licungo, Meluli, Lurio and Rovuma rivers. The area with potential for irrigated agriculture was estimated at 3 million hectares (Figure 3-77).

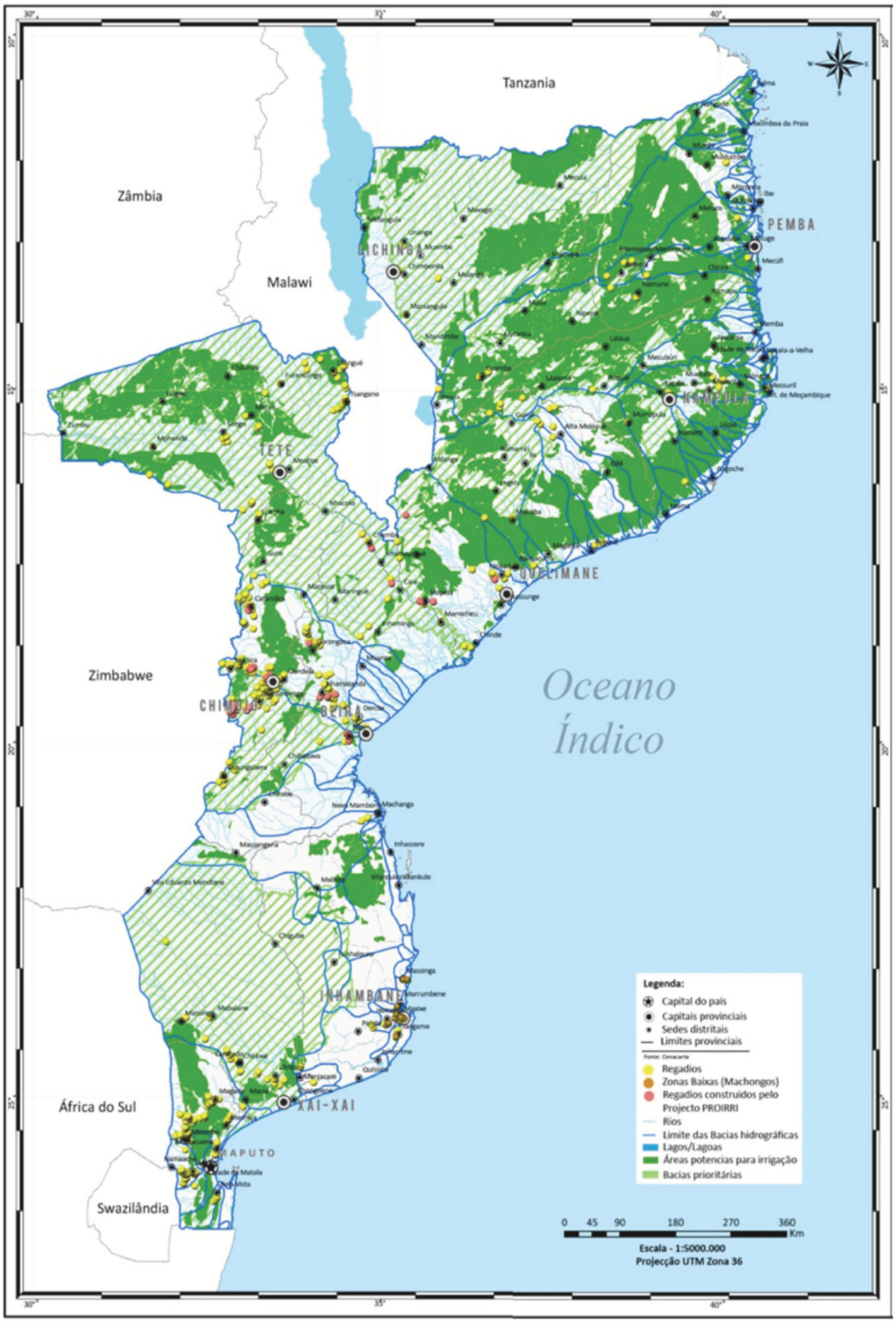


Figure 3-77 Location map of Irrigation scheme

Source: PNI

b) Development status

(i) Japan's Assistance Policy

Japan will assist the industrial development that contribute to economic revitalization and diversification such as agriculture and social infrastructure development, fisheries and aquaculture, natural resource development, and tourism, which Mozambique has identified as priority areas. The main initiatives in the area of agricultural development are to improve the livelihoods of rural residents, support the improvement of administration in agriculture and rural development, support the increase of rice production, and improve nutrition.

Japan's major assistance in the agricultural sector related to this project in recent years are summarized below. In addition, individual trainings for agricultural technology promotion and food security have been implemented.

Table 3-50 Japan's Assistance

Project	Summary	Duration
Project for Improvement of Rice Production in Zambezia Province (ProAPA) (Technical Cooperation)	The project supported the extension of rice cultivation technologies, improvement of seed production management systems, maintenance of irrigation facilities and enhancement of farmers' organizations in the target areas with irrigated and rain-fed rice cultivation in Zambezia Province.	2016 - 2021
Adviser of Food Security and Nutation (IFNA) (Dispatch of an expert)	The adviser supports the building of SETSAN's capacity as a coordinating agency for the planning and implementing of food security and nutrition-related policies and measures.	2021 - 2022

Source: JICA Study Team

(ii) Assistance by related donors and private sectors

Assistance by related donors and private sectors in the agricultural sector related to this project in recent years are summarized below. The WB aims to improve food security and farmers' livelihoods, and sustainable use of natural resources through irrigation development, improvement of market access, and appropriate management of natural resources. In addition to improving irrigation development and market access, the AfDB is implementing projects on drought and climate change.

China, the world's largest rice producer and importer, has been developing irrigation structures and implementing training to farmers in Gaza Province of the Limpopo River basin for about 10 years. Therefore, the assistance for the increase of rice production in the same province is difficult.

Since Japan has been implementing projects to improve rice productivity in Zambezia province, which makes Japan to build a smooth relationship with the ministry and local farmers. While coordinating with WB and AfDB, which assist in the northern region, Japan can contribute to food security in Mozambique by combining its strengths in disaster management and rice production assistance.

Table 3-51 Assistance by related donors and private sectors

Project / Donor	Sumarry	Duration / Cost
Northern Mozambique Rural Resilience Project / WB	The project will improve access to livelihood opportunities for vulnerable communities and management of natural resources, including forestry, fisheries, biodiversity and soil in rural areas of northern Mozambique.	2021 - 2026 US$ 150.00 million
Sustainable Rural Economy Program / WB	The project will improve the performance of small-scale farmers and AgriMSME, and natural resource management practices in the target area.	2021 - 2026 US$ 150.00 million
Smallholder Irrigated Agriculture and Market Access Project- IRRIGA 1 / WB	The project will improve farmers' productivity and rural livelihoods through the improvement of access to irrigation and markets. It comprises of five components: (i) institutional capacity building; (ii) smallholder irrigation development and management; (iii) agriculture intensification and market linkages; (iv) project management; and (v) contingency and emergency response. However, a cyclone is expected in 2019. However, Cyclone Idai in 2019 damaged 1,700 ha of this area. Construction of irrigation facilities were implemented in the provinces of Manica, Zambezia, Sofala and Nampula, resulting in the expansion of 3,000 ha of farmland. However, 1,700 ha of that was damaged by Cyclone Idai in 2019.	2018 - 2024 US$ 57.00 million
Moz Agriculture and Natural Resources Landscape Management Project / WB	The project will integrate rural households into sustainable agriculture and forest-based value chains in the Project area and, in the event of an Eligible Crisis or Emergency, to provide immediate and effective response to said Eligible Crisis or Emergency. It comprises of four components: (i) the integration of smallholder farmers (SFs) and Small Emerging Commercial Farmers (SECF) in key agriculture and forest-based value chains (VCs); (ii) land tenure regularization, improvement of land administration services, strengthening of the capacity to manage integrated landscapes and restoration of natural habitats that are critical for the VCs in the landscape; (iii) the Project coordination and management; and (iv)	2016 - 2023 US$ 100.00 million (Additional loan: US$ 60.00 million)

Project / Donor	Sumarry	Duration / Cost
	immediate response to an eligible crisis or emergency (scaling up the original project by extending its geographical coverage to support the recovery efforts in the cyclone affected areas).	
MZ PROIRRI Sustainable Irrigation Development / WB	The Project contributed to increase agricultural production marketed and raise farm productivity in the new of improved irrigation schemes in the provinces of Sofala, Manica and Zambezia. It rehabilitated and constructed irrigation and drainage facilities in agricultural land area of 4,200 ha of the provinces.	2011 - 2018 US$ 92.15 million
Climate Insurance Finance and Resilient Development Project (CLINFREDEP) / AfDB	CLINFREDEP is an integrated project to strengthen the capacity of the rural communities through the provision of water harvesting infrastructure, and improving food production and marketing activities as well as capacity building for climate change adaptation, water harvesting techniques, and agricultural marketing for the affected communities. It has been implementing over 5 years in the 10 drought prone districts of the Maputo, Gaza and Inhambane provinces.	2021 - 2026 US$ 47.78 million
Agricultural Value Chain and Youth Empowerment Project (AVACYEP) / AfDB	AVACYEP is an integrated project to strengthen the capacity of rural communities to address the inter-linked challenges of food production, rural poverty, food insecurity and access to markets through the provision of horticulture and livestock related infrastructure, and improving food production and marketing activities, as well as capacity building for the affected communities. It has been implementing in the districts of the Moamba, Namaacha, Chókwé and Chonguene.	2018 - 2023 US$ 17.294 million
Drought Recovery and Agriculture Resilience Project (DRARP) / AfDB	DRARP is an integrated project to strengthen the capacity of the rural communities to address the inter-linked challenges of climate change, rural poverty, food insecurity and land degradation through the provision of water harvesting infrastructure, and improving food production and marketing activities as well as capacity building for the affected communities. It has been implementing in the four drought prone districts of the Magude, Matutuine, Chigubo and Chibuto.	2018 - 2022 US$ 15.51 million
Project Preparation Facility (PPF) for the Value Chains and Market Development Program in Pemba-Lichinga Corridor / AfDB	The project contributed to enable Mozambique to implement the transformation strategy based on value chain approach with respect to irrigation development for selected crops while enhancing market opportunities, industrialization and protecting biophysical environment in the area (Pemba-Lichinga Corridor).	2018 - 2021 US$ - million

Project / Donor	Sumarry	Duration / Cost
Baixo Limpopo Irrigation and Climate Resilience Project (BLICRP) / AfDB	BLICRP contributed towards poverty reduction through increased value addition and provision of climate resilient (CR) infrastructure for increased agricultural productivity through support for the development of 3,050 ha for cash crops and provision of marketing and agro-processing facilities. It comprises of three components: (i) market infrastructure and agro-processing facilities; (ii) improvement of irrigation infrastructure and rural road; and (iii) promotion of agricultural diversification.	2012 - 2017
Agriculture Insurance / Guy Carpenter & Company	Guy Carpenter & Company developed the agricultural insurance with a US$1.0 million grant from the International Finance Corporation. The insurance was provided to farmers by Hollard Mozambique through agribusiness companies. To date cumulatively, the insurance managed to develop and deliver risk solutions against drought and excess rain for approx. 17,000 farmers, reaching out to close to 85,000 end-beneficiaries with insurance coverage. The Government of Mozambique committed US$ 1 million to provide premium subsidies for agricultural insurance products over a five-year period, starting from 2018. Government's support has been covering up to 40% of the premium, with the remainder being borne by the beneficiaries.	2011 - 2020
China-Africa Xai-Xai Agricultural Cooperation Project / China-Africa Development Fund	The rice farming project with 2,480 ha in Xai-Xai district of Gaza province is invested by the China-Africa Development Fund and managed by China Railway 20th Bureau Group Co., Ltd. To increase rice production, the company introduced Chinese rice farming techniques and resources to the project and improved the productivity from 1.5 t/ha to 6.0 t/ha, which helps relieve the country's food insecurity (2021). Approx. 1,500 households received training on rice farming techniques and more than 10,000 people benefited from the project directly and indirectly. The Agricultural Technology Demonstration Centers (ATDCs) launched in 2016 by the governments of China and Mozambique with the China Development Bank and China-Africa Development Fund, has contributed support of rice farming techniques.	2017-
China Wanbao Co., Ltd. (Hubei Province in China)	China has implemented a project to comprehensively improve the food supply system in Mozambique, in Xai-Xai district of Gaza province. In 2006, Government of Mozambique had allocated the crop field of	2006-

Project / Donor	Sumarry	Duration / Cost
	1,000 ha in Xai-Xai district of Gaza province to Hubei province of China. The farm for the rice production has been constructed there. China Wanbao Co., Ltd. in Hubei province expanded the field to 20,000 ha with the rehabilitation of irrigation infrastructure and the large-scale farm for the rice production was constructed in 2011. The farmers trained in this model project are expected to become producers to cultivate the planned 100,000 ha rice field.	

Source: JICA Study Team

3) Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Loss and damage to the agricultural sector caused by recent disasters are summarized in the following table.

Table 3-52 Damage and loss to the agricultural sector (flood)

Year	Area	Outline
Jan. 2015	Licungo river basin, Shire river basin Zambezia province, Sofala province, Niassa province, Nampula province, Tete province,	・ Total damaged area: 65,000 ha ・ Total affected area (Crop losses): 104,430 ha (incl. rice, maize, cowpeas, beans, vegetables and cassava) ・ Affected irrigation systems: 1,850 ha (Zambezia province) ・ Total cost of damage: US$ 371 million (incl. US$ 83 million for crop loss and US$ 14 million for irrigation infrastructure) ・ Total recovery and reconstruction cost: US$ 46 million
Jan. 2013	Licungo river basin, Limpopo river basin, Zambezia province, Sofala province, Gaza province, Inhambane province, Maputo city	・ Total damaged area: 266,698 ha (incl. completely destroyed area of 210,587 ha) ・ Total affected area (Crop losses): 110,000 ha ・ Affected rice seeds: 1,000m3 (Xai-Xai district and Chokwe district) ・ Affected livestock: 890 heads of cattle, 1,986 goats, 211 sheep, 540 pigs and 11,863 birds, mainly in Gaza province) ・ Chokwe and Chicumbane districts are severely affected. In both districts the floods caused serious destruction of the irrigation systems channels and machinery. ・ Total recovery and reconstruction cost: US$ 4 million

Source: JICA Study Team

Table 3-53 Loss and damage to the agricultural sector (Cyclone)

Year	Area	Outline
Apr. 2019 Cyclone Kenneth	Cabo Delgado province, Nampula province	・ Total damaged area: 1,835,375 ha ・ Total affected area (Crop losses): 34,803 ha ・ Affected irrigation systems (agricultural and infrastructure): 290 ha (Nampula province) ・ Total cost of damage: US$ 98 million for all sectors and US$ 21 million for agricultural sector (Breakdown: US$ 18 million for agricultural land, US$ 0.8 million for livestock, US$ 0.05 million for administrative infrastructures, US$ 2 million for irrigation system) ・ Total cost of loss: US$ 61 million for all sector and US$ 61 million for agricultural sector (Breakdown: US$ 60 million for crops, US$ 0.8 million for livestock) ・ Total recovery and reconstruction cost: US$ 50 million
Mar. 2019 Cyclone Idai	Manica province, Zambezia province, Sofala province, Tete province	・ Total damaged area: 813,000 ha (incl. affected area by flooding: 715,378 ha) ・ Affected irrigation systems (agricultural land and infrastructure): 4,309 ha (Approx. 43% is accounted for by Zambezia province, 33% by Manica province, 21% by Sofala province and 3% by Tete province.) ・ Affected livestock: 9,710 heads ・ Total cost of damage: US$ 1.4 billion for all sectors and US$ 48 million for agricultural sector (Breakdown: US$ 17 million for agricultural land, US$ 16 million for livestock, US$ 0.7 million for administrative infrastructures, US$ 14 million for irrigation system) ・ Total cost of loss: US$ 1.39 billion for all sector and US$ 513 million for agricultural sector (Breakdown: US$ 470 million for crops, US$ 43 million for livestock) ・ Total recovery and reconstruction cost: US$ 203.9 million
February, 2017 Cyclone Dineo	Inhambane province, Gaza province	・ Total damaged area: 13,477 ha by flooding

Source: JICA Study Team

According to the flood risk analysis implemented all over Mozambique in the Development of Master Plan for Water Resources Management, Gaza Province in Limpopo river basin, and Sofala and Zambezia Provinces in the Zambezi river basin are vulnerable to flooding. Besides, recent cyclones and heavy rains have caused severe damage to irrigation facilities in Chokwe and Xai-Xai districts (Chicumbane) of Gaza province in the Licungo basin in 2013, in Zambezia province in the Licungo river basin in 2015, and in Zambezia province in the Zambezi river basin in 2019. Since the affected provinces of Gaza, Manica, Sofala, Tete, Nampula and Zambezia are the breadbasket of Mozambique, a disaster in these areas would cause food insecurity in the country and loss of livelihoods of many subsistence farmers. In addition, Sofala and Maputo provinces have large scale farms spread out of sugarcane, an export crop, therefore, a diaster in the provinecs affects foreign currency earnings.

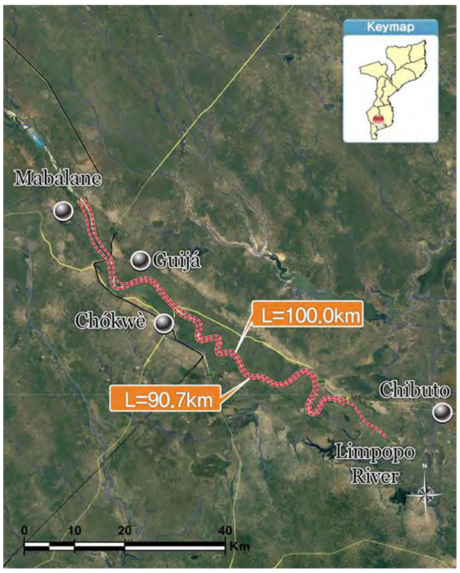
The situation of the disaster suggests that levee breaches and inadequate capacity of drainage systems in cropland causes damage to cropland and irrigation system and loss of crops due to flooding. The levees of Licungo and Zambezi rivers were breached in the 2015 flood. They are old infrastructure consructed from 1960s to 1980s, and has been eroded by recurrent flooding (every one or two years) and consequent erosion with lack of maintenance. Therefore, important breaches have been sometimes occured43. The figure below shows the plan to construct river levees for protecting residential areas & farmlands in area with high disaster risk along the rivers.

Chinde, Chinde District,
Zambezia Province
Protection of residential areas (160ha) & farmlands (1,800ha)

Nante, Maganja da Costa District,
Zambezia Province
Protection of residential areas (300ha) & farmlands (970ha)

[43] GoM, UN, WFP and WB, Damage Assessment and Early Recovery / Sustainable Reconstruction Priorities

Marromeu, Marromeu District,
Sofala Province
Protection of residential areas (700ha) & arable lands (17,500ha)



Mabalane, Guijá,Chókwè, Chibuto District, Gaza Provinces
Protection of residential areas (6,000ha) & arable lands (44,500ha)

Figure 3-78 River levee construction plan

Source : Development of Master Plan for Water Resources Management in Mozambique, National Directorate of Water Resources Management (DNGRH)

4) Consideration of Disaster Risk Reduction Measures

Japan's assistance in the area of agricultural development includes increasing rice production. The rice productivity should be improved while protecting agricultural land from flood to satisfy the demand for rice. Since Zambezia province is especially the largest rice production area in Mozambique, a disaster in the areas would cause food insecurity in the country. Therefore, rehabilitation and improvement of irrigation and drainage systems as well as levee rehabilitation along the Licungo and Zambezi rivers, could be effective in reducing flood damage to agricultural land and irrigation and drainage systems.

Since the affected provinces of Gaza, Manica, Sofala, Tete, Nampula and Zambezia are the breadbasket of Mozambique, a disaster in these areas would cause food insecurity in the country and loss of livelihoods of many subsistence farmers. The details of area and activities should be decided after confirming the following points through a surveys of the current status of irrigation and drainage systems, and interviews with stakeholders since only the desk research has been conducted due to the Covid-19; (i) Need for assistance, (ii) Cause of flood damage and (iii) priority area.

(9) River management and Coastal Management

1） Overview of Relevant Organizations and Legal systems

In Mozambique, each ministry has its own approach to flood management, including meteorological observation, early warning and disaster response (MOPHRH for flood control and water resources management, INAM for meteorological observation and INGD for early warning and disaster response). River management offices also exist, but they lack the capacity to carry out integrated risk assessment and facility development for flood control.

In addition to floods, Mozambique is also significantly affected by droughts, etc. Therefore, it is necessary for the country to be capable of integrated river management that includes water resource management and environmental conservation in addition to flood control. In addition, the region, which has several international rivers, needs to strengthen the framework for regional cooperation in order to promote coordinated activities among countries.

The current status of the river management system in Mozambique was assessed based on the information provided by the JICA Mozambique Office and the "Mozambique Disaster Risk Reduction Sector Information Collection and Verification Survey Report, August 2013, p.3-1 to 5-18, JICA."

Ministry of Public Works, Housing and Water Resources (MOPHRH) is the institution responsible for Flood control and water resources management in Mozambique. MOPHRH has several divisions (see figure below), including the National Directorate of Water Resource Management (DNGRH) and five regional water resource management offices (ARA, Regional Water Authority) that were established as a result of decentralization and have jurisdiction over the region's river basins.

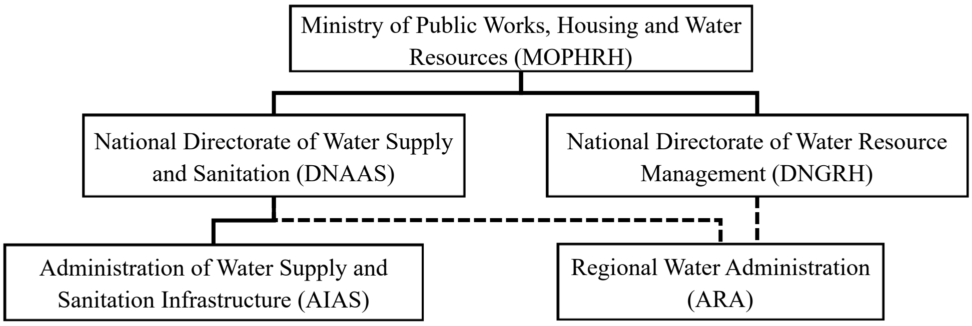


Figure 3-79 Organization chart for flood control and water resources management

Source: Prepared by the JICA Study Team based on information provided by JICA Mozambique Office

Mozambique has more than 100 rivers system, including small and medium-sized rivers, of which nine international and four national rivers are considered to be major rivers. The 13 major rivers under the jurisdiction of the ARA and their jurisdictional classification are shown in the table and figure below.

In 2020, ARA have changed its organization structure from five regional administration to three regional administration. ARA Sounth (hereinafter written as ARA Sul) have no change in the jurisdiction and ARA Central and ARA Zambezi was combined and ARA North and ARA Central North was combined.

Table 3-54 ARA jurisdictional classification of major rivers

Jurisdiction (Center Location)	River name	Extension (km)		Watershed area (km2)		River classification
		domestic	Total length	domestic	All watersheds	
ARA South（Maputo）	Umbeluzi River	100	314	2,356	5,600	Transboundary rivers
	Maputo River	150	565	1,570	29,800	
	Incomati River	283	714	14,925	46,246	
	Limpopo River	561	1,461	79,620	412,000	
ARA Central（Beira）	Save River	330	735	4,550	88,395	
	Buzi River	320	360	25,600	28,800	
	Pungwe River	322	372	28,000	29,500	
ARA Zambezi（Tete）	Zambeze River	820	2,700	140,000	1,200,000	
ARA North（Pembe）	Rovuma River	650	800	101,160	155,400	
	Messlo River	530	530	24,000	24,000	Domestic rivers
ARA Central North（Nampula）	Lurio River	605	605	60,800	60,800	
	Licungo River	336	336	27,726	27,726	
	Ligonha River	295	295	16,299	16,299	
Source: Republic of Mozambique: Basic Hydrographic Scale 1 : 2,000,000						

Source: Report on Information Collection and Confirmation Survey on Disaster Risk Reduction Sector in Mozambique, pp. 5-1, August 2013.

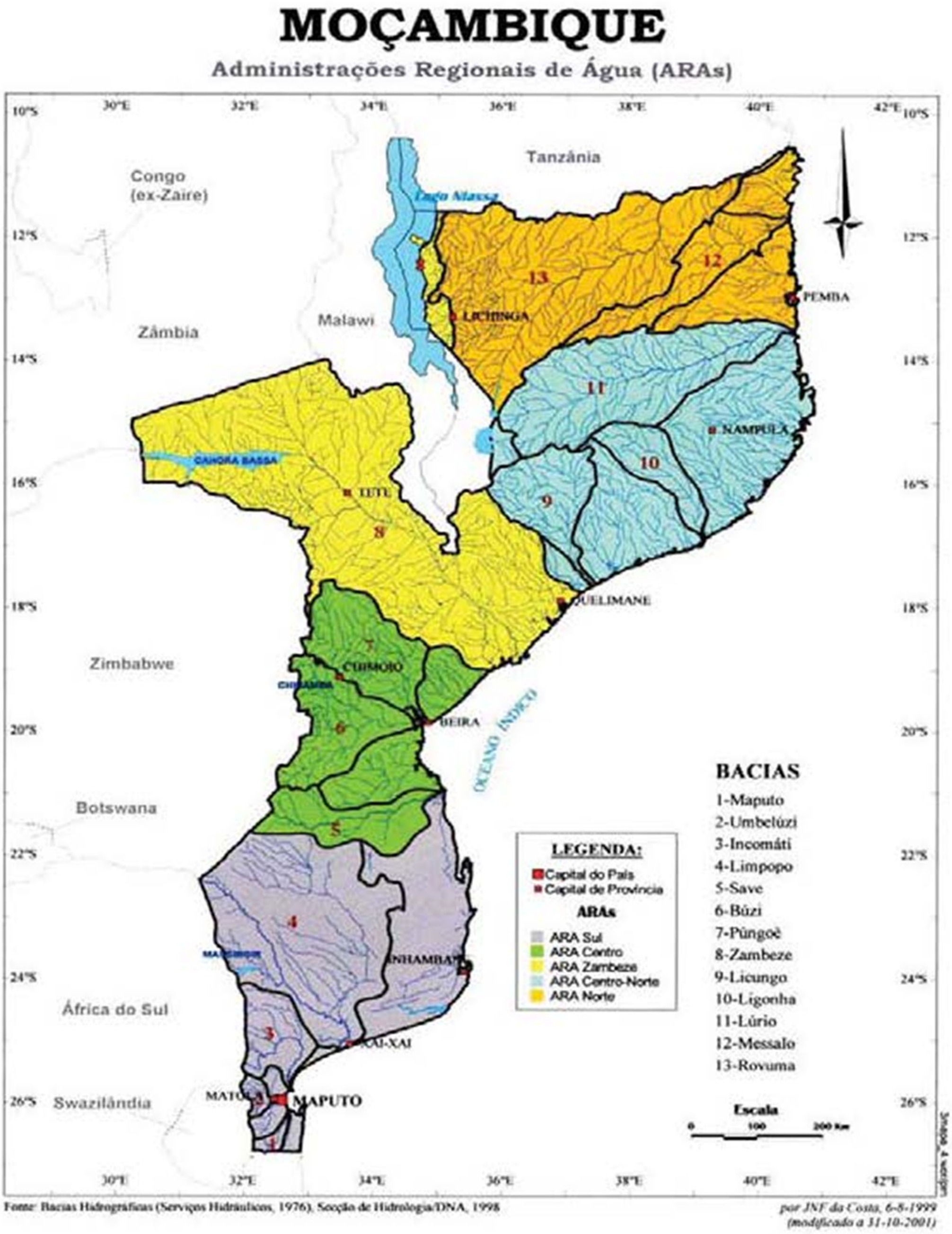


Figure 3-80 Location of major rivers and ARA jurisdictional classification

Source: Report on Information Collection and Confirmation Survey on Disaster Risk Reduction Sector in Mozambique, pp. 5-2, August 2013.

Due to the large area of jurisdiction of ARA in each region, regional centers are located in Maputo, Beira, Tete, Pemba, and Nampula, and branch offices have been established at major points inside the jurisdiction.

As mentioned above, the ARAs are river basin management organizations established as a result of decentralization. Entrusted by MOPHRH, the ARAs measure river flow and rainfall levels and report them to DNGRH, and also maintain facilities for water supply such as dams (excluding small-scale dams for irrigation purposes). ARA's also relay forecasts and early alert from DNGRH to relevant institution and carry out necessary response. In case a transboundary rivers flow through the jurisdiction of an ARA, the ARA will hold Management Committee meetings where stakeholder representatives from each river basin. However, they are not involved in the maintenance and management of river embankments as they are managed by the beneficiaries.

Mozambique has 10 provinces and one city that is equivalent to a province (Maputo Cidade). Under the provinces there are districts, and within the districts are administrative posts.

With decentralization in Mozambique, the provincial-level outpost of the Ministry of Public Works, Housing and Water Resources (MOPHRH) has been abolished. In addition to the Provincial Directorate of Public Works (DPOP) under the Governor, the Provincial Service of Infrastructure (SPI) under the Secretary of State, who is appointed directly by the President, has been established as the organization responsible for water resources management at the provincial level. The DPOP is in charge of projects at the provincial level, and SPI advises on projects implemented by the DPOP.

Meteorological observations and forecasts in Mozambique are carried out by the National Institute of Meteorology (INAM). As shown in the figure below, the National Meteorological Institute (INAM) is responsible for meteorological observations and forecasts, as well as issuing weather advisories and warnings. In detail, the results of the usual forecast are re-analyzed, and after consultation among several forecasters, the results are announced with the approval of the Director of the Forecast Division.

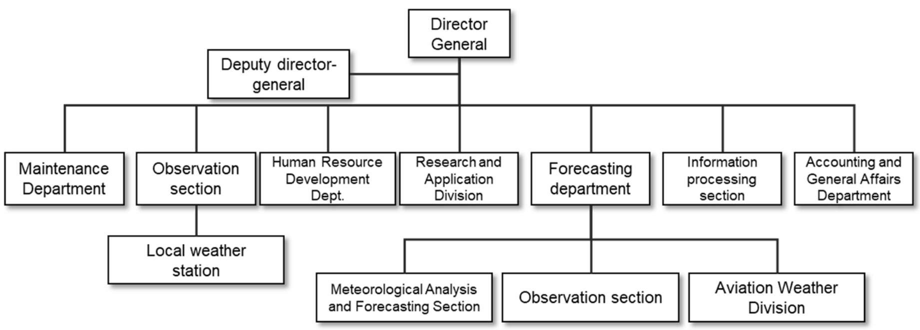


Figure 3-81 Organizational chart of the National Institute of Meteorology (INAM)

Source: Report on Information Collection and Confirmation Survey on Disaster Risk Reduction Sector in Mozambique, pp. 4-2, August 2013.

2） Overview of Related Plans and Development Status

According to the DNGRH document “Development of Master Plan (MP) for Water Resources Management in Mozambique” (February 2018), there are 104 rivers in Mozambique, and these rivers are classified into 13 major rivers and 22 strategic small/medium scale rivers.

Figure 3-82 Location map of 13 major rivers and 22 strategic small/medium scale rivers

Source: Development of Master Plan (MP) for Water Resources Management in Mozambique, p. 2, February 2018, DNGRH.

(Matches the river numbers with the table of 13 major rivers; does not match the river numbers with the table of the 22 strategic small/medium scale rivers)

Table 3-55　List of specifications for 13 major rivers

No.	River	Catchment area (km^2)		Length (km)	
		In Moz.	Total	In Moz.	Total
1	Maputo	1,979	30,903	150	535
2	Umbeluzi	2,319	5,589	100	274
3	Incomati	14,998	46,649	283	783
4	Limpopo	86,398	422,741	561	1542
5	Save	16,845	103,076	330	811
6	Buzi	26,005	29,790	320	382
7	Pungoe	29,911	31,366	322	429
8	Zambezi	181,834	1,474,004	820	3321
9	Licungo	22,761	22,761	369	369
10	Lurio	61,011	61,015	657	657
11	Rovuma	100,126	154,727	650	974
12	Messalo	24,456	24,456	594	594
13	Montepuez	10,040	10,040	387	387

Source: Development of Master Plan (MP) for Water Resources Management in Mozambique, p. 2, February 2018, DNGRH.

Table 3-56　List of dimensions of 22 Strategic small/medium scale rivers

No.	River	Catchment area(km^2)	Length (km)	No.	River	Catchment area(km^2)	Length (km)
1	Mutamba	929	85	12	Malato	106	7
2	Guiua	90	16	13	Monapo	8,006	269
3	Inhanhombe	1,295	87	14	Mucuburi	9,439	305
4	Inharrime	13,478	337	15	Megaruma	5,446	256
5	Govuro	11,289	280	16	Namacura	7,563	248
6	Ucarranga	3,016	147	17	Gorongose	10,212	240
7	Raraga	9,123	254	18	Mongicual	3,254	152
8	Melela	8,180	328	19	Calundi	2,619	112
9	Molocue	6,512	397	20	Meronvi	1,089	94
10	Ligonha	14,737	385	21	Macanga	330	40
11	Melui	10,253	292	22	Quibanda	361	12

Source: Development of Master Plan (MP) for Water Resources Management in Mozambique, p. 2, February 2018, DNGRH.

The Master Plan (MP) for Water Resources Management by the DNGRH examines envisioned projects for water resources management and flood control measures, and the following points can be observed:

- 13 major rivers were selected based on analysis from the perspective of water resource and flood risk (see figure below).
- In addition to flood management, the MP also takes into account the perspective of water

resource development, and considers measures including meteorological and hydrological observation networks, dams, river embankment construction, and countermeasures against urban flood.

- The Water Law, which is the basis for water resource development and flood control, is currently being revised, and the DNGRH is interested in studying the prioritization of rivers where projects should be implemented.

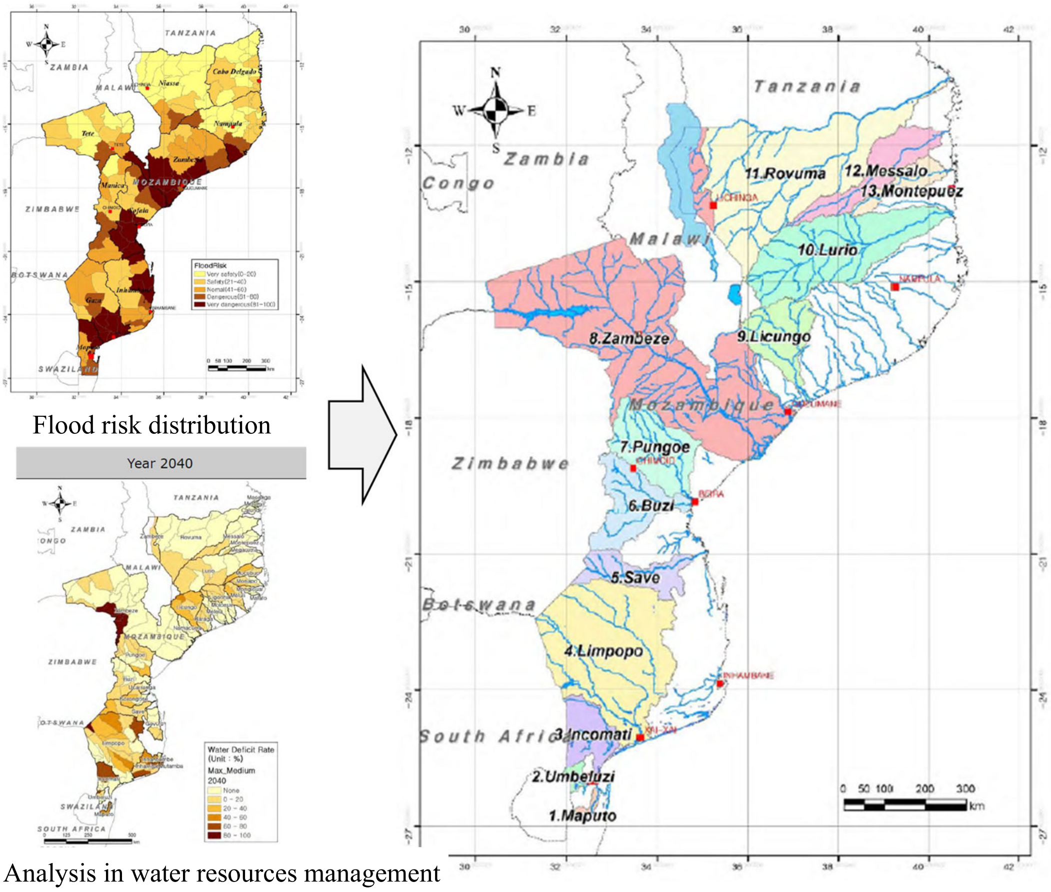


Figure 3-83 Basis for selection of 13 major rivers

Source: Development of Master Plan (MP) for Water Resource Management in Mozambique, p.2, February 2018,DNGRH.

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Bellow shows the damage caused to the river management and coastal management sector due to the recent disasters

Table 3-57 Damage caused by disaster in river management and coastal management sector in Mozambique

Date	Affected Area	Damage
April, 2019 Cyclone Kenneth	Province of Cabo Delgado, Nampula	Meteorological stations：5, Meteorological data logger：2 Digital thermometer：2、Udometer：1
March, 2019 Cyclone Idai	Province of Manica, Zambezia, Sofala, Tete	Dam：Eribacela dam, River embankment：Nicoadala (5 km)、Nante (11 km／Licungo river), Hydrological gauge stations：69 Telemetric stations：5, Dopler radar system (Beira)：1 Community alert sensors：27 Community and conventional rainfall gauge stations：39
January, 2015 Flood	Licungo river, Shire river, Province of Zambezia, Sofala, Niassa, Nampula, Tete	River embankment：Nante (15km／Licungo river), Luabo (1.5km／Zambezi river) Urban drainage：Mocuba, Nacala Hydrological gauge stations：34, Meteorological stations：7
2000 Flood	Limpopo river	River embankment：XaiXai（Elephant river） Damage in Hydrological gauge stations Damage in Meteorological stations *Details are not available on the PDNA

Source: Consolidated by JICA Study Team from PDNA

As mentioned above, dams and river embankments related to river management have been frequently damaged by floods caused by cyclones and heavy rains in Mozambique. As also described in "(8) Agriculture Sector", in response to such repeated damage, the development of embankments to protect villages and farmlands is being considered.

In addition, the Master Plan for Water Resources Development considers counter measures for each priority basin, including meteorological and hydrological observation networks, dams, river embankment, and measures against urban flood, and it will be necessary to implement flood control measures in accordance with the Master Plan in the future. On the other hand, since the budget for river management is limited, it is important to implement measures by priorities.

4） Consideration of Disaster Risk Reduction Measures

In this survey, rivers around the Greater Maputo Metropolitan area and Beira city, which are major cities, from the viewpoint that it is important to invest in disaster risk reduction in areas with high potential for damage due to floods and storm surges, as well as in areas where assets and population are concentrated.

In addition, in "3.1.1 Disaster Risk Profile" potential economic loss due to disasters was estimated in the Greater Maputo Metropolitan Area and Beira City. As a result, it was found that the potential economic loss due to flooding, including urban flooding is large in the Greater Maputo Metropolitan Area.

Therefore, based on the request of ARA SUL, which is in charge of river management in the region, this survey will focus on flood management measures in the Greater Maputo metropolitan area and on the operation and management of dams in the surrounding regions. The details of the study are described in the following pages.

5） Greater Maputo Metropolitan Area River Management Master Plan Development Project

In order to determine focus points for the Greater Maputo Metropolitan Area River Management Master Plan Development Project, interviews with relevant organizations and field surveys of candidate rivers were conducted as shown in bellow.

Table 3-58 Survey contents for the project to develop a Master Plan for River Management to Strengthen the Maputo Metropolitan Area

Topic	Key points
Flood mechanism analysis (presence of external flooding risk)	- Past flood occurrence for rivers around the Greater Maputo Metropolitan Area - Analysis of the causes of past floods in rivers around the Greater Maputo metropolitan area
Status of the action plan for the existing project "Support for Capacity Building of Water-related Disaster Risk Management Institution in Mozambique"	- Confirmation of status (status of river and flood control capacity in ARA-Sul and DNGRH, implementation policy of flood control in Maputo metropolitan area, organization structure, budget, results from technology transfer and its usage status, etc.)
C/Ps' flood control policy, organizational capacity (planning, project implementation)	- Reconfirmation of the capacity and enthusiasm for the development of the Master Plan for Flood Disaster Risk Reduction in Maputo and Matola, the outline of the flood control projects currently being implemented, and the budget plan - Confirmation of the Regional Administration of Waters in the South's (ARA-Sul) flood control plan, flood control project outline, budget plan, and policy on river disaster risk reduction in the Maputo Metropolitan Area - Confirm the knowledge and skill level of engineers involved in new projects of ARA-Sul - Confirmation of the jurisdiction of ARA-Sul (does it have jurisdiction over the rivers in the new project?)
Ideas for grant candidates that have immediate effects, such as drainage	- In particular, since there are some projects in the Maputo Metropolitan Area that have not yet been implemented and are listed in the World Bank's Master Plan for Drainage, we will confirm whether they can be considered for the JICA grant and whether they are expected to have immediate effects

a) Flood mechanism analysis (possibility of external flooding risk)

The target rivers of the Greater Maputo Metropolitan Area Flood Countermeasures Master Plan Development Project are shown in the table below. Of the six rivers in the Greater Maputo metropolitan area, there are four transboundary rivers, and two national rivers, the Matola river and Infulene river.

Table 3-59 List of rivers to be studied

No.	River Name	River Basin Area (km^2)		Length (km)	
		In Moz.	Total	In Moz.	Total
1	Maputo	1,979	30,903	150	535
2	Umbeluzi	2,319	5,589	100	274
3	Incomati	14,998	46,649	283	783
4	Matola	401	401	50*	50*
5	Infulene	276	276	20*	20*

*Estimated by JICA research team using Google Earth

Source: Development of Master Platform WRM in Moz, p. 2, DNGRH, Feb 2018.

An overview map of the river basin around the Maputo metropolitan area is shown in the figure bellow. From this, it can be seen that the population is concentrated throughout all of the Infulene River basin, in the left bank of Matola River middle to the lower part of the river, in the right bank of Incomati River at the mouth of the river, and in the Tembe River in the lower part of the river. On the other hand, the population of the Umbeluzi and Maputo river basins is very small.

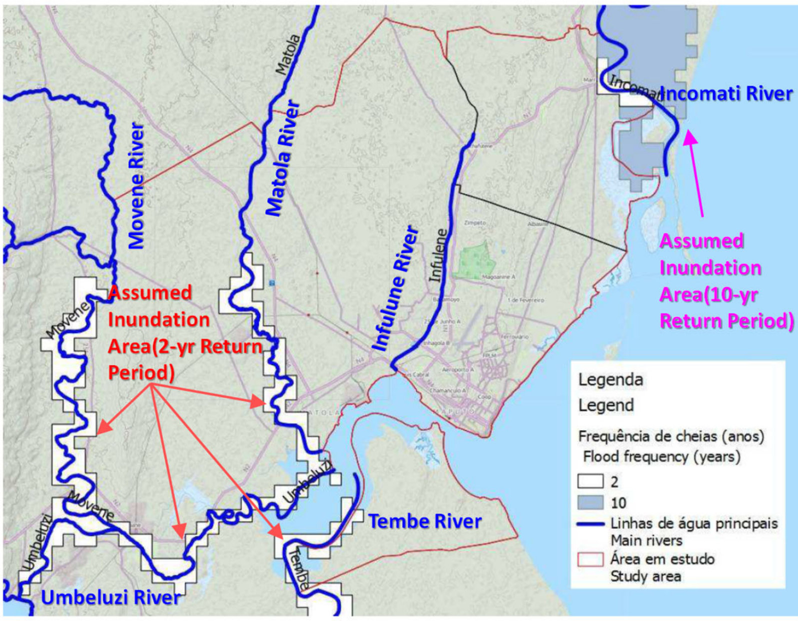


Figure 3-84 River Basin Overview in the Greater Maputo Metropolitan Area

The area around the Maputo metropolitan area suffers from frequent flooding (shown in the tables below). In particular, the 2000 flood was recorded as the most damaging floods in the last 150 years (shown in the tables below).

Table 3-60 List of major floods in and around the Maputo metropolitan area

Year	Description
2013	Average and high magnitude flows in the basin of Incomati river; floods in the cities of Maputo (most affected neighborhoods Magoanine A, B and C; Inhagóia A, Hulene, Ferroviário and Costa do Sol, including recently constructed areas in the core of Sommerschield, Triunfo and Pescadores, these two in the neighborhood Costa do Sol) and Matola
2001	Floods in the Umbeluzi and Incomati rivers
2000	Floods in the Umbeluzi and Incomati rivers; considered the worse floods of the last 150 years
1996	Floods in all southern rivers: 200 000 affected
1985	In the south, 9 rivers flooded. Worse floods in 50 years after 4 years of drought; 500 000 people affected

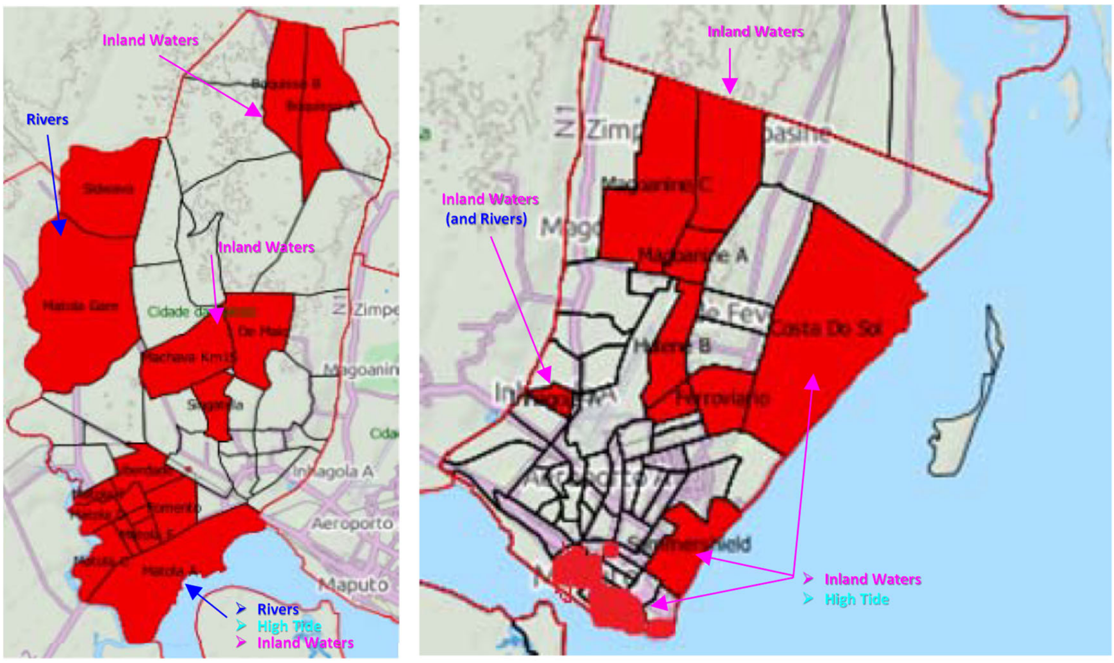
Source: SANITATION AND DRAINAGE MASTER PLAN FOR THE GREATER MAPUTO METROPOLITAN AREA ANALYSIS OF EXISTING SITUATION VOLUME 1 - MAPUTO METROPOLITAN AREA FINAL REPORT, pp. 75-76, Feb. 2015.

Table 3-61 List of existing floods in the Umbeluzi and Incomati rivers

Basin	Historical Floods
Umbeluzi	4 floods in the period 1966-1984; the 1984 flood had the highest flow (6 150 m^3/s). Flow from the 2000 flood in this basin reached 1 410 m^3/s
Incomati	12 floods in the period 1937-1998; the 1976 flood reached the highest flow (5260 m^3/s). Flow from the 2000 flood in this basin reached 11 000 m^3/s

Source: SANITATION AND DRAINAGE MASTER PLAN FOR THE GREATER MAPUTO METROPOLITAN AREA ANALYSIS OF EXISTING SITUATION VOLUME 1 - MAPUTO METROPOLITAN AREA FINAL REPORT, pp. 75-76, Feb. 2015.

Based on interviews with relevant organizations such as DNGRH, ARA-Sul, AIAS, etc., it was found that although there were no actual inundation maps from major flood events, the Sanitation and Drainage Master Plan for the Greater Maputo Metropolitan Area has a flood vulnerability maps that were prepared based on interviews with residents and other information (shown in the figure below). These maps show that the cities of Maputo and Matola, which are in the Infulene and Matola river basins, are vulnerable to flooding. On the other hand, the Master Plan does not mention the mechanism of flood vulnerability, therefore JICA Study Team added the inundation factors determined based on the characteristics of the river basin and mentioned in the figure below. However, the mechanism of flooding needs to be investigated and clarified in the future.



(a) Matola City (b) Maputo City

Figure 3-85 Flood vulnerability map of the Maputo metropolitan area

Source: Plano director de saneamento e drenagem da Área metropolitana de Maputo, pp. 7-8. AIAS, 2017.

In addition, flood hazard map focusing on river-line flood (overflow from river) is shown in (Figure 3-86). The figure shows that the lower Incomati River is inundated by 10-year floods, while the Matola, Umbeluzi and Tembe Rivers are inundated by 2-year floods. This is generally consistent with the flood vulnerability areas shown in Figure 3-85. On the other hand, according to Mr. Carlos Laisse, Construction Management Specialist of AIAS, AIAS have not conduct flood analysis that includes river-line flood (overflow from river), and further investigation is necessary to confirm the how the flood hazard map was developed.

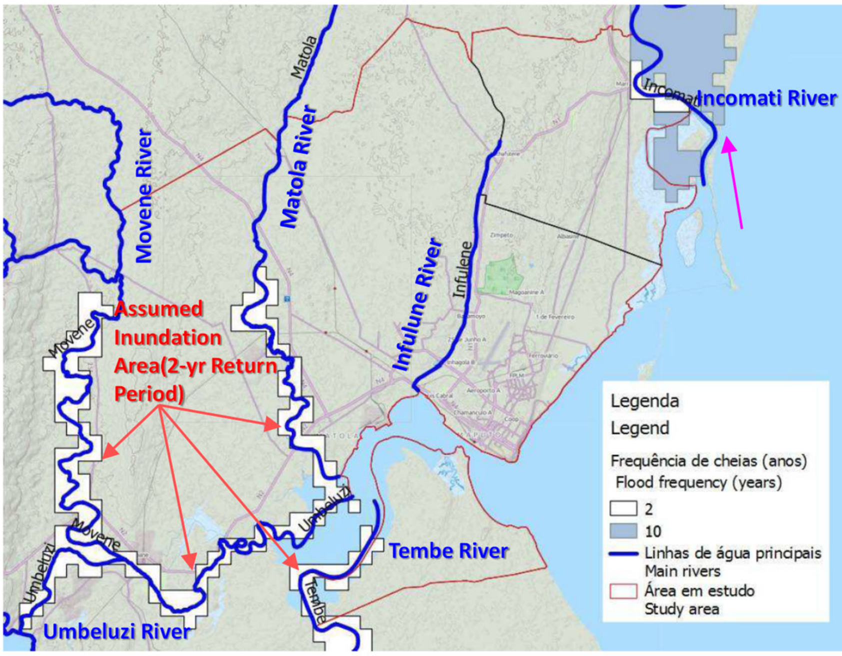


Figure 3-86　Flood (external water) hazard map for Maputo metropolitan area

Source: SANITATION AND DRAINAGE MASTER PLAN FOR THE GREATER MAPUTO METROPOLITAN AREA ANALYSIS OF EXISTING SITUATION VOLUME 1 - MAPUTO METROPOLITAN AREA FINAL REPORT, p. 75, Feb. 2015.

JICA Study Team collected rainfall data around the Maputo metropolitan area and calculated the total annual rainfall (Figure 3-87) and the maximum annual rainfall (Figure 3-88). The rainfall data collected is only daily rainfall. Hourly rainfall is available only at INAM's Maputo station. Based on interviews with INAM (Mr. Mussa Mustafa. Msc, Deputy General Director) and DNGRH (Mr. Messias Macie, National Director), the duration of rainfall during major floods around the Maputo Metropolitan Area is about one day, and rainfall of 40mm/day or more causes internal flooding that prevents people from returning home from their offices in the Maputo Metropolitan Area. (Figure 3-88 shows that rainfall of 40 mm/day or more occurs every year and that flood control is an urgent issue.)

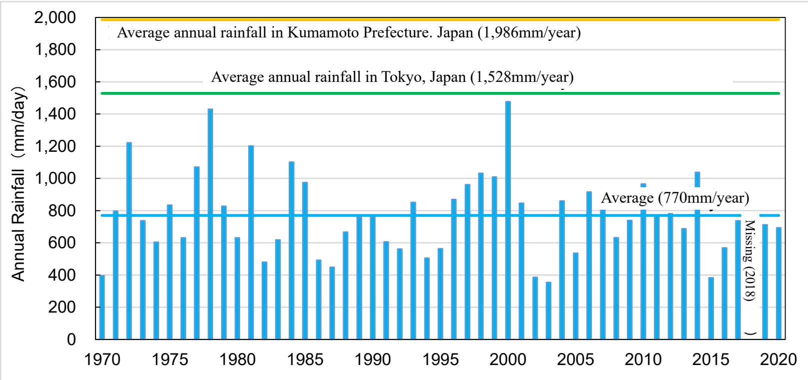


Figure 3-87　Total annual rainfall at the Maputo meteorology station

Source: JICA research team

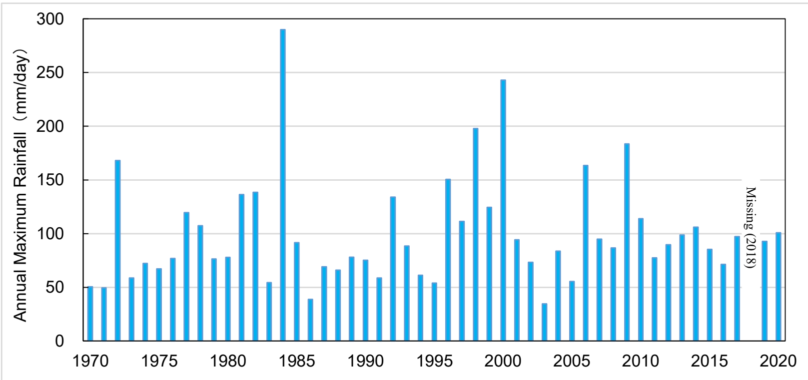


Figure 3-88　Maximum annual daily rainfall at Maputo station

Source: Processed data provided by INAM

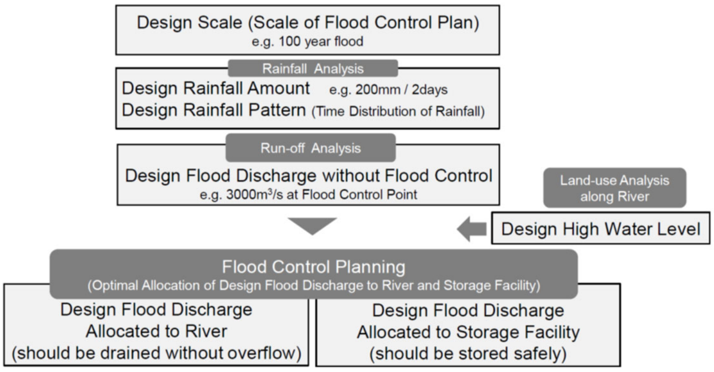
Based on the Figure 3-88 Rainfall analysis was conducted (Table 3-62　Hydrological analysis results) Here, a generalized extreme value distribution satisfying SLSC ≤ 0.04 was adopted as the probability distribution model.

Table 3-62　Hydrological analysis results

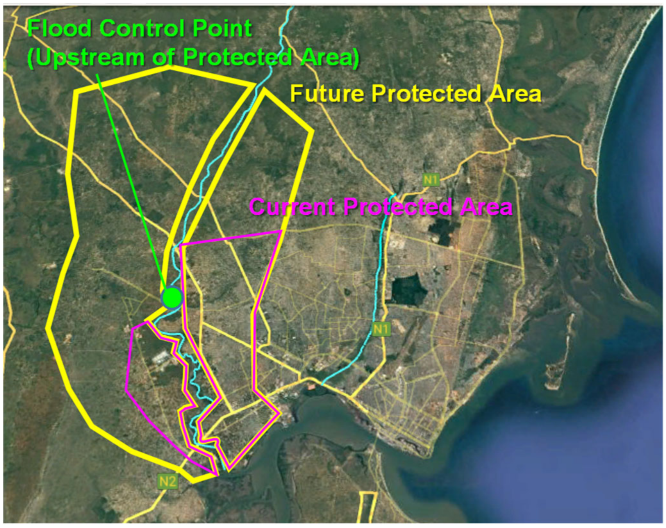
Probability years	150	100	80	50	30	20	10	5	2
Probable rainfall (mm/day)	331.3	299	282.3	249.6	217.4	194.1	158.2	126.1	86.4

Source: JICA research team

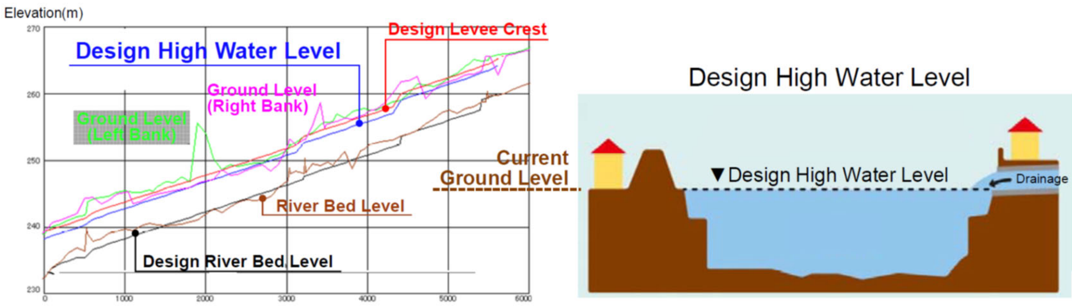
In Japan, as shown in Figure 3-89, a methodology for flood control planning has been established, which includes setting the design scale, rainfall analysis, runoff analysis, setting the design high water level, and flood control planning (optimal allocation of flood discharge to storage facilities and river channels). In the future, master plans for each target river are expected to be formulated in accordance with this methodology in the Maputo Metropolitan Area River Management Master Plan Development Project.



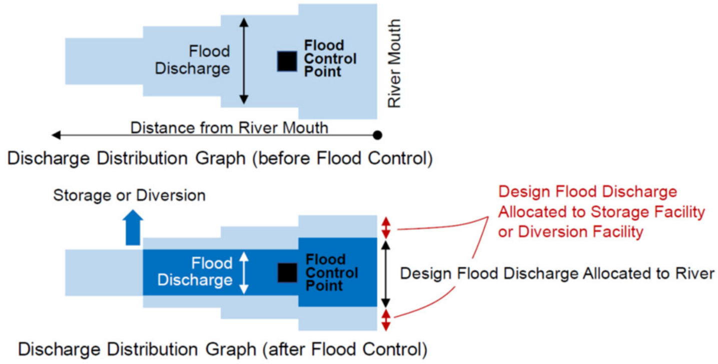
(a) Flood control planning procedure



(b) Image of flood control points (Matola River basin)



(c) Image of Design High Water Level setting



(d) Image of flood discharge allocation plan

Figure 3-89 Outline of flood control planning methods in Japan

Source: Some information corrected based on the Detailed Planning Study of the Urban Flood Control Project (Flood Control and Drainage Planning), India, pp. 4-35, March 2021.

It is important to estimate flood discharge distribution in the basin on a broad scale, based on the basin and river characteristics, before conducting the detailed rainfall-runoff analysis and flood control planning indicated in Figure 3-89 (a) "Flood control planning procedure". This methodology should be used in the development survey oriented technical cooperation projects to be formulated based on this study, and countermeasures should be envisioned. Research and analysis should be conducted on the assumption that this methodology will be transferred to ARA-Sul. Here, as an example, the flood flow distribution in the basin was estimated for the Matola and Infulene rivers. The other rivers were excluded because they are transboundary rivers and more information needs to be collected and organized.

A longitudinal section of the river-bed gradient is shown in Figure 3-90 to show the channel characteristics of the Matola and Infulene rivers. It can be seen that the river-bed gradient changes from steep to gentle at around 18.0 K in the Matola River and around 7.0 K in the Infulene River, respectively, and it is assumed that the riverbed down-stream of these two rivers becomes an area for river-line flood.

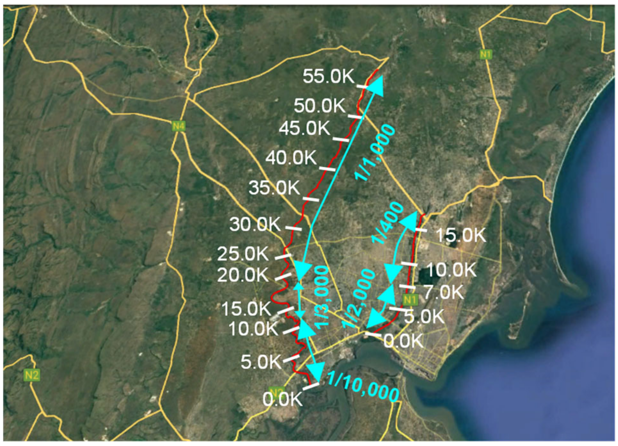


Figure 3-90 River Channel Characteristics of the Matola and Infulene rivers.

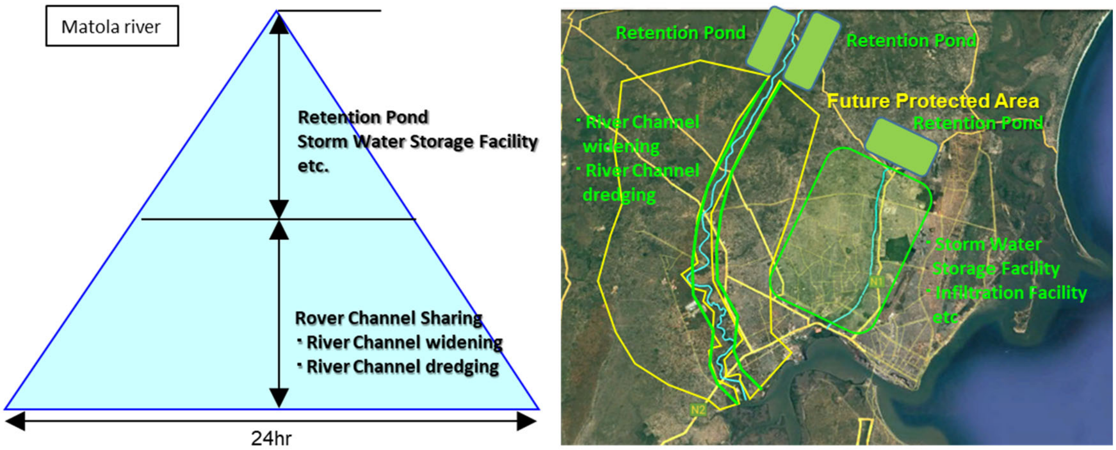
Source: JICA research team

The flood specific flow curve equation (Krieger equation, $q = C \cdot A^{(A^{-0.05}-1)}$, where q is the flood specific flow [$m^3/s/km^2$], A is the basin area [km2], and C is the regional coefficient) was used to estimate the flood discharge of the Matola and Infulene rivers among the target rivers. Based on the probability rainfall and runoff rate of Table 3-63, the flood flow rates of Figure 3-91 are assumed to represent the 50-year rainfall probability under the current land use conditions.

Table 3-63 Current Flood discharge calculated using the flood specific flow curve equation

No.	**River Name**	**River Basin Area (km^2)**		**Specific Discharge**	**Discharge**
		In Moz.	**Total**	**($m^3/s/km^2$)**	**(m^3/s)**
4	Matola	401	401	3.60	1,440
5	Infulene	276	276	4.04	1,100

Source: JICA research team



(a) Proposed flood flow distribution map (b) Area Map

Figure 3-91 Assumed flood flow distribution map and countermeasure area map

Source: JICA research team

b) Status of implementation of action plans for existing projects

An existing project, "Support to Strengthen the Capacity of Water-related Disaster Risk Management Organizations in Mozambique," has defined an action plan for after the completion of the project.

Interviews were conducted with ARA-Sul and DNGRH to ascertain the status of their response to this action plan.

The action plan (Table 3-64) and implementation status (Table 3-65) of the previous JICA project is described, and the detail of the implementation status is described in Table 3-66.

Table 3-64 Action plans of previous projects

	Activities	Technical Support	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
A	Hydrological Observation / Hydrological Database														
A1	To establish an integrated hydrological Database	Need													
	- To design a new hydrological database without necessity of license renewal														
	- To integrate the some existing database into the new database														
	- To establish a system that can share data maintained by other organizations (INAM, MINAG, etc.)														
A2	To inspect hydrological observation method and observation apparatus/facilities														
A3	To revise H-Q curve														
	(1) To clarify the years of establishing H-Q curve and cross-section survey, existing condition of cross-section, etc. and hydrological station necessary to revise H-Q curve														
	(2) To conduct cross-section survey														
	(3) To conduct discharge observation during rainy season and flooding														
	(4) To make H-Q curve with high water rainge														
A4	To instruct importance and a way of hydrological observation to resident in charge														
A5	To expand hydrological telemetry system (Existing systems are in Limpopo River and Zambeze River basins)	Need													
A6	To continue to utilize GSMaP or GFAS which provide rainfall distribution or flood probability on the web-site in order to deepen the understanding of rainfall features.														
A7	To check the observed data comparing with the last data or the trend, or evaluate deviation from H-Q curve as a habit														
B	Characteristics of River/River Basin														
B1	To well observe satellite image, topography map, river basin on site and to deepen understandings of river and river basin														
C	Structural Measures														
C1	To try to study water related disaster management plan for other river of other flool scale and to conduct relevant training in order to improve the capability	Need													
D	Flood Early Warning System														
D1	To keep the records of observed data, simulation result, alert message, etc. and to review timing of alert issue, alert level, etc. after flood of rainy season.														
D2	To conduct hourly water level observation at Mocuba bridge in order to improve the simulation accuracy														
D3	To establish 24-hour oepration system during flood														
D4	To conduct training on hydrology, hydraulics, river engineering by Auto-IFAS trainers in order to improve the basic engineering capability														
D5	To build the flood early warning system in oher river through the above training														
E	Easiliy Understandable Disaster Information														
E1	To revise the disaster information by review it after flood														
F	Inventory of River Management Structures														
F1	To prepare the inventory for all structures and to continue revising														
F2	To conduct maintenance through inspection and early repair using the inventory														
G	Human Resource and Institutional Development														
G1	To improve staff capacity, secure human resource, quality of work of the new unit of flood & draught in order to strengthen institutional capacity of water related disaster risk management	Need													
G2	To establish new department in charge of maintenance in charge of lead of maintenance works by ARAs, river spatial control, water water use right, ets.														
G3	To incorporate the training syllabus about water related disaster risk management, which made in the Assistance, into the annual training plan of DNGRH														

Source: Assistance for enhancement of institutional capacity to manage water related disaster risks in Mozambique: final report

Table 3-65 Implementation Status of action plan for previous projects

Activities	Technical Support	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
A Hydrological Observation / Hydrological Database														
A1 To establish an integrated hydrological Database - To design a new hydrological database without necessity of license renewal ○ - To integrate the some existing database into the new database ○ - To establish a system that can share data maintained by other organizations (INAM, MINAG, etc.) ×	Need					➢ Have developed and integrated to one database of ARAs。 ➢ Integration with other institution not confirmed								
A2 To inspect hydrological observation method and observation apparatus/facilities △(Done in important observation center by WB project						Size of rainfall observation equipment is not appropriate Observation Inventory has not yet been confirmed								
A3 To revise H-Q curve														
○ (1) To clarify the years of establishing H-Q curve and cross-section survey, existing condition of cross-section, etc. and hydrological station necessary to revise H-Q curve						H-Q carve is organized and checked every year								
× (2) To conduct cross-section survey							Cross section survey is not done							
△ (3) To conduct discharge observation during rainy season and flooding ➢ Not regular but done several times a year ➢ High water discharge observation not done, issue in the previous project														
× (4) To make H-Q curve with high water rainge ➢ H-Q curve is not ready in time of high water														
A4 To instruct importance and a way of hydrological observation to resident in charge No missing data, recognize the importance —(Salary payment from ARA Sul is a issue before the understanding of importance														
A5 To expand hydrological telemetry system (Existing systems are in Limpopo River and Zambeze River basins) ○	Need	Installed in Umbeluzi river												
A6 To continue to utilize GSMaP or GFAS which provide rainfall distribution or flood probability on the web-site in order to deepen the understanding of rainfall features. ○														
A7 To check the observed data comparing with the last data or the trend, or evaluate deviation from H-Q curve as a habit △							Evaluation of water discharge evaluation and H-Qcurve and needs more capacity building							
B Characteristics of River/River Basin														
B1 To well observe satellite image, topography map, river basin on site and to deepen understandings of river and river basin Continuous capacity building needed							Less engineer and difficult to consider the river characteristic , needs for capacity building high							
C Structural Measures														
C1 To try to study water related disaster management plan for other river of other flool scale and to conduct relevant training in order to improve the capability Effective to formulate HM and RM in Maputo Metropolitan area to consider flood risk management plan	Need													
D Flood Early Warning System														
D1 To keep the records of observed data, simulation result, alert message, etc. and to review timing of alert issue, alert level etc. after flood of rainy season. ○ Observation record kept, Needs to review the dam flood control in Umbeluzi														
D2 To conduct hourly water level observation at Mocuba bridge in order to improve the simulation accuracy Not applicable Responsible under ARA Central North														
D3 To establish 24-hour oepration system during flood ○ Telemeter observation done in upstream dam in Umbeluzi river														
D4 To conduct training on hydrology, hydraulics, river engineering by Auto-IFAS trainers in order to improve the basic engineering capability Continuous capacity building needed Not many professor in the area, needs for capacity building high														
D5 To build the flood early warning system in oher river through the above training Continuous capacity building needed Not many professor in the area, needs for capacity building high														
E Easiliy Understandable Disaster Information														
E1 To revise the disaster information by review it after flood ×														
F Inventory of River Management Structures														
F1 To prepare the inventory for all structures and to continue revising ○ Inventory in organized by river facility division														
F2 To conduct maintenance through inspection and early repair using the inventory ○														
G Human Resource and Institutional Development														
G1 To improve staff capacity, secure human resource, quality of work of the new unit of flood & draught in order to strengthen institutional capacity of water related disaster risk management Continuous capacity building needed Expert in river engineering is less and needs for capacity building high	Need													
G2 To establish new department in charge of maintenance in charge of lead of maintenance works by ARAs, river spatial control, water water use right, ets. △ Operation and Maintenance division established														
G3 To incorporate the training syllabus about water related disaster risk management, which made in the Assistance, into the annual training plan of DNGRH △														

*HM: Hazard map; RM: Risk map, ○: Action plan is implemented; △: Action plan partially implemented; ×: Action plan is not implemented

Source: Assistance for enhancement of institutional capacity to manage water related disaster risks in Mozambique: final report

Table 3-66 List of questions and answers on the implementation status of action plans for existing projects (1/6)

No.	Question	Action period	Implementation status*	Answer
A1	Build a hydrological database.	2018-2021	○	- Observations from all stations are properly stored and archived in a hydrological database (Table 3-67).
	(1) Design a hydrological database based on a free license.	2018-2019	○	- All stations are managed in one database (Table 3-67). - The database we are currently using was built before the previous project.
	(2) Integrate data stored in multiple existing databases into a new database.	2019-2020	○	- The database is built at the ARAs, and necessary data can be checked in an Excel table by entering the observation station, observation item, and observation period (Table 3-67).
	(3) Integrate data held by other organizations, such as INAM and MINAG, into this database and establish a system that allows sharing among related organizations.	2020-2021	○	- The database has been built for use within ARAs and is not shared with other institutions. - For example, even in Japan, the Ministry of Land, Infrastructure, Transport and Tourism (Hydrology and Water Quality Database) and the Japan Meteorological Agency (AMeDAS) have not been integrated, so the current database in Mozambique can be considered acceptable.
A2	Inspect hydrological observation methods and equipment for all stations.	2020	△	- The WB project is currently being implemented, although not at all stations (so far 17 stations including the hydrological station on the Limpopo River). - The ARA-Sul hydrological station is being built by several donors, including Germany and Austria. For this reason, there are issues such as different equipment from each donor, which results in different maintenance and management methods, and the inability to manage hydrological stations in one network.

*○: Action plan implemented as planned; △: Partially implemented; ×: Not implemented

Table 3-66 List of questions and answers on the status of implementation of action plans for existing projects (2/6)

No.	Question	Action period	Implementation status*	Answer
A3	Update the H-Q curve.			
	(1) Confirm the year of creation of the H-Q curve currently in use, the status of changes in river crossings, and the current status of hydrological observation facilities.	2020-2021	○	- In the rivers around the Maputo metropolitan area, the H-Q equation changes due to flooding and other factors, so the H-Q equation is updated about once every few years.
	(2) Conduct river crossing survey.	2021-2022	×	River surveying has not been conducted.
	(3) Conduct regular flow observation as well as observation during runoff.	From 2023	△	- Low-water flow observation is carried out using the same observation method and flow calculation method as in Japan, and flow observation is carried out several times a year, although not on a periodic basis. - The H-Q equation itself is also managed in a database, and observation records similar to the flow calculation sheets used in Japan are prepared and stored (Table 3-67). - Observation during runoff (high-water flow observation) has not yet been conducted.
	(4) Create an H-Q curve including the high-water level.	2026	×	- Observation during runoff (high-water flow observation) has not yet been conducted. - In the previous project, we have been using the buoy measurement method, which requires a large number of observers and a large cost burden, so there are issues with the technical cooperation.
A4	The importance of hydrological data will be made clear to the residents to whom the hydrological observations are outsourced, and they will be instructed on the observation method.	From 2021	×	Reports state that is has been very difficult to secure observers because the annual payment for observers is less than 50 USD per station (some stations also dismiss observers in the middle of the year).

*○: Action plan implemented as planned; △: Partially implemented; ×: Not implemented

Table 3-66 List of questions and answers on the status of implementation of action plans for existing projects (3/6)

No.	Question	Action period	Implementation status*	Answer
A5	Promote telemetering of hydrological observations. (Currently being introduced in the Limpopo River basin and parts of the Zambezi River basin.)	From 2021	○	Telemetering has been implemented for two dams on the Umbeluzi River (Pequenos Limbombos Dam) and Incomati River (Corumana Dam) and three hydrological stations (one each on the Umbeluzi River (Goba), Magude River, and Incomati River (Ressano Garcia).
A6	Continue to use GSMaP and GFAS that allow users to check the distribution of rainfall and the probability of flooding on websites, to deepen their understanding of rainfall.	2018-2020	○	- ARA-Sul staff do their own analysis. For example, they do not have software to calculate the probable rainfall, but they use Excel to do so.
A7	Once the flow rate is observed, make it a habit to check its validity by comparing it with the value of the previous observation, past trends, and the consistency with the H-Q curve.	2018-2022	△	- Validity of the data in the database was being checked. - On the other hand, since the flow calculation sheets are handwritten records and there is no evidence of calculation checking, and the H-Q equation is not shown graphically, we believe that the results have not been verified (Table 3-67).
B Characteristics of rivers and river basins				
B1	Deepen the understanding of rivers and river basins by carefully observing and examining them using satellite images, topographic maps, and field observations.	2018-2022	×	- In a situation where even, civil engineers are scarce; it is unlikely that river basin and river channel characteristics are being examined on their own. - Ongoing capacity building is needed.

*○: Action plan implemented as planned; △: Partially implemented; ×: Not implemented

Table 3-66 List of questions and answers on the status of implementation of action plans for existing projects (4/6)

No.	Question	Action period	Implementation status*	Answer
C Structural measures				
C1	Review and develop flood risk management plans for locations and rivers other than the pilot site, as well as for floods of different scales. Conduct training as needed to continue to develop practical skills.	2021	×	- ARA-Sul has not carried out any river works such as continuous embankment, detention basins, or river channel excavation. On the other hand, flood control is being attempted at the Pequenos Libombos Dam on the Umbeluzi River. - Therefore, it is worthwhile to prepare flood hazard and risk maps for the Maputo metropolitan area and study flood risk management plans.
D Flood early warning system (non-structural measures)				
D1	Keep records of observed data, simulation results, and warnings issued /Review and revise the timing of flood warnings and river level warnings after floods.	2018	○	- The observation data is stored in a database. - There is a request to review the dam flood control on the Umbeluzi River.
D2	Monitor the water level hourly at Mocuba Bridge to improve the accuracy of water level prediction.	2021-2023	Excluded	The Mocuba Bridge is under the jurisdiction of ARA Central North.
D3	Establish a 24-hour early warning system for runoff periods.	2024-2026	○	Telemetered stations such as at the upper reaches of the Umbeluzi River Dam are being implemented.

*○: Action plan implemented as planned; △: Partially implemented; ×: Not implemented

Table 3-66 List of questions and answers on the status of implementation of action plans for existing projects (5/6)

No.	Question	Action period	Implementation status*	Answer
D4	Training on hydrology and river engineering will be conducted by hydrology trainers to improve basic technical skills.	2018	×	- In an environment where river engineers are scarce, the efforts of ARA-Sul alone are considered to be limited. - In the first place, there are almost no university professors or other specialists in river engineering in the Mozambican delegation, so capacity building would be beneficial.
D5	Through the above training, build a flood early warning system for other rivers.	2020	×	- Despite the lack of professional personnel and training indicated in D4, they answered that they want to implement telemeter systems at the observation stations, so it can be concluded that they are aware of the problem.
E Easy-to-understand disaster information (non-structural measures)				
E1	After floods, the communication of disaster information and the behavior of residents will be reviewed, and if necessary, the way information is communicated will be revised.	2018-2022	×	➢ A review of the communication of disaster information and the behavior of residents after the flood has not yet been conducted. ➢ On the other hand, they answered that they want to implement telemeter systems at the observation stations, so it can be concluded that they are aware of the problem.
F River management facility ledger				
F1	Maintain a ledger and update it on an ongoing basis.	2018-2020	○	There is a river facilities department, which organizes ledgers.
F2	Carry out maintenance management such as inspections and early repairs using a ledger.	2021	○	- Maintenance and management such as inspections and early repairs are being carried out using the ledger. - On the other hand, we have not been able to directly confirm that they are actually implementing the program.
G. Human resource development and organizational development.				
G1	Improve the technical capacity, staffing and operations of the newly established Flood and Drought Unit to enhance organizational capacity for flood risk management.	2018-2025	×	- In an environment where river engineers are scarce, the efforts of ARA-Sul alone are considered to be limited.

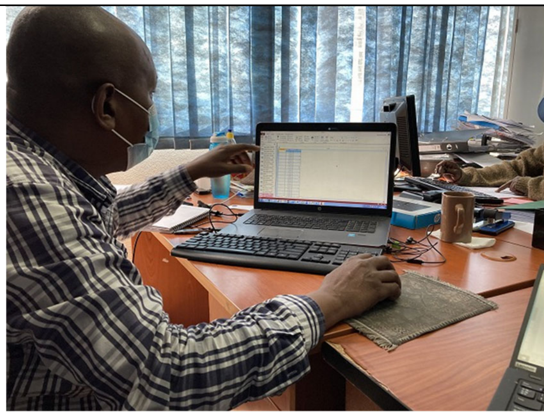
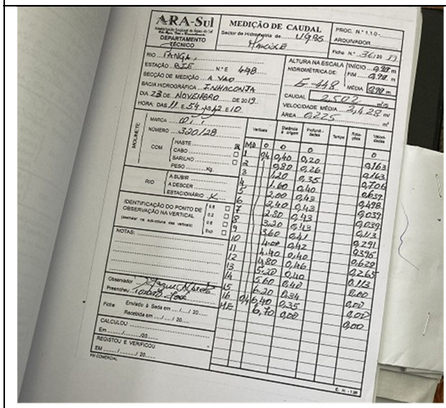
*○: Action plan implemented as planned; △: Partially implemented; ×: Not implemented

Table 3-66 List of questions and answers on the status of implementation of action plans for existing projects (6/6)

No.	Question	Action period	Implementation status*	Answer
G2	Set up a department to oversee maintenance and management and lead the maintenance and management implemented by ARAs, as well as river space management and water rights management.	2026	△	- We have confirmed that the maintenance department has been established. - On the other hand, it has not been possible to directly confirm whether the department is leading the maintenance and management carried out by ARAs and managing river space and water rights.
G3	Incorporate the training plan on flood risk management developed in this operation into the overall DNGRH training plan.	2018	△	- The overall DNGRH training plan has incorporated the technical content acquired in the previous projects. - On the other hand, the content was mainly numerical analysis and not flood risk management.

*○: Action plan implemented as planned; △: Partially implemented; ×: Not implemented

Table 3-67 Examples of action plan implementation for existing projects

 Image of a monitoring station location map in the database	 Image of a daily rainfall data display in the database
 Examples of flow observation results (equivalent to Japanese flow calculation sheets)	

Source: JICA Study Team

c) Organizational capacity (planning, project implementation), flood control policy of C/P

It is assumed that ARA-Sul, which is the river administrator around the Greater Maputo Metropolitan Area, will be the implementing agency for the Greater Maputo Metropolitan Area Flood Countermeasures Master Plan Development Project. For this reason, interviews were conducted on the organizational capacity of ARA-Sul (planning and project implementation) and its flood control policy.

Table 3-68 and Table 3-69 show the results of the interviews, from which the following was found:

1. The organizational structure of ARA-Sul is shown in Figure 3-92. The organizational structure of the ARAs changed in 2020, and accordingly, as of November 2021, the organizational structure of ARA-Sul has changed.
2. The participants of the previous projects were able to explain the contents of their training in Japan and the situation in the rivers they visited and were also able to explain the contents of the practical training on hydrological observation in Mozambique. In addition, the three people who participated in the training are still working, and the colleagues we interviewed understood the content of the training. We believe that they have the organizational capacity to implement the project because they have sufficient knowledge for sharing information within the organization.
3. Through interviews with ARA-Sul, it is believed that the agency does not have a clear flood control policy as of the end of October 2021. One of the main reasons for this is that although they understand the necessity of creating maps of past maximum inundation levels and flood hazard maps, they do not have them, making it difficult for them to quantitatively determine where and what kind of inundation damage will occur.

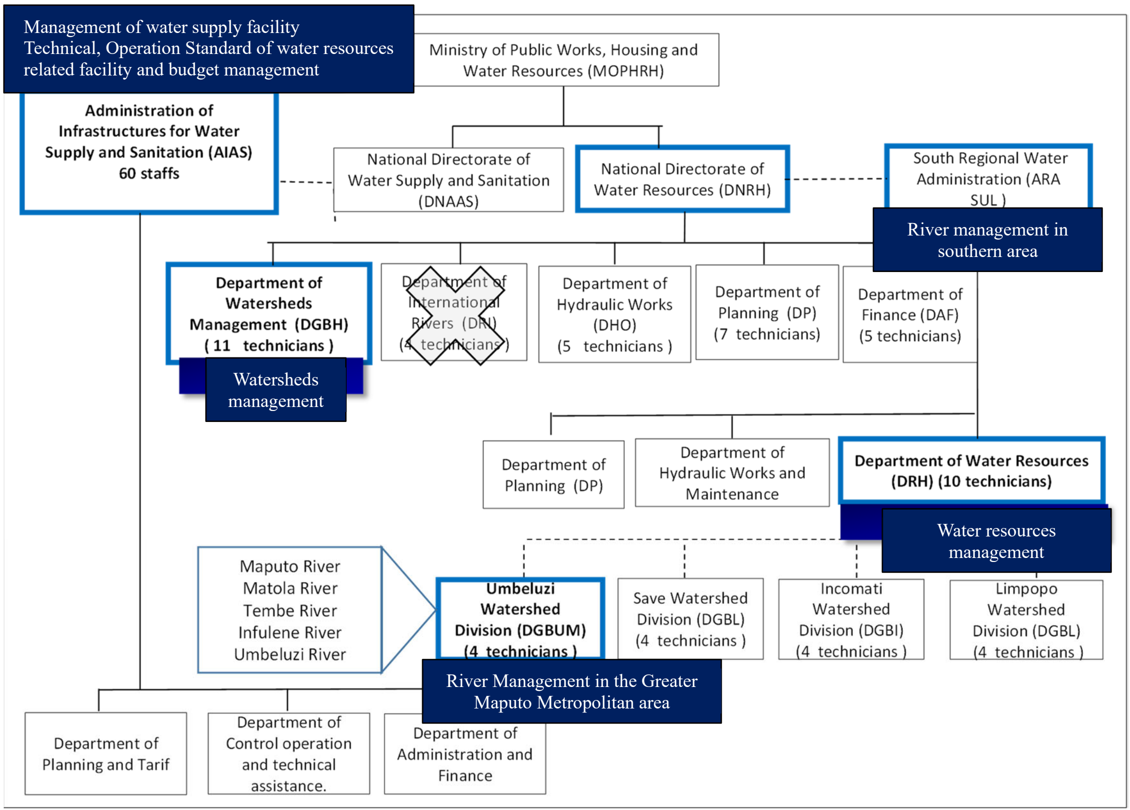


Figure 3-92 Organizational structure of ARA-Sul

Source: Materials provided by JICA Mozambique Office with some additions

Table 3-68 List of questions and findings from answers related to the organizational structure of ARA-Sul (including ARAs)

No.	Questions	Findings from ARA-Sul's answers
1	How many ARAs officers are there as of October 2021?	- The ARAs were previously five regional water management offices (Sul, Centro, Zambezi, Centro-Norte, and Norte), but in 2020, it was changed to three (Centro and Zambezi, and Centro- Norte and Norte were merged respectively, while the jurisdiction of ARA-Sul remained unchanged). Organizational changes within ARA-Sul are still underway. - ARA-Sul does not know the total of number of staff across the ARAs. It is only an estimation, but the two regional water management offices other than ARA-Sul may have around half the number of ARA-Sul's staff each. Therefore, it may be around 700 people.
2	How many of them are back officers like general affairs division and engineers in ARAs?	- ARA-Sul is not aware of the number or ratio of clerical and technical staff across all the ARAs. - Technicians are divided into engineers and technicians, and there are more engineers than technicians. - Engineers are defined as college graduates with at least two years of technician work experience.
3	How many engineers in ARAs have mastered the river engineering and the hydraulics? (JICA Study Team considers that engineers have several specialized fields such as civil engineering (river engineer), machinery, and telecommunications)?	- The majority of the technical staff are civil engineers, with some mechanical and communications engineers. The number of them across all the ARAs or for ARA-Sul specifically could not be confirmed.
4	How many of them are back officers like general affairs division and engineers in ARA Sul?	- The number of staff in ARA-Sul is 362. - There is around 40% clerical staff and 60% technicians, however these percentages may not be fully accurate as the organization is still being reorganized.
5	How many engineers in ARA Sul have mastered the river engineering and the hydraulics?	- In Mozambique, river engineering is not taught in universities. However, new hires these days may have learned something about it while at university.
6	What kind of skills does ARA Sul need at this time? Or what kind of capacity building do you think is needed?	- In Mozambique, aspects of river engineering and management are studied in Geography at the university level. However, since students do not learn about river facilities, capacity building with the help of JICA and other organizations will be necessary. - We do not know of any engineers from ARA-Sul who have participated in previous projects. For this reason, we would like to ask ARA-Sul engineers to strengthen their capabilities.
7	How much is the annual budget for ARAs? GNI in Malawi is 14.9billion USD (2019: WB)	- ARA-Sul is not aware of the annual budget for the entire ARA.
8	How much annual budget can be used for the river work projects and the disaster risk reduction?	- It is not known at this time.
9	How much is the annual budget for ARA Sul?	- The annual budget for ARA-Sul is approximately 200,000,000 MT (358,100,000 yen, 1 MT = 1.79 yen). - ARA-Sul staff salary is 4,500,000 MT/month (8,057,000 yen/month). Personnel costs account for about

No.	Questions	Findings from ARA-Sul's answers
		27% of the annual budget. It cannot be used for anything other than personnel expenses. - The above annual budget is the situation before the COVID-19 disaster, and now that the COVID-19 disaster has occurred, the budget has been reduced.
10	Is there any difference in organizational involvement and budgetary measures depending on whether it is a major river like the Incomati River and the Umbeluzi River or not?	- There are budgetary differences depending on the importance of the river. For example, the budget for the rivers around the Maputo metropolitan area is large because of their importance.

Table 3-69 List of questions and findings from answers on flood control projects by ARA-Sul (including ARAs)

No.	Questions	Findings from ARA-Sul's answers
1	JICA Study Team would like to know the past, on-going and planned river works and structure measures in the Maputo metropolitan area that the ARA Sul has carried out so far.	- Telemetry systems have been installed for two dams; Pequenos Limbombos Dam on the Umbeluzi River and Corumana Dam on the Incomati River; and three hydrological stations (on the Umbeluzi River (Goba), Magude River, and Incomati River (Ressano Garcia). - River works such as continuous dikes, detention basins, and river channel excavation have never been implemented. - The reasons for selecting these three hydrological stations for telemetry systems are as follows. The stations are located at the national borders along the Umbeluzi River and Incomati River to monitor the flow from other countries upstream. The Magude River is for irrigation (especially for sugar farms). Sugar farms in the Magude River basin are an important industry in Mozambique. - The installation of telemetry systems in hydrological stations will continue to be promoted. For example, if telemetry systems are installed at water level monitoring stations, river water levels can be monitored in real time, and an early warning system can be established. Currently, due to manual observation by staff, a water level standard for evacuation preparation and commencement has not been determined.
2	If you have a track record of the river works (structure measures), from what perspective did you decide on that river works (structure measures)? Did the ARA Sul make hazard maps and flood risk maps for the flood risk assessment before the river works (structure measures)?	- They have no experience in river works. - On the other hand, if they have flood hazard maps, they can see where the flooding will occur and can think of countermeasures. - Specific countermeasures could include early warning of rainfall events, land use regulations, and drainage channel measures. However, drainage channel measures are outside the jurisdiction of ARA-Sul.
3	If the ARA Sul has conducted the river works (structure measures), we would like to know the locations/ sections of the rivers which ARA Sul conducted the river works (structure measures).	- They have no experience in river works.
4	If the ARA Sul has conducted the river works (structure measures), what kind of the river works (structure measures) did ARA Sul conduct such as dikes and retarding basins?	- They have no experience in river works.
5	Does the ARA Sul have flood hazard maps not only the 13 major rivers but also the Infulene River?	- ARA-Sul has not prepared flood hazard maps. - The area around the Incomati River occasionally floods when the water from South Africa is high. Other factors include flooding due to high tide levels.
6	Does the ARA Sul have flood risk maps not only the 13 major rivers but	- No flood risk maps have been prepared for ARA-Sul, but maps for Ka-Tembe and

No.	Questions	Findings from ARA-Sul's answers
	also the Infulene River?	Ka-Mhaka have been prepared by INGD. - The cities of Maputo and Matola and the DNGRH possess the same maps.
7	If the ARA Sul doesn't have the flood hazard maps, does the ARA Sul utilize the inundation area map such as the global flood model?	- ARA-Sul has not utilized the maps so far. - As shown in Table, ARA-Sul would also like to learn modeling techniques and create flood hazard maps.

d) Implementation status of hydrological observation and surveying in river basins around the Greater Maputo metropolitan area.

In the previous JICA projects, activities related to the following seven areas have been implemented.

A. Hydrological observation/hydrological data

B. Characteristics of Rivers and River Basins

C. Structural measures

D. Flood early warning systems (non-structural measures)

E. Easy-to-understand disaster information (non-structural measures)

F. River management facility database

G. Capacity development and organizational development

In particular, since "A. Hydrological Observation/Hydrological Data" is the most important activity in the previous JICA project, we conducted detailed interviews on its implementation status（Table 3-70 and Table 3-71).

Table 3-70 List of questions and findings from answers regarding hydrological observations of ARA-Sul

No.	Questions	Findings from ARA-Sul's answers
1	How many rainfall stations are there in Mozambique? Also, JICA Study Team would like to get the location map of rainfall stations such as GIS data.	- GIS is used to manage the rainfall at monitoring station locations and other information nationwide (Figure 3-93). The GIS data itself is produced by CENACARTA, which is also used by ARA-Sul. - Separate rainfall stations have been set up for INAM and ARAs.
2	What kind of the rainfall instrument does the ARA Sul use, normal rain gauges or tipping bucket rain gauges?	- Most of them are ordinary manual rain gauges. - In ARA-Sul, there is one AWS station located upstream of the Pequenos Limbombos dam on the Umbeluzi River.
3	Is the rainfall observation data properly stored such as an annual record of rainfall? And is the stored data the digital(soft) data or paper data?	- Observations from all stations are properly saved and stored digitally. - The database is built at the ARAs, and necessary data can be checked in an Excel table by entering the observation station, observation item, and observation period (Table 3-67).
4	How many river water level stations are there in Mozambique? Also, JICA Study Team would like to get the location map of river water level stations such as GIS data.	- As in No. 1, the location information of water level monitoring stations across the country and other information is managed by GIS (Table 3-73).
5	Is there an automatic river water level gauge at the river water level stations? Is it mainly observed with a manual gauge?	- The water level monitoring stations only uses a water level marker (Table 3-73).
6	Is the river water level observation data properly stored such as an annual record of the river water level? And is the stored data the digital(soft) data or paper data?	- As in the case of rainfall stations (No. 3), observation values of all the stations are properly stored and kept digitally (Table 3-67).
7	How many river discharge stations are there in Mozambique? Also, JICA Study Team would like to get the location map of river discharge	- Flow observation in Mozambique started in 1990, and like No. 1, it is managed using GIS.

No.	Questions	Findings from ARA-Sul's answers
	stations such as GIS data.	
8	How does the ARA Sul observe the river discharge?	- Flow observations are made using either ADCP current meters or one of two types of Price-type current meters. - Since the ADCP and the Price-type current meters are used, high-water flow during floods has not been observed, and only low-water flow has been observed during normal times. (On the other hand, they answered that the flow observation values were recorded for understanding the flow rate during irrigation and droughts, so it is possible that only low-water flow observation has been conducted since this is the main focus.) - They were not aware of the buoy method of high-water flow observation that is used in Japan because as they had not participated in previous projects. - The rivers around the Maputo metropolitan area are inhabited by crocodiles, but as long as there are several low-flow observation staff working together, they will not be attacked by crocodiles. No casualties have been reported so far.
9	How is the river discharge calculated?	- The low-water flow observation is calculated using almost the same observation method and flow calculation as in Japan. - As shown in No. 10 below, the H-Q equation itself is managed in a database. Not only that, but we were able to confirm that they had created and kept a record of their observations, similar to the flow calculation sheets used in Japan (Table 3-67).
10	Does the ARA Sul have the H-Q curve at each river discharge station?	- A database has been built, which can be checked like an Excel table by entering the observation stations and observation items. - In the rivers around the Maputo metropolitan area, the H-Q equation changes due to flooding and other factors, so it is updated about once every few years. - On the other hand, since the flow calculation sheets are hand-written records and there is no evidence of calculation checking, and the H-Q equation is not shown graphically, we believe that the results have not been verified. There are also issues with verification as there is the possibility that the observed values and H-Q equation are incorrect.
11	What have been improved or newly implemented since the previous JICA project?	- In Mozambique, there are no observation standards or manuals published by government agencies such as ARA-Sul, and the standards of Portugal are used in the field. It was mentioned that different rivers and regions have different manuals to refer to.

Table 3-71 List of questions and findings from answers regarding the use of ARA-Sul hydrological observation results

No.	Questions	Findings from ARA-Sul's answers
1	What has the ARA Sul used the observation data for?	- It has been used to monitor river flows during irrigation and droughts. Low-water flow observations are conducted for these purposes.
2	It is recognized that Mozambique government such as INAM has been observing rainfall properly for more than 50 years. For example, have you not conducted statistical analysis such as probability rainfall scale using these observation data?	- The ARA-Sul staff are also conducting analysis. - For example, it was mentioned that they do not have software to calculate the probability rainfall scale, but they calculate it themselves using Excel.
3	Are the river water level and river discharge data useful for countermeasures against not only the flood disaster but also the drought?	- As with No. 1, it is being used for irrigation and for monitoring river flow during droughts. Low-water flow observations are conducted for these purposes.
4	Isn't the dam outflow controlled from the river water level and river discharge data at the stations located at the downstream of the dam?	- They have used the data for the Umbeluzi River during the February 2021 flood. Specifically, there was flooding damage downstream of the Pequenos Limbombos dam. At this time, the dam on the Umbeluzi River was used to control floods and reduce damage from flooding. - On the other hand, since the effectiveness of dam flood control has not been verified and publicized as is the case with dam managers in Japan, verification of the effectiveness of dam flood control will help clarify the need for flood control.

Table 3-72 List of questions and findings from answers on river surveying by ARA-Sul

No.	Questions	Findings from ARA-Sul's answers
1	Have ARA Sul been conducting river surveying, for example regular cross-sectional surveying?	- No cross-sectional surveying has been conducted by ARA-Sul. - We believe that the situation will be similar for other ARAs. - Although there are cross-sectional survey results from low-water flow observation, there are no standard reference points for measuring levels and reference points for high water levels are not being managed. Therefore, it can be concluded that there are actually no reliable cross-sectional survey results. - On the other hand, staff mentioned that cross-sectional surveying results are necessary for inundation analysis, etc., so it can be concluded that they understand their necessity and how to utilize them.
2	Is there any standard or manual for ARA Sul regarding river surveying?	- As with hydrological observations and river planning, there are no standards or manuals unique to Mozambique, but those of Portugal are used as a reference. - The ARAs do not necessarily conduct hydrological observation and river planning in the same way.

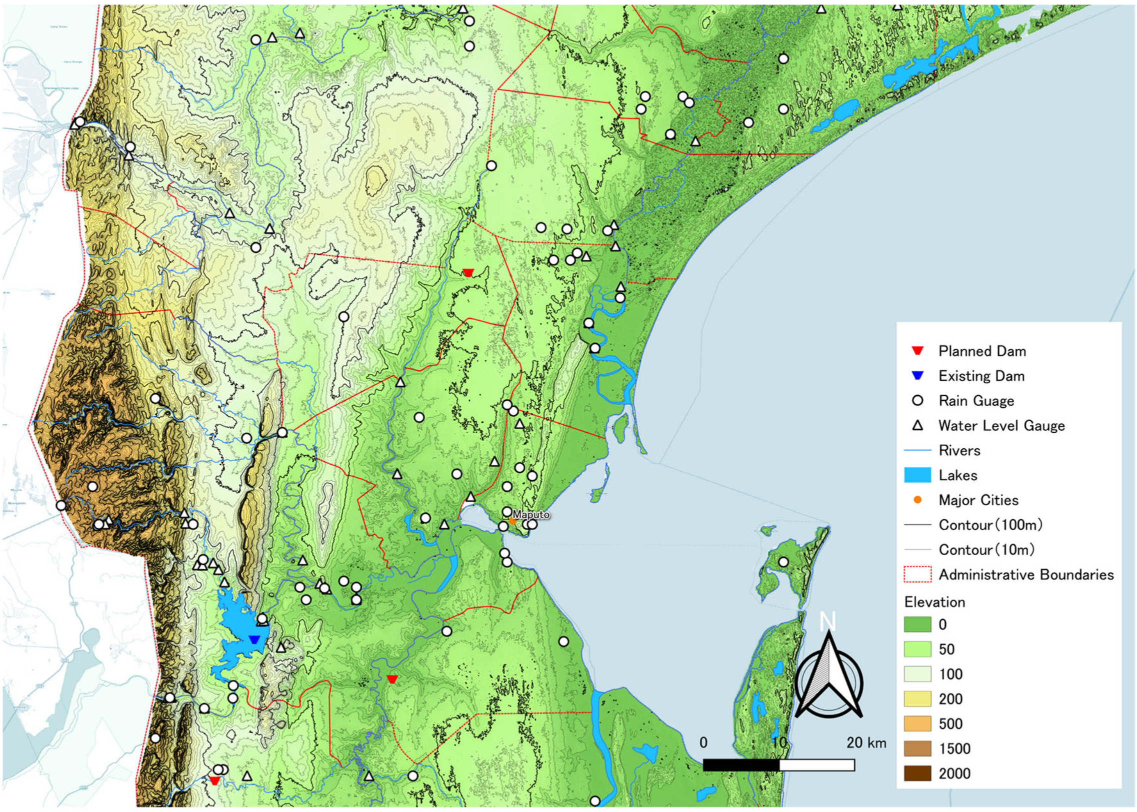


Figure 3-93 Hydrological stations under the jurisdiction of ARA-Sul around the Greater Maputo metropolitan area

Source: ARA-Sul

Table 3-73 Examples of water level monitoring stations

 Manual water level monitoring station on Umbeluzi River	 Manual water level monitoring station on the Umbeluzi River (crocodile warning sign)

Source: JICA research team

The challenges for hydrological observation based on the field survey are as follows.

Compared to other donors, one of the distinctive characteristics of Japanese cooperation for river flood control projects and integrated water resources development and management is that river plans are formulated based on proper observations (for example, the accuracy of studies using numerical analysis results can only be discussed through comparison with observed values).

Although ARA-Sul has been diligently conducting rainfall, river level and river flow observations, the following issues have been identified:

Rainfall observation

1. Rainfall observation stations are not located according to river systems. (For example, in Japan, locations are based on the results of previous observations, and the area to be observed is divided into regions of approximately 50 km2. One station is set up in each region, based on the assumption that rainfall conditions will be uniform for each 50 km2 area.)
2. Only daily rainfall observation has been conducted, and hourly rainfall observation, which is necessary for studying the formulation of flood control plans, has not been continuously conducted.
3. Proper maintenance of self-registered rain gauges and ordinary rain gauges has not been possible due to budget shortage.
4. Due to budget shortage, observed values are not being verified.

River water level observation

1. Water level monitoring stations are not located at important points that would form a suitable observation network for the entire river system. (For example, before and after the divergence and confluence of important tributary rivers, upstream and downstream of weirs, sluice gates, dams, etc., flow observation points, and points necessary to know the hydraulic conditions at contractions, etc.)
2. Hourly river water level observations are not continuously conducted. Observations are performed 3 times per day during normal times and 5 times per day during floods. The peak flood water level, which is essential for flood control planning studies, cannot be measured.
3. Due to the lack of experience in conducting river surveying, reference levels for water level monitoring stations have not been set.
4. Due to budget shortage, proper maintenance of self-registered water level gauges and water level markers has not been possible.
5. Due to budget shortage, observed values are not being verified.

6.

River Flow Observation

1. Monitoring stations are not located at points that are important for river planning/management and flood control planning (e.g., upstream and downstream of dams, and areas corresponding to flood control reference points).
2. The peak flow rate during floods, which is essential for flood control planning, has not been continuously observed (high-water flow rate observation has not been conducted in the first place).
3. Due to budget shortage, observed values are not being verified.

In order to provide cooperation and support to the Maputo metropolitan area in the future through a proper Japanese-style river project, these issues need to be resolved.

Hydrological observations are statistical data and must be carried out continuously at the same point without missing measurements. In addition, it is necessary to use the same method as much as possible (especially for high-water flow observation) so that the accuracy of observed values does not vary from river to river or station to station.

Based on these methodological principles, the following measures for river level and flow observation have been developed and studied by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) since 2012, and were put into practical use around 2016. They are also fully applicable to Mozambique. Rainfall observation is omitted here because the only way to observe rainfall is to install a tipping bucket rain gauge as is used in Japan.

For river water levels, the development of an observation network using 3 L (Low cost, Long life, Localized) water level meters is mentioned. The 3 L water level gauge is a localized version of the crisis management water level gauge that is used in Japan. It is specialized for flood monitoring and costs around t 1/10 of the price of conventional gauges. This water level monitoring network using 3 L water level gauges is an extremely useful technology that was introduced at the 7th Tokyo International Conference on African Development (TICAD7, 2019), and is also listed in the Ministry of Land, Infrastructure and Transport's “Infrastructure Exports, 2021.”

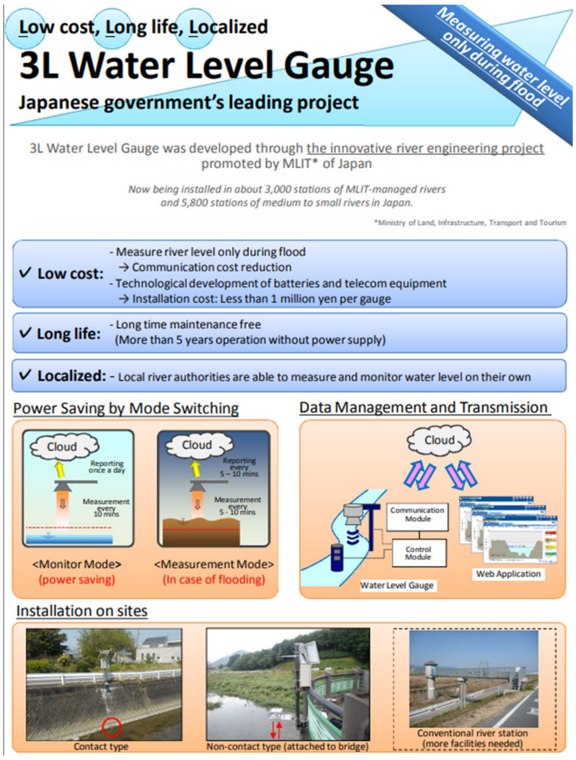


Figure 3-94 Overview of the 3L Water Level Gauge

Source: Ministry of Land, Infrastructure, Transport and Tourism

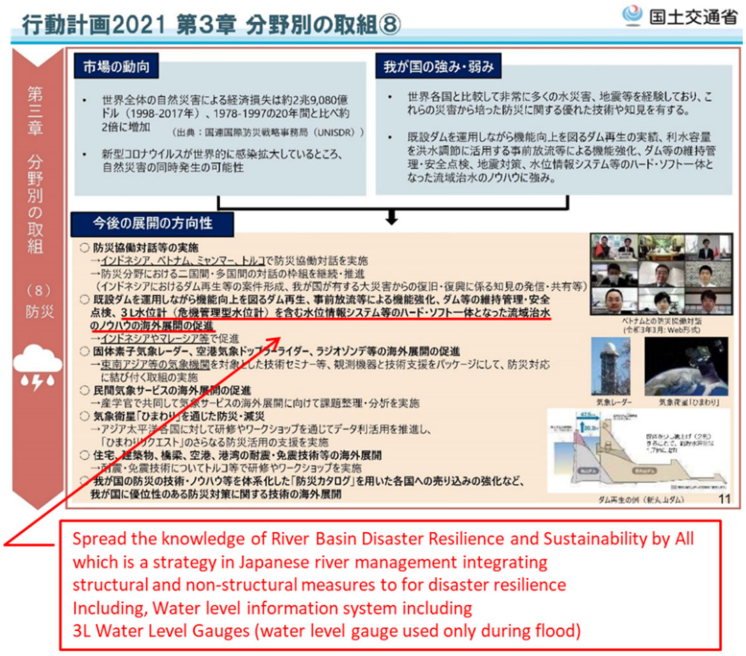


Figure 3-95 3L Water Level Gauge mentioned in the strategy to spread the knowledge in Japan

Source: Ministry of Land, Infrastructure, Transport and Tourism

In regard to river discharge monitoring, it is important to conduct high-water flow observation, which is required by the Greater Maputo Metropolitan Area River Management Master Plan Development Project. It would therefore be effective to popularize high-water flow observation by image analysis instead of the conventional buoy measurement method (observation using floats).

In Japan, as of February 2022, high-water flow observation using the floatation method is still the main type. This is because of the following reasons:

- The observation of high-water flow rates using floats started in the early Meiji era, and the continuity of the observation data is important.
- The buoy measurement method is a method to measure the time taken by a buoy to flow down a certain section to obtain the average velocity of the section. The steepness of Japanese rivers results in high velocities during floods and a large number of debris and driftwood. The buoy measurement method has the advantage of being able to reliably measure the flow velocity of a river even under such severe conditions during floods.

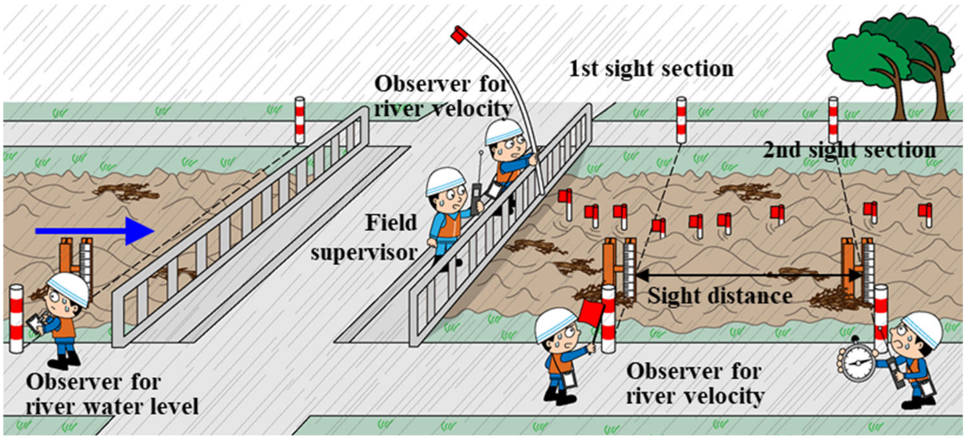


Figure 3-96　Image of the buoy measurement method

Source: JICA research team

On the other hand, due to the severe flooding in recent years, there have been situations in Japan where it has been difficult to monitor using the flotation method, such as when bridges have been flooded at flow monitoring stations (Table 3-74). In addition, with the declining birthrate and aging population, the number of companies handling orders for hydrological observation services is decreasing and there are many unsuccessful projects, and the expenses related to hydrological observation are putting pressure on the budget.

Table 3-74 Examples of conditions based on recent high-water flow observations in Japan

 Bridge flooded by floodwaters and closed to traffic	 Past maximum (observation at the water pipe bridge is dangerous)	 Bridge flooded by floodwaters and closed to traffic

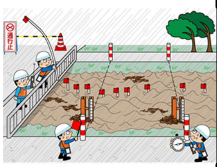
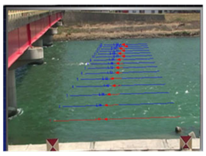
Source: Ministry of Land, Infrastructure, Transport and Tourism

For this reason, various types of current meters have been developed in recent years as alternatives to floats and have become widely used.

In Mozambique, there is no need to use the same buoy measurement method as in Japan since high-water flow observation has never been done before.

In the case of ARA-Sul (and ARAs), where budgets and observers are scarce, an image analysis method that can solve these problems and calculate the flow rate as accurately as the buoy measurement method is very useful. This image analysis method has already been put to practical use by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) in its study on upgrading flow observation.

Table 3-75　List of current meters used in high-water flow observation

	Swim buoy	Image analysis	Radio flow meter	ADCP
Image/Photo				
Flow rate observable range	No limitation	From 0.5m/s	From 0.5m/s	To 3.0m/s
Observed flow velocity	Average flow velocity of buoy	Water surface velocity	Water surface velocity	Cross-sectional distribution of flow velocity
Cost (equipment only) (10,000s of yen / 1 observation station)	10 to 100 (Per flood)	5–10	100	800
Required observation staff	5–6	0	2–3	5–6
Status of use in Japan*	○	○	△	×

*0: Used in many stations, △: Used in a few stations, ×: Not used

Source: JICA research team

6） Study on technical cooperation for the safe operation and management of four dams around the Maputo Metropolitan Area

On August 11, 2021, proposal project concept note from ARA-Sul titled "Modernization of Dam Safety Features of ARA-Sul Dams" was submitted and discussions on technical cooperation was conducted.

a) Contents of the project concept note

The project concept note consists of the following three cooperation requests:

1） Observation system and instrumentation diagnosis
2） Safety Control Instruments
3） Capacity Building

b) Current status and challenges of four dams around Greater Maputo Metropolitan Area

Target four dams are Massingir Dam, Macarretane Dam, Corumana Dam, and Pequenos Limbombos Dam, which are multipurpose dams (Figure 3-97 / Table 3-76, Table 3-77).

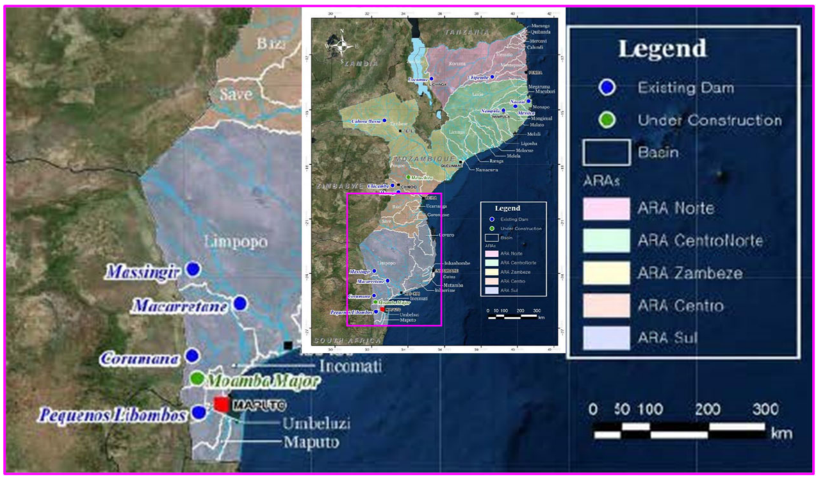


Figure 3-97 Location map of the four target dams in the request

Source: Development of Master Plan (MP) for Water Resources Management in Mozambique, pp.3-42, DNGRH, 2018

Table 3-76 List of specifications of the four target dams in the request

Dam	province	District	River	Completion Year	Dam Type	Specifications			Purpose*			
						H (m)	L (m)	Total Storage (Mm^3)	IRR	WS	FC	HP
Massingir	Gaza	Massingir	Elefantes - Limpopo	1976	Rock-fill	47	4,630	2,256	×		×	×
Macarretane	Gaza	Chirrunduo	Limpopo	1956	CGD	25	651	15	×	×		
Corumana	Maputo	Moamba	Sabie-Incomati	1988	Earth-fill	46	3,185	1,273	×		×	×
Pequenos Limbombos	Maputo	Boane	Umbeluzi	1987	Earth-fill	46	1,540	400	×	×	×	

*IRR: Irrigation, WS: Water Supply, FC: Flood Control, HP: Hydro Power

Source: Development of Master Plan (MP) for Water Resources Management in Mozambique, pp. 3-42, DNGRH, 2018

Table 3-77 Four target dams in the request

 Massingir Dam（Elefantes-Limpopo）	 Corumana（Sabie-Incomati）
 Macarretane Weir（Limpopo）	 Pequenos Limbombos Dam（Umbeluzi）

Source: Development of Master Plan (MP) for Water Resources Management in Mozambique, pp. 3-40, DNGRH, 2018.

In order to understand the current status of these four target dams, interviews with Mr. Fernando Miguel, the engineer in charge of ARA-Sul dam management (Table 3-78) was conducted. From this interview, the following point was identified.

- The main purpose of the four target dams is irrigation and water supply use, not flood control (No. 4 in Table 3-78).
- A survey in the dam lake has not been carried out, and the water level-reservoir volume (H-V curve) used is assumed to be the one taken at the time the dam was completed. As a result, it has not been possible to quantitatively determine the extent of sediment deposition.
- As a result, ARA-Sul believes that the accuracy of the H-V curve is low and that the accuracy of the dam inflow, which is calculated using the curve and the discharge volume, is low.
- Observed values of dam inflow and discharge are daily data, not hourly data. Hourly data acquisition, such as that being performed at the Pequenos Limbombos Dam on the Umbeluzi River, is considered essential to control floods that last for around one day.
- From the current status of the observation system, instruments, and safety control equipment (Table 3-79 エラー！参照元が見つかりません。), it is clear that maintenance is weak, with many of the instruments in disrepair or having not been installed since construction was completed. On the other hand, the request from Macarretane Dam (Limpopo River) is to examine which instruments need to be installed and install them.
- As for capacity building, the request includes strengthening the lack of monitoring capacity for observation systems, observation equipment, and safety control equipment. For example, comprehensive capacity building for dam maintenance and measurement, including surveying, is thought to be essential.

Table 3-78 List of questions and answers to ARA-Sul (1/3)

No.	Questions	Findings from ARA-Sul's answers
1	Please tell JICA Study Team which country supported the Macarretane Dam (Limpopo River), Massingir Dam (Limpopo River), Pequenos Libombos Dam (Umbeluzi River), and Corumana Dam (Incomati River).	- The Macarretane Dam is supported by Portugal, the Massingir dam by France, and Pequenos Libombos Dam and Corumana Dam are supported by Italy.
2	JICA Study Team would like to know the dam parameters / dam specifications of each dam as follows: 1) dam water level (design flood level, surcharge water level, constant full water level, minimum water level, flood period limit water level) 2) water storage capacity (effective water storage capacity, flood control capacity, water utilization capacity, sedimentation etc.)	- There are reports prepared by the consultant and these will be provided (Development of Master Plan (MP) for Water Resources Management in Mozambique, DNGRH, 2018.) - The survey team confirmed that the basic dam specifications shown on the left were included in the report.
3	How much water volume (m^3) of flood control capacity is secured (or what percentage of the total water storage capacity) in each dam?	- Reports prepared by consultants are available and these will be provided (as with No. 2). - For example, the Pequenos Libombos Dam (on the Umbeluzi River) has never reached 100% of its total storage in recent years and is water scarce (90% at most in 2020). We believe this is due to the effects of climate change. Therefore, there is ample room for flood control.
4	How has the ARA Sul used the data such as dam outflow and dam inflow that you have observed so far?	- Inflows for the Pequenos Libombos Dam are particularly important because it supplies water to the Maputo metropolitan area. - Inflows are also important for the Macarretane, Massingir, and Corumana dams as their main purpose is irrigation.
5	How has the ARA Sul stored the observed data? Has the ARA Sul stored electronic data such as Excel files and text data?	- As with rainfall and water level observation data from rainfall and water level monitoring stations, the data is stored and preserved in a database.
6	Please tell us about the sedimentation status in each dam. For example, sedimentation has already progressed to the extent that the dam capacity cannot be secured, and the amount of sediment flowing into the dam is small.	- Four dams, Macarretane Weir (Limpopo River), Massingir Dam (Limpopo River), Pequenos Libombos Dam (Umbeluzi River), and Corumana Dam (Incomati River), do not have dam capacity problems due to sedimentation at this time. - The 2020 Environmental Assessment Survey Report recognized that the Pequenos Limbombos Dam had very low sedimentation, but low dam flow rate accuracy compared to the four targeted dams. - When we asked for details on why the amount of sediment in the dam was low, the answer was that they had not checked the results of surveying in the dam lake over the

No.	Questions	Findings from ARA-Sul's answers
		years but had just relied on the results of the environmental assessment conducted by consultants.
7	Whether surveying inside the dam lake is carried out, for example, after a cyclone or heavy rain, even if not every year (since it is necessary to know the amount of sedimentation, the water level-capacity curve used when calculating the inflow of the dam Because it is necessary to update HV) every year).	- Foreign consultants and other donors are surveying in the dam lake, but ARA-Sul and domestic engineers do not understand the survey method. - We do not know exactly if the H-V method they are using now is correct, but they are aware that accuracy for measuring inflow is low and would like to see capacity building for the surveying method.

Source: JICA Study Team

Table 3-78 List of questions and answers to ARA-Sul (2/3)

No.	Questions	Findings from ARA-Sul's answers
8	Is it possible to show the operation regulations of the dam?	- It is possible (the document should be owned by the dam manager, but the report prepared by a consultant was provided to the study team by ARA-Sul).
9	Do the dam operation regulations describe how to implement flood control?	- It is described.
10	What kind of dam operation have you done during the flood? Have you ever implemented flood control?	- Flood control has been implemented in the past. - They have used the data for the Umbeluzi River during the February 2021 flood. Specifically, there was flooding damage downstream of the Pequenos Limbombos dam. At this time, the dam on the Umbeluzi River was used to control floods and reduce damage from flooding.
11	When the ARA Sul conducts the dam operation for the flood control, we think that the ARA Sul will control the dam outflow discharge while looking at the predicted precipitation value and the weather forecast. Please tell us when to start the flood control, how much water should be stored in the dam, and when to stop flood control.	- Flood control is carried out while monitoring the forecasted rainfall. Rainfall estimates are provided by INAM. - We were asked to refer to the dam operation rules to find out when flood control should be started and stopped.
12	Are you using rainfall forecasts while operating the dam? Also, how do you predict the inflow of dams (is it calculated from rainfall in the runoff model, or is it predicted from the rise in the water level of the inflowing river?)	- Rainfall forecasting is used. As shown in No. 11 above, rainfall forecast values are provided by INAM. - The prediction of the dam inflow is based on the observations of the water level monitoring station upstream of the dam. - We informed them that dam inflow cannot be predicted by using only one water level monitoring station upstream of the dam (because dam inflow cannot be determined based on only one inflowing river).
13	Are you monitoring the downstream river water level in real time when the ARA Sul conduct the dam operations for the flood control? Also, do you check the real-time river water level when operating the dam?	- They are conducting real-time monitoring of river water levels downstream. - However, occasionally there is flooding downstream of the dam due to mismanagement of the dam discharge. - Monitoring at the water level monitoring station downstream of the dam is performed visually by observers five times a day (not hourly). Furthermore, since the river has not been surveyed, the current flow capacity and the speed of water level rise are not known at all, so in effect, flood control is based on general approximations.
14	Do you think it is necessary to review the dam operation regulations during floods, including flood control capacity?	- They believe that dam operation needs to be reformed. - For example, in the past, discharge gates were not installed in dams, but in

No.	Questions	Findings from ARA-Sul's answers
		recent years, some dams have been equipped with discharge gates. Other than that, some facilities are being updated every year. - In addition to this, Corumana Dam has installed water supply facilities for drinking water in 2020, which need to be revised.

Source: JICA Study Team

Table 3-78 List of questions and answers to ARA-Sul (3/3)

No.	Questions	Findings from ARA-Sul's answers
15	What is the main purpose of each dam? Power generation, irrigation, flood control (I think we should check this first)	- Purposes of dams are as follows. - The Macarretane Dam (Limpopo River) is purely for irrigation purposes. - The Massingir Dam (Limpopo River) is for irrigation purposes and is not generating electricity as the turbine is currently out of order. - The Pequenos Libombos Dam (Umbeluzi River) is used primarily for water supply to the cities of Maputo and Matola. The water is used for drinking water and irrigation, and electricity is generated when the water is discharged. - The Corumana Dam (Incomati River) is used for irrigation purposes.
16	When are you operating the dam outflow discharge? (Flood or drought?)	- Discharge operations are conducted both during floods and droughts.
17	Which operation is most important during floods or droughts? (Is it a concern, is it struggling?)	- They are aware that both are important.
18	How much time scale is the operation during flood (gate operation)? (Is it necessary to adjust the gate opening every few tens of minutes like a Japanese dam? Is it a time scale operation that changes the gate opening every day?)	- It is controlled depending on the flood situation and the amount of dam inflow; however, gate opening is not performed at the same speed as in Japan. - The Pequenos Libombos Dam is operated at 4 min/m because the gate sluice is small.
19	Dams are old in 1956 (Macarretane Dam, Limpopo River), 1976 (Massingir Dam, Limpopo River), 1987 (Pequenos Libombos Dam, Umbeluzi River), 1988 (Corumana Dam, Incomati River). Please tell us what kind of dam management you have been doing so far.	- Dams are classified by year of completion, but no further management is done. - Table 3-78 No.7 of 2/3, they would like assistance in capacity building.

Source: JICA Study Team

Table 3-79 List of current status related to observation system, observation equipment, and safety control equipment

Topic	Corumana Dam	Pequenos Libombos Dam	Massingir Dam
Surface Landmarks	Out Service	Out Service	Defective
Assistimeters	Defective	Not Installed	Not Installed
Inclinometers	Defective	Not Installed	Not Installed
Repression Meters	Not Installed	Not Installed	Not Installed
Electropneumatic Piezometers	Defective	Good Operation	Good Operation
Relief Wells		Good Operation	Almost In Operation (Partial Defective)
Gallery Drains		Good Operation	
Neutral Tention Cells		Good Operation	
Seismmetric Accelerographs		Not Installed	Not Installed
Vertical Drains in Dam Gallery	Defective		Good Operation
Full Voltage Cells	Defective		
Vertical drains in the dam bottom outlet	Defective		
Secondary drains	Defective		Good Operation
Flow Meter	Defective		Good Operation
Flow Measurement Chambers	Good Operation		Good Operation
Dam Portela Dike Instrumentation	Not Installed		
Sismological Station	Not Installed		
Total Station	Not Installed	Not Installed	Not Installed

3.2 Madagascar

3.2.1 Disaster Risk Profile

(1) Qualitative Evaluation of Hazard Distribution

1) Situation of Hazard Distribution in Madagascar

The hazard data described in "2.1.2 How to identify overview of disaster risk" was visualized in GIS to identify the profile of hazard as shown in the figure below.

- The flood inundation area east of the Eastern Range is large, while the flood inundation area west of the Eastern Range is small.
- Cyclones have a large area of influence over the northeast and hazard of strong wind is high. Some cyclones approach from the Mozambique Channel, so there is the possibility of storm surge damage in almost all coastal areas.
- There are large flood inundation areas downstream of rivers flowing west of the Eastern Range. In addition, the capital, Antananarivo, is located on a high plateau, but as urbanization expands, there is a possibility that flood damage in the surrounding areas will increase.
- Eastern mountainous areas have high landslide potential.

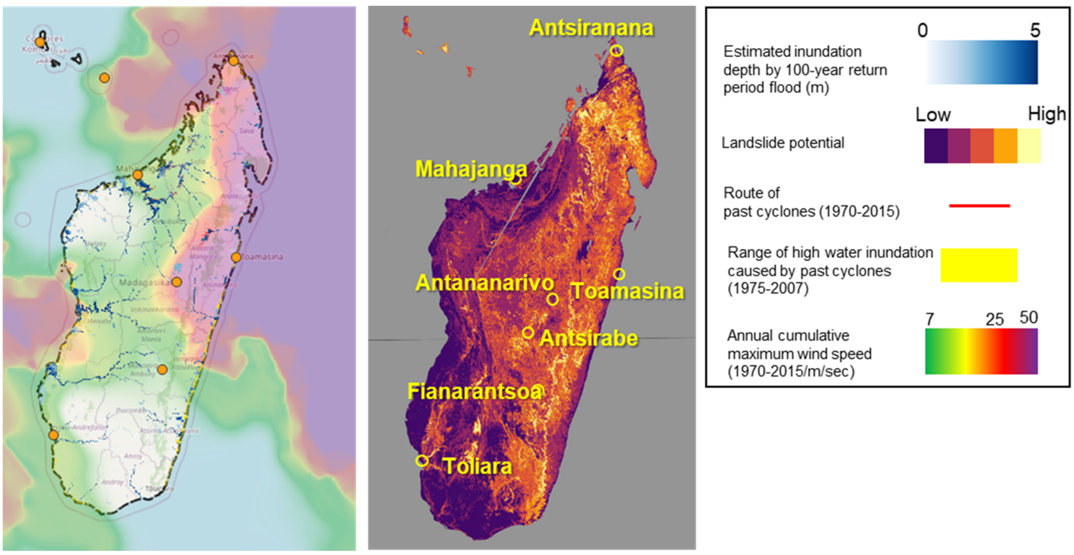


Figure 3-98 Hazard distribution in Madagascar
Source: Each data source is listed in Chapter 2, Open Street Map (background map)

2） Situation of Hazard Distribution in Major Cities of Madagascar

Situation of hazard distribution in each major city was identified according to the criteria shown in "2.1.2 Basic Idea and Methodology to Identify Disaster Risk Profile ". The population of major cities was confirmed based on UN-Habitat and World Population Review, and the major cities with large population sizes were sorted out.

Table 3-80 Hazard status in major cities in Madagascar

City name	Population size (thousand pers0n)	Hazard Status			
		Flood	Cyclone	Storm Surge	Landslide
Antananarivo	3,368	✓	✓✓✓	–	✓✓
Toamasina	434	✓✓	✓✓✓	✓✓✓	✓
Antsirabe	356	✓	✓✓	–	✓✓
Fianarantsoa	167	✓	✓✓	–	✓✓
Mahajanga	155	✓✓	✓✓	✓✓✓	–
Toliara	115	✓✓✓	✓✓	✓✓✓	–
Antsiranana	83	✓	✓✓✓	✓✓✓	✓

a) Antananarivo

Antananarivo is a capital city located in central Madagascar and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "✓✓" inundation area is distributed in the city area along the Ikopa river (Figure bellow (1)). Storm surge hazard was evaluated as "-" since it is an inland city. Hazard of the strong wind was evaluated as "✓✓✓" since the Annual accumulative wind speed is over 25m/sec (colour in red to purple) broadly in the city (Figure bellow (5)). Landslide hazard was evaluated as "✓✓" since area with high landslide potential score over the medium level exists in the southern area (Figure bellow (2)).

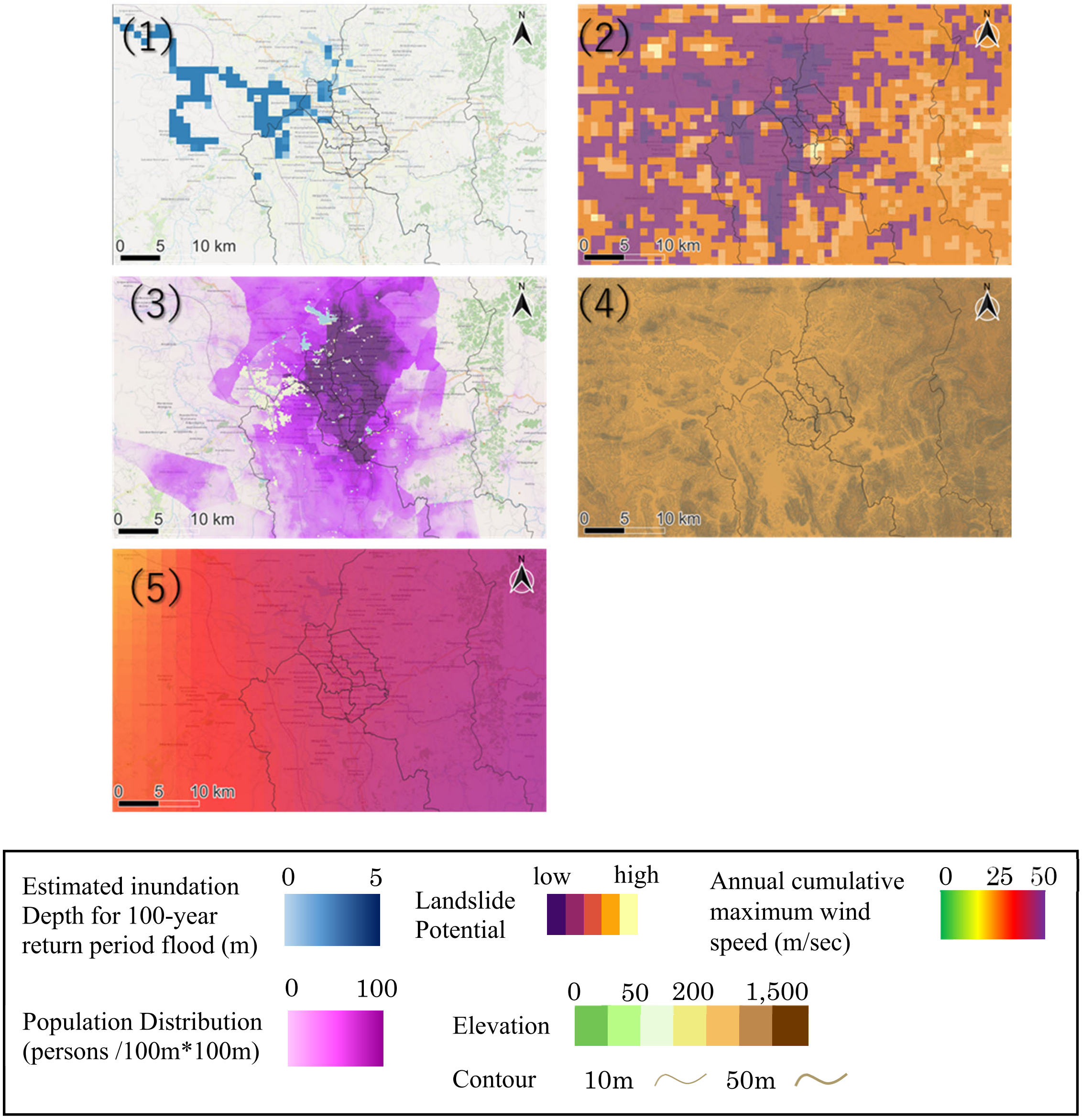


Figure 3-99 Situation of Hazard Distribution in Antananarivo

Source: JICA Study Team

b) Toamasina

Toamasina is a city located in eastern coast of Madagascar and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "✓✓" inundation area is distributed in the city area along the Ivondro river (Figure bellow (1)). Storm surge hazard was evaluated as "✓✓✓" since the inundation area is distributed broadly (Figure bellow (6)). Hazard of the strong wind was evaluated as "✓✓✓" since the Annual accumulative wind speed is over 25m/sec (colour in red to purple) broadly in the city (Figure bellow (5)). Landslide hazard was evaluated as "✓" since area with high landslide potential score over the medium level do not exist in the urban area but in the mountain area there area with high landslide potential score over the medium level (Figure bellow (2)).

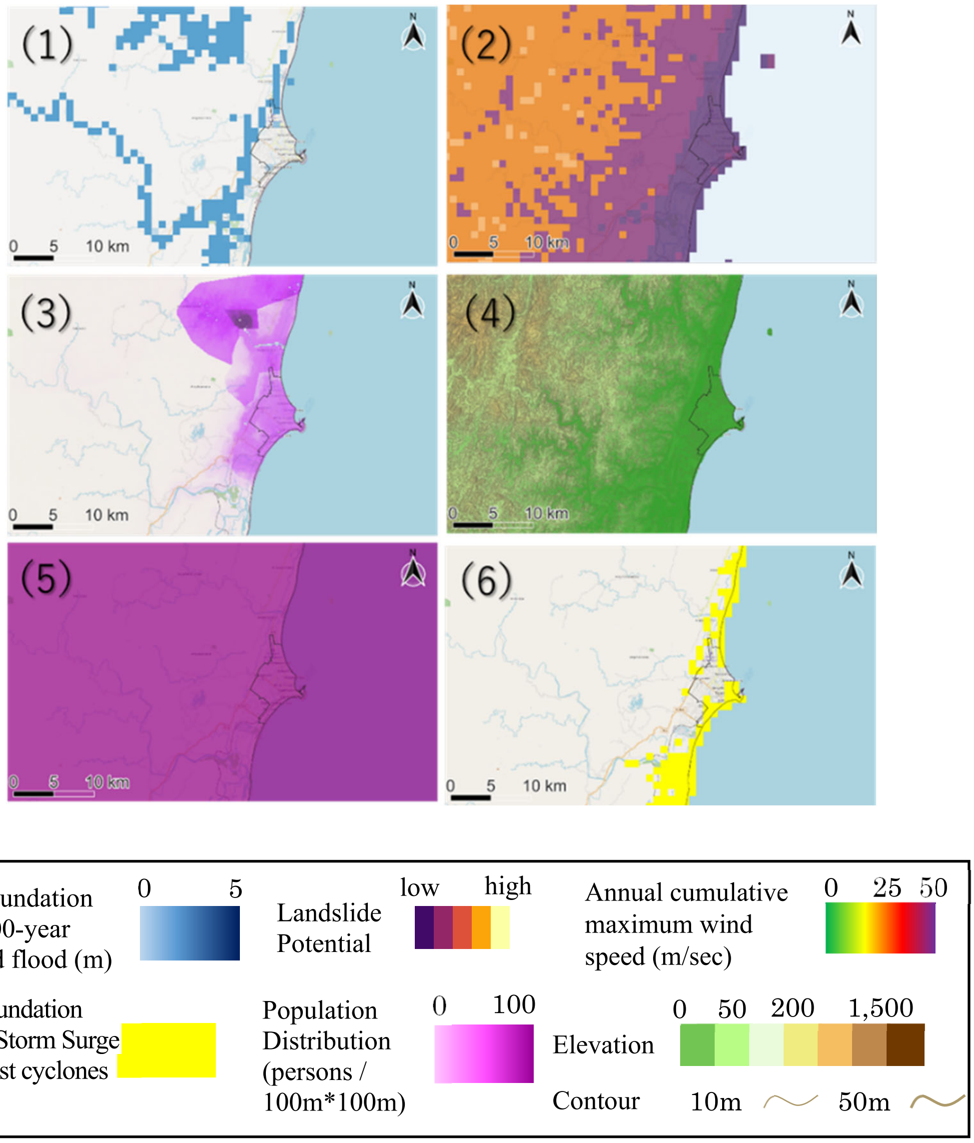


Figure 3-100　Situation of Hazard Distribution in Toamasina

Source: JICA Study Team

c) Antsirabe

Antsirabe is a city located in central Madagascar and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "–" since inundation area is not distributed in the city area (Figure bellow (1)). Storm surge hazard was evaluated as "-" since it is an inland city. Hazard of the strong wind was evaluated as "✓✓" since the Annual accumulative wind speed is below 25m/sec (colour in green to yellow) broadly in the city (Figure bellow (5)). Landslide hazard was evaluated as "✓✓" since area with high landslide potential score over the medium level exists in the southern area (Figure bellow (2)).

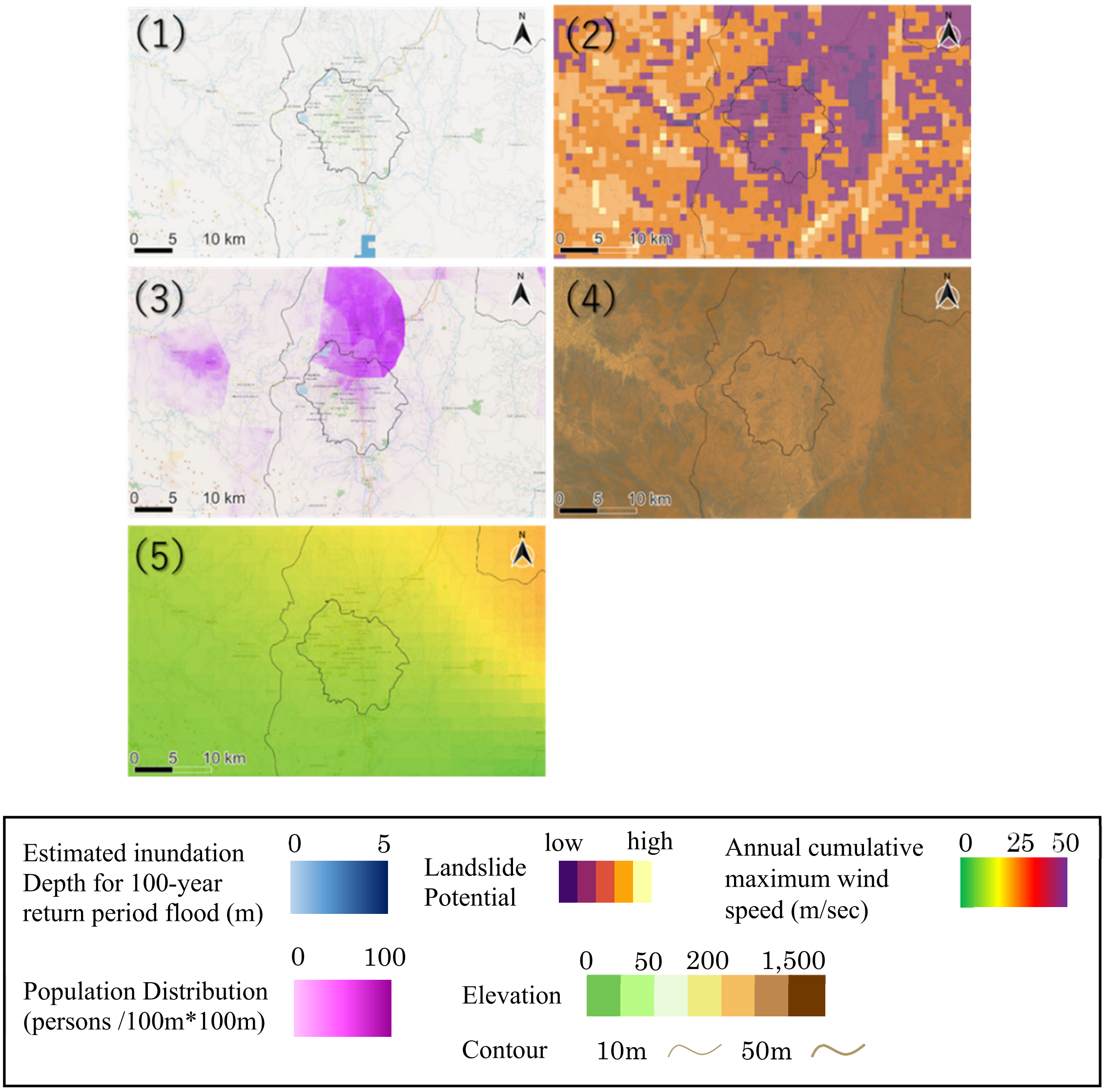


Figure 3-101 Situation of Hazard Distribution in Antsirabe

Source: JICA Study team

d) Fianarantsoa

Fianarantsoa is a city located in central Madagascar and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "–" since inundation area is not distributed in the city area (Figure bellow (1)). Storm surge hazard was evaluated as "-" since it is an inland city. Hazard of the strong wind was evaluated as "✓✓" since the Annual accumulative wind speed is below 25m/sec (colour in green to yellow) broadly in the city (Figure bellow (5)). Landslide hazard was evaluated as "✓✓✓" since area with high landslide potential score over the medium level exists in the southern area (Figure bellow (2)).

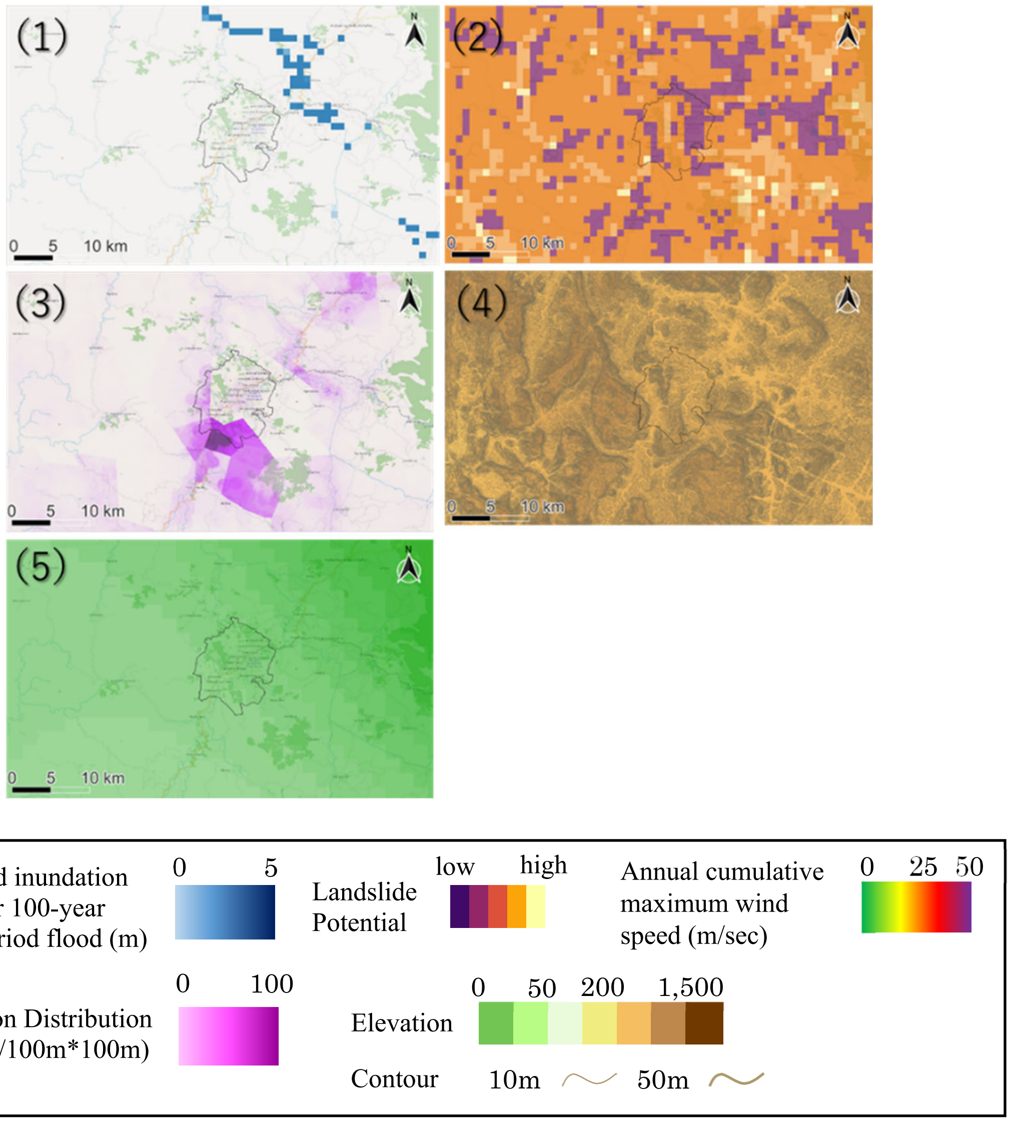


Figure 3-102 Situation of Hazard Distribution in Fianarantsoa

Source: JICA Study Team

e) Mahajanga

Mahajanga is a city located in north-western coast of Madagascar and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "✓✓" inundation area is distributed in the city area along the Betsiboka river (Figure bellow (1)). Storm surge hazard was evaluated as "✓✓✓" since the inundation area is distributed broadly (Figure bellow (6)). Hazard of the strong wind was evaluated as "✓✓" since the Annual accumulative wind speed is below 25m/sec (colour in green to yellow) broadly in the city (Figure bellow (5)). Landslide hazard was evaluated as "-" since area with high landslide potential score over the medium level do not exist in the city (Figure bellow (2)).

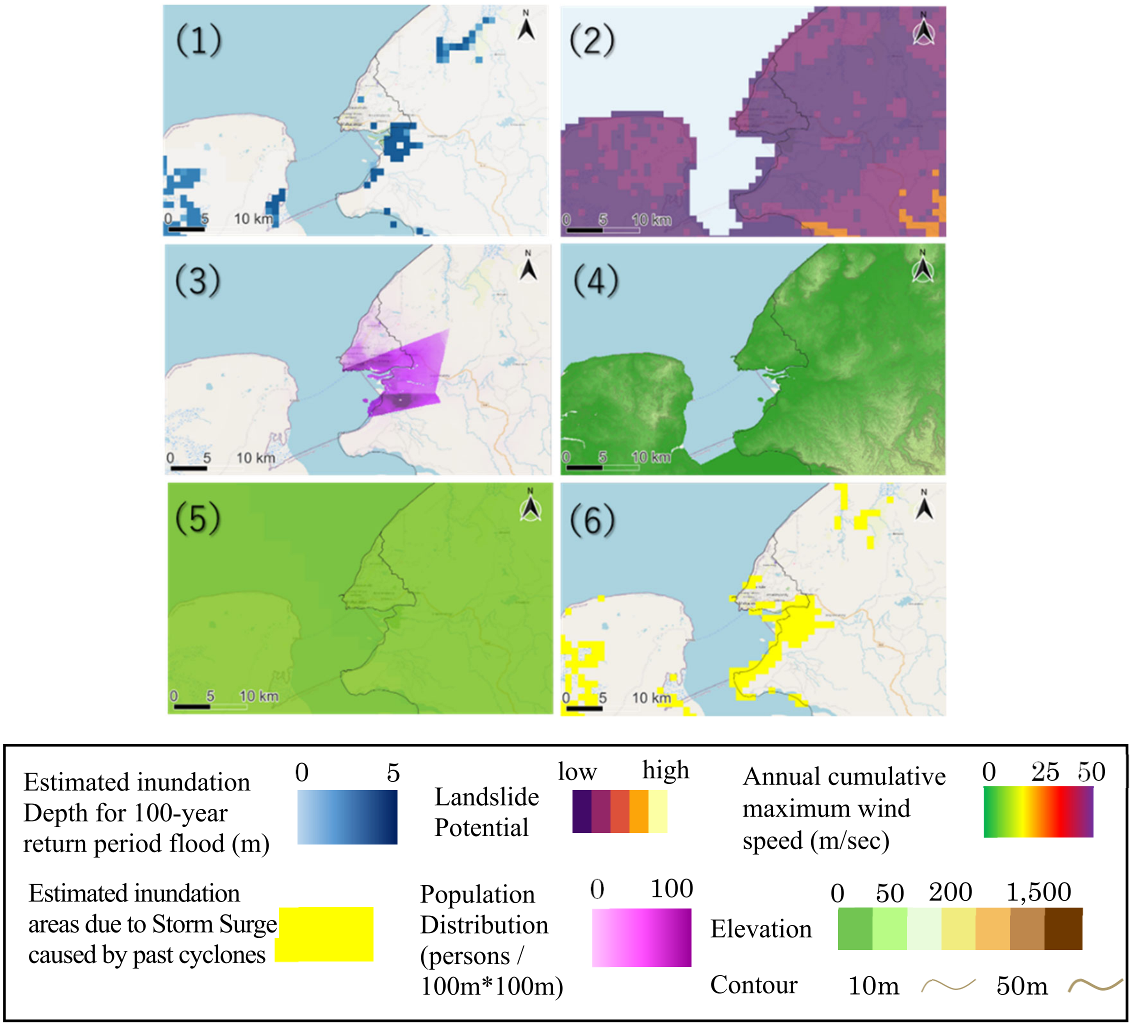


Figure 3-103 Situation of Hazard Distribution in Mahajanga

Source: JICA Study Team

f) Toliara

Toliara is a city located in north-western coast of Madagascar and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "✓✓✓" inundation area is distributed in the city area along the Onilahy river (Figure bellow (1)). Storm surge hazard was evaluated as "✓✓✓" since the inundation area is distributed broadly (Figure bellow (6)). Hazard of the strong wind was evaluated as "✓✓" since the Annual accumulative wind speed is below 25m/sec (colour in green to yellow) broadly in the city (Figure bellow (5)). Landslide hazard was evaluated as "-" since area with high landslide potential score over the medium level do not exist in the city (Figure bellow (2)).

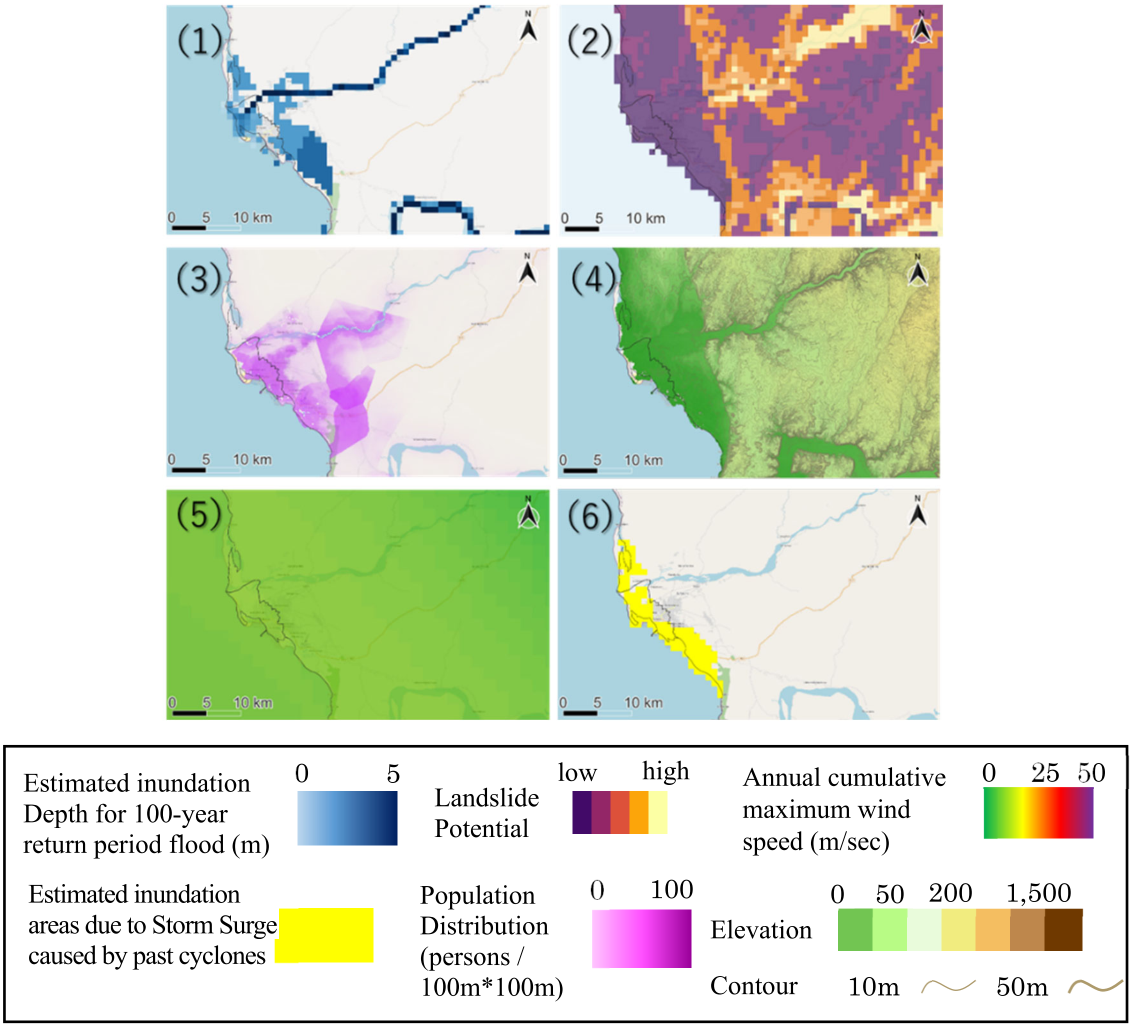


Figure 3-104 Situation of Hazard Distribution in Toliara

Source: JICA Study Team

g) Antsiranana

Toliara is a city located in north-western coast of Madagascar and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "✓" inundation area exists in the city area (Figure bellow (1)). Storm surge hazard was evaluated as "✓✓✓" since the inundation area is distributed broadly (Figure bellow (6)). Hazard of the strong wind was evaluated as "✓✓✓" since the Annual accumulative wind speed is over 25m/sec (colour in red to purple) broadly in the city (Figure bellow (5)). Landslide hazard was evaluated as "✓" since area with high landslide potential score over the medium level exist in the city (Figure bellow (2)).

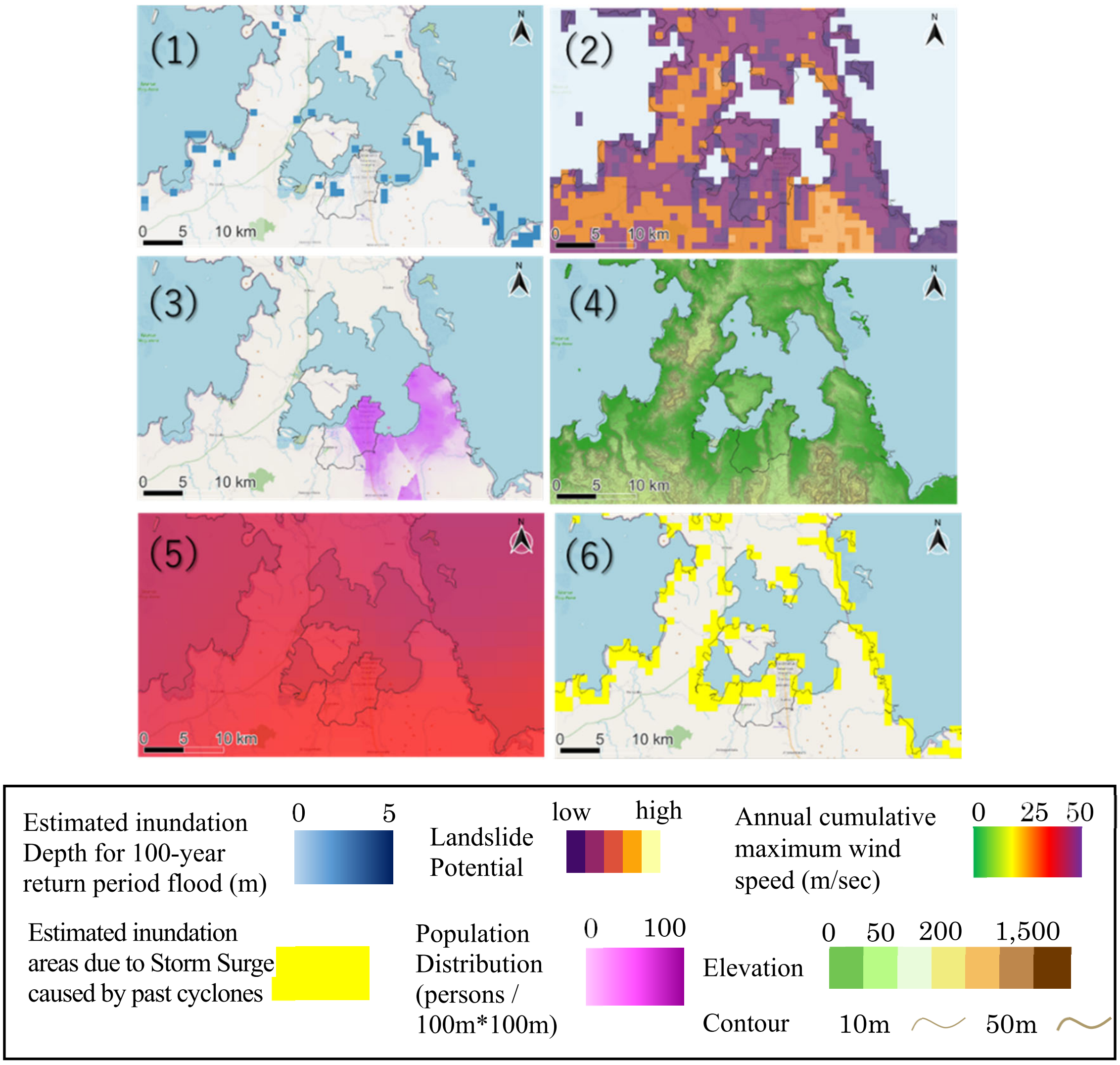


Figure 3-105 Situation of Hazard Distribution in Antsiranana

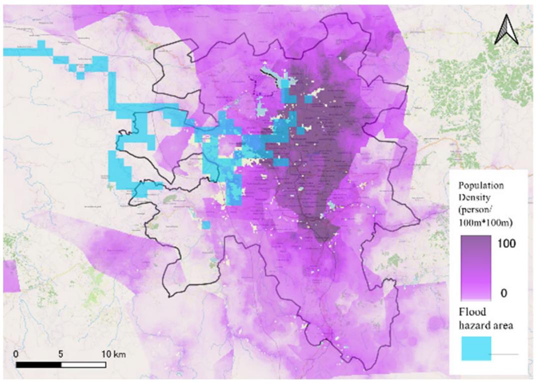
Source: JICA Study Team

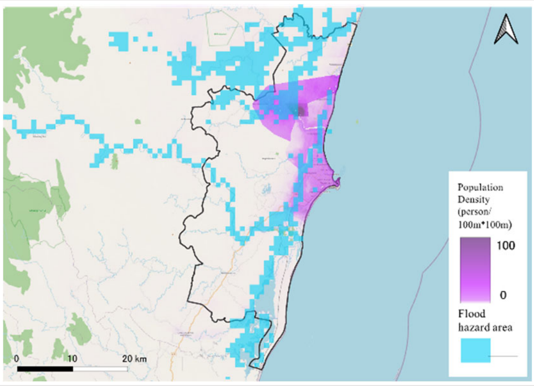
(2) Estimation of Potential Economic Loss due to Disasters

Based on the results of the qualitative assessment of the hazard distribution, a more detailed assessment of the disaster risk was conducted for the Antananarivo capital region which has a significantly larger population than other cities, and the Toamasina metropolitan area, which is the second largest city and has high hazard risk. For GDP per capita, the data from World Bank was used for the year 2020. The relationship among each hazard area and population distribution is shown in the table below.

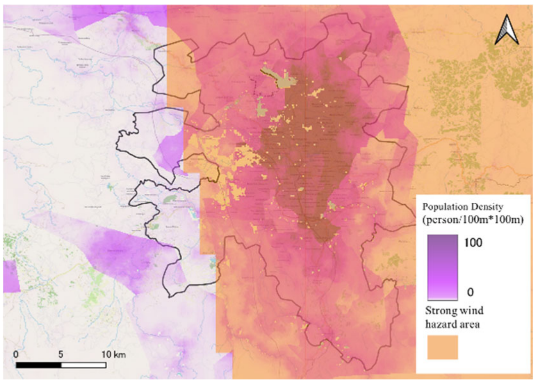
Antananarivo metropolitan area **Toamasina metropolitan area**

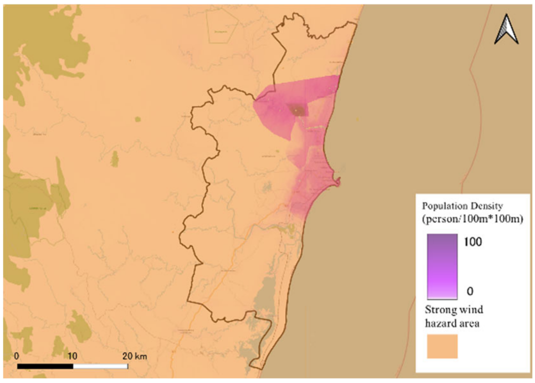
Flood hazard and population distribution



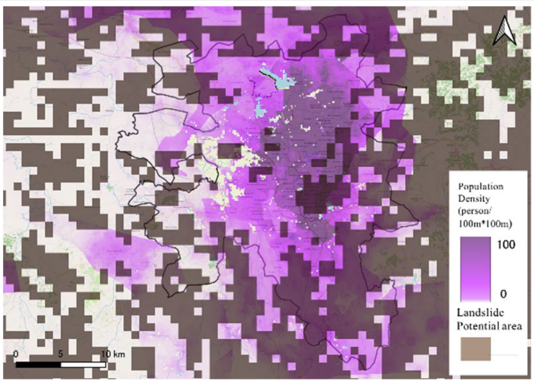


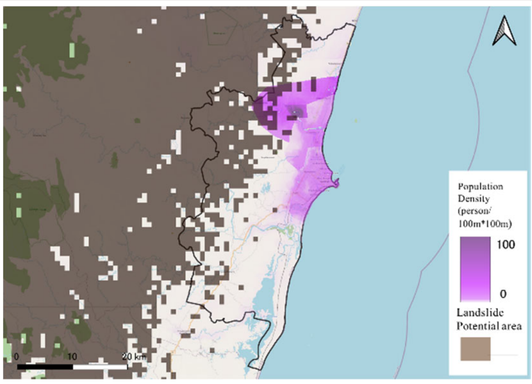
Strong wind hazard and population distribution





Landslide hazard and population distribution





Storm surge hazard and population distribution

No distribution of Storm Surge hazard in the Antananarivo metropolitan area

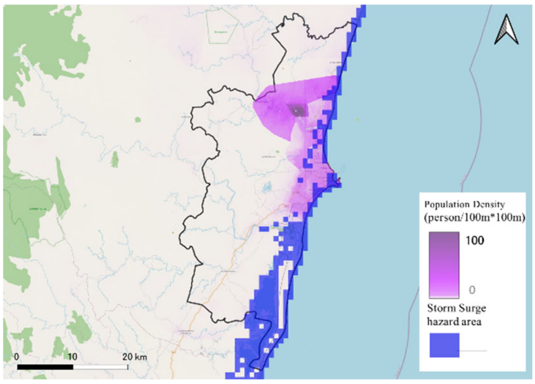


Figure 3-106 Distribution of Hazard and Population in in major cities in Madagascar

Source: JICA Study Team

Table 3-81 Potential Economic Loss of Major Cities in Madagascar

Hazard	Target city	Antananarivo Metropolitan Area	Toamasina Metropolitan Area
Flood	Damaged area (㎢)	64.0	220
	Damage area ratio (%)	8%	21%
	Population affected ('0000 persons)	35.0	16
	Estimated damage (million USD)	**166**	**75**
High water	Damaged area (㎢)	0.0	132
	Damage area ratio (%)	0%	12%
	Population affected ('0000 persons)	0.0	4
	Estimated damage (million USD)	**0**	**20**
Storm	Damaged area (㎢)	655.0	1,060
	Damage area ratio (%)	85%	100%
	Population affected ('0000 persons)	314.0	43
	Estimated damage (million USD)	**1,478**	**203**
Sediment disaster	Damaged area (㎢)	284.0	304
	Damage area ratio (%)	37%	29%
	Population affected ('0000 persons)	67.0	7
	Estimated damage (million USD)	**316**	**34**

* GDP per Capita (Current USD / person) used the data from WB
the value in the year 2020 which is (471.5USD / person) was used

Source: JICA Study Team

The above results show that the damage caused by floods and strong wind high in both the Antananarivo metropolitan area and the Toamasina metropolitan area. Since flood hazard shown above does not include inland flooding, it can be assumed that the Antananarivo metropolitan area has a high priority in implementing measures regarding flood control, including for inland flooding, because of the increasing population concentration in the Antananarivo capital region.

The Toamasina metropolitan area is also found to be a high disaster risk city, with floods, storm surge, strong wind, and landslide all posing a disaster risk. As for strong wind, the entire urban area is likely to be affected, and countermeasures are required. As for the three hazards of floods, storm surge and landslide, the potential economic loss due to floods is the highest and can be considered a high priority for countermeasure implementation.

In addition, the southern part of Toamasina is an area of high risk for both flooding and storm surge. National Road NR2 and a railroad line are being constructed from Toamasina to the south, and industrial land development is planned in the southern region, which may lead to increased disaster risks in the future.

As for landslide, the risk in the Antananarivo metropolitan area and the Toamasina metropolitan area is not high compared to other disaster types, but the periphery of the Antananarivo metropolitan area and National Road NR2 from Toamasina to Antananarivo include areas with high risk of landslide.

(3) Damage and Loss Disaggregated by Sector

1) GFDRR Disaster Risk Profile

Damage estimates for cyclone and flood hazards are being studied separately for buildings in general, commercial, and industrial facilities, public facilities, and infrastructure. Damage estimates are estimated for each sector on a 10-year probability scale, a 100-year probability scale, and a 250-year probability scale. Furthermore, based on these probability scale damage assumptions, the Average Annual Loss (AAL) is estimated.

Table 3-82 Sectoral damage estimates in Madagascar in GFDRR disaster risk profiles

Disaster type		Cyclones	Flood
Conditions for analysis		Estimated annual damage	Estimated annual damage
Building (residence)	Amount of damage (Thousand USD)	65,000	1,000
Commercial and industrial	Amount of damage (Thousand USD)	8,000	500
Public facilities	Amount of damage (Thousand USD)	7,500	600
Infrastructure	Amount of damage (Thousand USD)	2,000	350

Source: Summarized by the JICA Study Team from GFDRR Disaster Risk Profile (Madagascar)

In the GFDRR disaster risk profile the distribution of disaster risks by province is visualized by disaster type and by sector as follows:

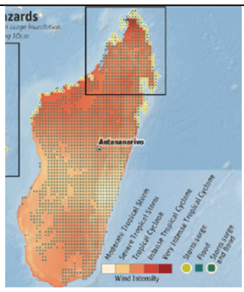
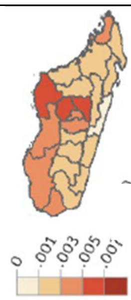
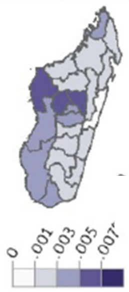
	Hazard distribution	Residential	Commercial and industrial	Public facilities	Infrastructure
Cyclone	 *Wind speed of 63 km/h or more due to a 100-year cyclone, storm surge of 1 m or more, and flood inundation of 10 cm or more	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)
Flood	 *Extent of inundation by a 100-year return period flood	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)

Figure 3-107 Distribution of Disaster Risk by Type and Sector in Madagascar

Source: Summarized by the JICA Study Team from GFDRR Disaster Risk Profile (Madagascar)

From the above results, it can be seen that the damage to buildings is outstandingly large in terms of the amount of damage by sector, and thus that damage to residences is significant.

Flood disaster risk is high in the periphery of the capital city of Antananarivo and in the western region of Meraki, while cyclone disaster risk is high in the eastern Toamasina metropolitan area and in the northern cities of Antsiranana and Mahajanga. Based on the results of the estimation of potential economic loss described above, Toamasina is also considered to have high disaster risk due to flooding. The southern region of Madagascar has a lower disaster risk compared to the northern region, although the south-western area has a distribution of flood risk.

In particular, countermeasures for flood and storm surge in Toamasina and countermeasures for flood in Antananarivo are important. However, the city of Antsiranana in the north suffers a lot of damage from cyclones, and future cyclone countermeasures for strong wind and storm surge need to be considered.

2） Sectoral damage summarized in PDNAs

In Madagascar, PDNA has been prepared for 2008 floods, and the table below shows the amount of damage. The amount of damage to agriculture, houses, and transportation infrastructure is significant and shown in light blue colour on the table. Particularly in the agricultural sector, the amount of damage is comparable to that in the housing sector, and it can be assumed that support for agricultural sector countermeasures for disaster risk reduction is important.

In terms of damage to infrastructure, the amount of damage to transportation infrastructure is larger than that for electricity, telecommunications, and water and sewage, and support for the strengthening of transportation infrastructure is assumed to be important.

Table 3-83 Damage to each sector summarized in PDNA in Madagascar (million USD)

Sector		2008 (Cyclones)
Industry	Agriculture	**103.1**
	Fishery	0.0
	Industrial, commercial, and other damage	18.4
	Sightseeing	15.7
Social asse	Houses	**127.6**
	Education	3.8
	Hygiene	10.3
	Other	1.8
Infrastructu	Traffic	**45.7**
	Electricity and communications	4.8
	Water and sewage	1.4
	Other	0.5

Source: PDNA

3） Disaster Damage and Loss Statistics

Disaster damage and loss statistics in Madagascar includes the number of fatalities, damage to houses, economic losses, education and health facilities, agricultural land, livestock, and actual road damage from 1,036 events between 1982 and 2018 for the targeted disasters (floods, cyclones, and landslide) are aggregated and organized as shown in the table below.

Table 3-84 Disaster damage statistics for Madagascar by sector

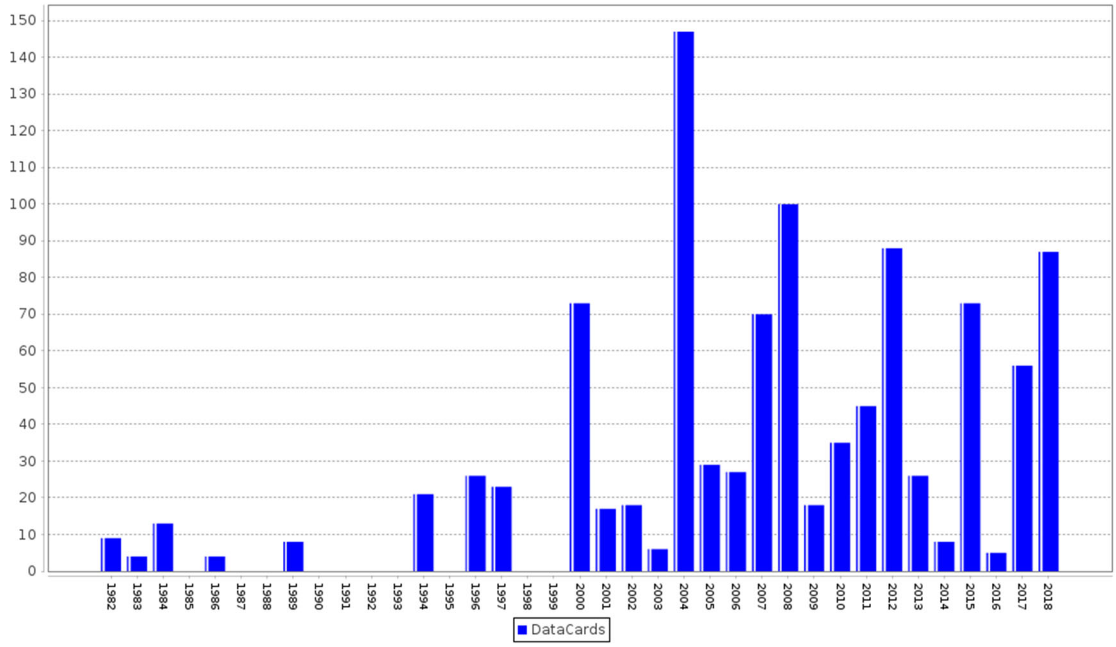
Targeted disaster types	Floods, cyclones, landslide
Target year	1982-2018
Number of disaster events	1,036
Number of deaths	1,612
Total destruction of houses (buildings)	448,878
Partial damage to houses (buildings)	212,303
Economic loss (USD)	1,176,972,201
Educational Facilities	1,575
Public health facility	165
Agricultural land (ha)	966,617
Livestock (head)	23,894
Road (m)	177

Source: Data collected from DesInventar and summarized by JICA Study Team

In addition, the annual trends of the number of disaster events and the number of damaged houses (destroyed + partial damaged) were confirmed to analyse the trend of damage.

The number of disaster events shows an increasing trend. In terms of the number of houses damaged the value is high in year 2004, 2008 and 2017 and indicating an increasing trend.

Recently (after around 2000), due to the improvement of capacity to collect disaster damage and loss data including small-scale disasters, it is difficult to compare the previous and past statistics on the same basis. On the other hand, DesInventar has summarized information on large-scale disasters from the past, so it is possible to identify the rough trends. In DesInventar, information collected after 2005 will be used to evaluate the achievement of the indicators for the global target of the Sendai Framework for Disaster Risk Reduction, so it is expected that the information will be summarized on a uniform basis. Therefore, it is important to check the trend of the statistics continuously in order to understand the damage trend.



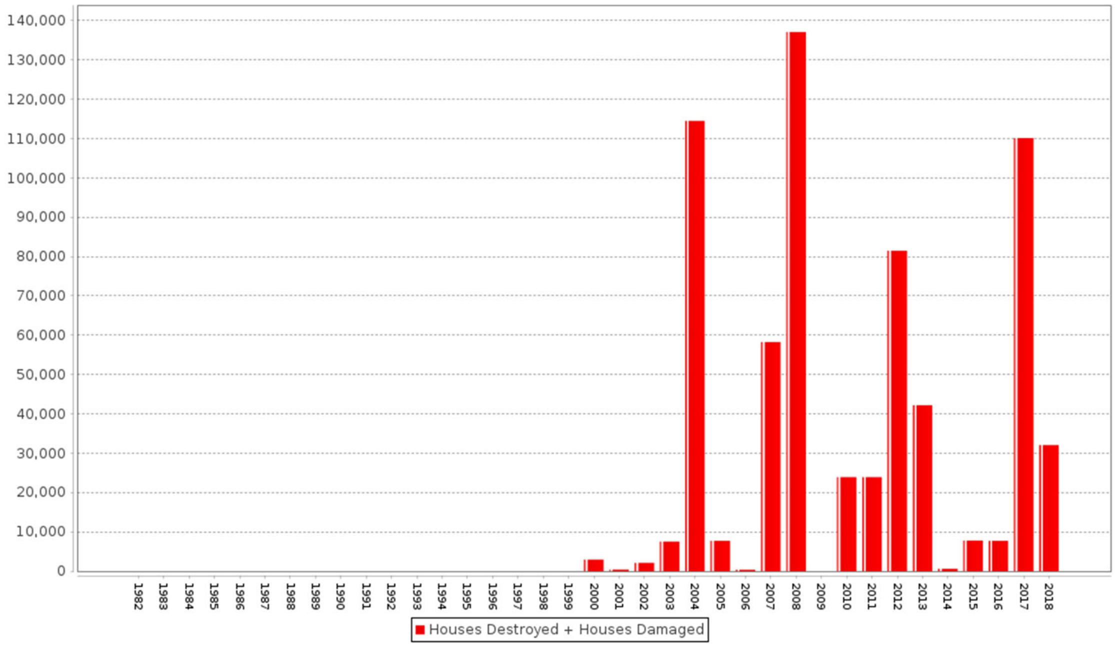


Figure 3-108 Trend of Disaster damage and loss in Madagascar from 1982 to 2019

(Above: Annual Disaster Event, Bellow: Annual damaged houses (destroyed & partial damaged))
Source: DesInventar

3.2.2 Climate change

(1) Observed and Projected Climate Change

In terms of observations that can be attributed to climate change in Madagascar, 17 of the 21 meteorological stations have recorded an increase in daily minimum temperatures over the period 1961-2005, across all seasons, and several stations have recorded an increasing trend in daily maximum temperatures. This has resulted in an overall trend of a temperature increase of 0.2°C in the northern regions and 0.1°C in the southern regions. On the other hand, although there have been significant changes in precipitation, there is no evidence to support this trend. However, the trend is for a decrease in winter and spring rainfall in most parts of the country with a steady decline in rainfall and an extended dry season in the central and eastern coastal areas between 1961 and 2005 have been observed.

The projections show that the temperature will be increased between 1.1°C and 2.6°C by 2065, with the lowest increase are projected for the northern coastal regions and the highest increase are projected for the south. In terms of rainfall, it is projected that rainfall will be increased in the summer months of January to April and by 2065 in the southern part of the country. And it is projected that it will be increased again in October and November, except in the southernmost part of the country.

In Madagascar, they had 53 natural disasters, including droughts, earthquakes, epidemics, floods, cyclones, and temperature extremes, resulting in economic losses of over US$1 billion between 1980 and 2010. Of these, cyclones have the highest frequency rate, followed by droughts and floods.

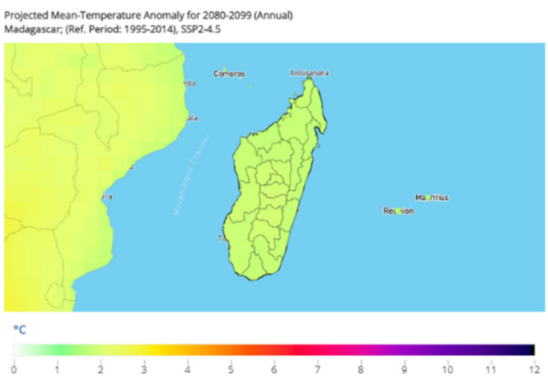


Figure 3-110 Annual average temperature
(2080-2099, compare to 1995-2014,SSP 2-4.5)
Source: Climate change knowledge Portal, WB

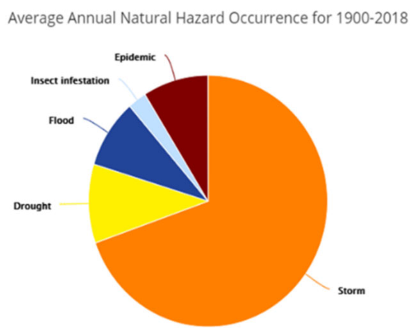


Figure 3-110 Frequency of natural disaster
(annual average 1900-2018)
Source: Climate change knowledge Portal,

In addition, future projections on climate change are indicated in the CLIMATE CHANGE SCENARIOS FOR MADAGASCAR published in 2019 as follow.

- Precipitation is likely to decrease in the 2030s and 2050s. Winter precipitation, in particular, is likely to decrease to a greater extent. At a regional level, precipitation could decrease on the east coast, in the central highlands and in the north-west zone, for all periods in the 2030s, 2050s and 2080s.
- Both maximum and minimum temperatures are likely to increase. By region, the south-west region is likely to be warmer, followed by the Central Highlands, north-west and east coast.
- Sea surface temperatures are likely to increase in the Southern Indian Ocean. Similar effects are likely to be seen in the waters around Madagascar.
- Sea levels have been rising for the past 20 years and could rise by up to 48cm in the future.
- The frequency of cyclones is likely to decrease. However, their intensity and precipitation are likely to increase.

The following impact will be projected as results of the projected climate change which are indicated in above.

Table 3-85 Projections of climate change impacts

Sector	Projected climate change impacts
Water	There are sufficient water resources and potential in the coastal and northern regions of the country. On the other hands, the climate in the southern part of the country is an arid climate and rainfall is less than 400 mm per year. Those cause limits the water resource potential. At the same time, the need for water supplies has been increasing as the demand for water for agriculture, domestic use and power generation. However, the current water resources management system is inadequate to meet future population growth and agricultural needs. Only 20% of the total population has access to tap water and only 50% of the total population has access to safe water resources. The effects of climate change are expected to become increasingly severe.
Agriculture	Major industries are agriculture, forestry, and fisheries, which account for more than 25% of GDP and 80% of the population. Agriculture is mainly based on traditional farming methods by small-scale farmers, which relies on rainwater. There are concerns that a decrease in rainfall and changes in rainfall patterns will have a significant impact on crop yields. The following impacts are projected for the crops. Rice：It will be affected by cyclone, flooding, heavy rains, drought, and water shortages due to the late start of the rainy season. The Lake Alaotra region, the largest rice producing area in the country, is expected to see a decline in crop yields. In addition, there are concerns about the impact of drought on rain-fed agriculture in the southern and southwestern regions. Vanilla：It is a major export crop, ranked first or second in the world in terms of production volume and is a leading source of foreign currency, but there are concerns about the risk of disasters in the northeastern part of the country due to strong winds and heavy rainfall. Other crops: Concerns on increase of incidence of pests and diseases due to heavy rainfall
Forestry	It has been pointed out that the distribution of vegetation and animal habitats may change and become extinct. While 90% of the original forest vegetation has already been lost, the impact of climate change and other anthropogenic factors on biodiversity is expected to be greater than before. In particular, deforestation for the procurement of firewood as a fuel source is a major problem. The impact of climate change on natural ecosystems, especially in the highlands, coupled with this anthropogenic deforestation, is causing soil erosion and loss. There are concerns that changes in rainfall and temperature will alter the optimal growing season for crops, resulting in increased crop failures and insufficient water supply for agriculture.
Fishery	Sea temperature rising cause coral bleaching, and the damage is especially pronounced in the southwestern part of the country. In the Tulear region, it has been reported that 40% of fish species were lost in 2004 due to coral reef degradation. In addition, sea level rise due to climate change, cyclones and floods are expected to inundate coastal lowlands, causing increased salinity and shoreline erosion. Then it will lead a decrease in fishery resources and changes in flora and fauna. Shrimp, one of the most important export marine products, is produced by coastal trawl fisheries and aquaculture using brackish water from mangrove forests. There is a concern that production will decline due to weather patterns and environmental changes in the ocean and mangrove forests.
Coastal area	The country have over 5,000 km of coastline and 65% of the population lives within these areas, and these coastal areas are expected to be more vulnerable to coastal erosion due to cyclones, sea level rise, and seawater oxidation. In particular, the following areas are predicted to be vulnerable. ・Morondava City: Sea level rise due to temperature rise of 19.3 to 86.3 cm (7.4 mm/year on average) is projected by 2100, and coastline recession is expected to be 5 to 6 m/year. In addition, the affected area by flooding is expected to reach a maximum of 1,550 (2025) to 2,330 ha (2100). ・Majunga city: Coastline is declining at a rate of 3 to 4 meters per year, and parts of the city are expected to be below sea level within 100 years. The maximum projected area of flood damage is 1,256 (2025) to 2,643 ha (2100). ・Toamasina city: Roads along the coast have already been damaged by erosion, and boulevards in the southeastern city of Manakara are facing similar crisis.

Sector	Projected climate change impacts
Health	According to the country's Pasteur Institute, there are concerns that climate change will cause the spread of infectious diseases such as malaria, dengue fever, Rift Valley fever, influenza, and plague. In addition, the Ministry of Health has pointed out the possibility of an increase in diarrheal diseases due to a decrease in the quantity and quality of water resources, and an increase in acute respiratory infections due to indirectly worsening air pollution caused by rising temperatures.

Source: Report on Information collection study for biodiversity conservation, climate change and disaster prevention in Republic of Madagascar, JICA, 2012

(2) Policies and Strategies for Climate Change

1) National level

The government of Madagascar submitted its National Adaptation Programme of Action (NAPA) to the UNFCCC in 2006. The NAPA identifies urgent and high-priority adaptation activities and summarizes them in an action plan, which mainly covers five sectors: water resources, coastal areas, forests, agriculture and livestock, and health and sanitation. The following are the 15 projects identified as priority projects.

Table 3-86 List of the prioritized project in NAPA

No.	Project name
1	Rehabilitation and/or construction of protective dams and dikes
2	Establishment and revitalization of water management associations
3	Support for the intensification of plant and animal production through the acquisition of agricultural equipment, the distribution of inputs, the development of income-generating activities in the various regional growth sectors, support for the promotion of the cattle vaccination campaign.
4	Adoption of erosion control through soil defense and restoration techniques (soil conservation) and dune stabilization.
5	Setting up a light structure and/or strengthening the decentralized Weather Service
6	Installation of infrastructure such as dykes and groynes as the sea level rises
7	Rehabilitation of sectors degraded by deflation by reprofiling the shoreline, installation of windbreaks by reforestation of filaos, planting of mangroves, riprapping of the seafront and installation of wave breaks
8	Reforestation of rural areas with reforestation plans with adapted / appropriate species
9	Promotion of forest management transfers to local grassroots communities (GELOSE, GCF)
10	Opening up potential production areas by rehabilitating communication and telecommunication networks to facilitate trade and marketing.
11	Development of IEC through appropriate media (radio operation; information system)
12	IEC of the population on: the causes of the disease and adequate measures to be taken during the transmission period, the need to reach health centres, construction of latrines, nutrition, the need for impregnated bed nets
13	Strengthening, consolidation of the capacity of basic health services through decentralization of personnel, strengthening of equipment, appropriate community pharmaceutical drugs, enhancement of COSAN (health community), preventive stock building measures, intensification of epidemiological surveillance
14	Provision of resources for the prevention and control of disease vectors
15	Developing, communicating and enforcing design and construction standards covering all infrastructure to ensure that it can withstand significant weather disruption

Source: Compiled from National Adaptation Programme of Action

In 2017, a National Strategy for Climate Resilience (Strategic Programme for Climate Resilience, SPCR) and Investment Plan was developed. The investment plan is structured to target the vulnerable sectors of hydrometeorology, urban development, coastal management, social protection, agriculture, and biodiversity, with a total investment of US$165 million, to be implemented within two to ten years. The six priority investment projects are as follows.

Table 3-87 List of the prioritized project in SPCR

Project 1: Strengthening Hydrometric Services (USD 25 million)	(i) improve weather, climate and hydrological information and monitoring networks, as well as early warning systems, and (ii) strengthen the capacity of hydrometric institutions to collect and analyse data and provide quality and timely climate and weather services
Project 2: Strengthening the Climate Resilience of Urban Communities and Infrastructure in Greater Antananarivo (USD 30 million)	To improve the living conditions of the poor in selected low-income neighborhoods of Greater Antananarivo by improving basic service delivery and flood resilience; and to strengthen the government's capacity to ensure integrated urban management and effective response to eligible crises and emergencies
Project 3: Building Climate Resilience in Coastal Cities (USD 30 million)	To strengthen the resilience of coastal cities to natural hazards and climate risks and to build municipal and community capacity to respond effectively to their impacts
Project 4: Climate Resilient Social Infrastructure and Regional Development in the 'Deep South' (USD 20 million)	To build climate resilience by scaling up social protection efforts, rehabilitating critical infrastructure and strengthening livelihood diversification in selected communities in the Deep South
Project 5: Improving climate-resilient agricultural production and food security in the 'Deep South' (USD 35 million)	Promote shared economic growth based on local drivers of growth and livelihoods and reduce poverty and vulnerability by area。
Project 6: Promoting Biodiversity and Ecotourism (US$25 million)	Preserve biodiversity, develop ecotourism to accelerate economic growth, improve conditions for communities living on the periphery of protected areas, foster the emergence of a local private sector that invests in green growth, and increase biodiversity resilience to climate change

The government of Madagascar signed the Paris Agreement on April 22, 2016 and announced its commitments and priorities for mitigation and adaptation measures through the Nationally Determined Contributions (INDCs/NDCs) on September 21, 2016.

< Prioritized mitigation and adaptation measures during 2020 and 2030>

- Real-time monitoring of climate information
- Effective implementation of multi-hazard early warning systems, including cyclones, floods, food security, drought, hunger, health, and phytosanitary monitoring
- Widespread application of Resilient Agriculture Integrated Models in major agricultural centre, cash crop zones, extensive livestock farming areas, priority areas for fisheries, mangroves, as well as drought hotspots
- Sustainable and integrated water resources management, particularly in sub-arid areas and

those vulnerable to drought periods

- Reinforcement of natural protection and reduction of the vulnerability of coastal, inshore, and marine areas affected by coastal erosion and receding shorelines progress (Menabe, Boeny, South-west and East)
- Strengthen and upgrade casualty multi-hazard early warning systems including the aspects of phytosanitary, agricultural, drought and food security monitoring
- Sustainable and integrated water resources management, especially in sub-arid areas and those vulnerable to drought periods
- Implementation of ecosystem-based adaptation to cope with sand-hill progression (multiple causes but phenomena aggravated by climate change) by leveraging research findings and best practices
- Restoration of natural habitats (forests and mangroves: 45,000 ha; lakes, streams, etc.).

The below effects are expected as results of these measures implementation.

By 2025	By 2030
- Stabilization of the case of human casualties due to cyclones - Reduction of the occurrence of hunger and food insecurity events associated with drought - periods, particularly in the South - National Food Security assured through a large-scale implementation of Resilient Agriculture - Integrated Models (climate-smart agriculture) in major agricultural centres - 45,000 ha of forest area restored.	- Cyclone-induced human loss of life Index reduced to 3 - Significant decrease in the proportion of people, particularly in Southern Madagascar, suffering from starvation - Paddy production maintained at 4 tons per hectare in agricultural centres that apply the Resilient - Agriculture Integrated Models (climate-smart agriculture) - Environmental amenities and ecosystem services associated with the restoration of 55,000 ha of forests and mangroves - Downturn up to trend 0 of the receding shorelines progression in the most affected coastal zones.

The total necessary budget for the implementation of these adaptation measures is estimated to be US$28.713 billion. In the NDC, as for the gaps and challenges in implementing climate change adaptation, lack of funds for implementation, technology, organization, financial mobilization and procurement capacity, technical capacity is identified and the need for support and technology transfer from developed countries are expressed.

It has been decided that each country should develop and submit a National Adaptation Plan (NAP) as a medium- to long-term adaptation measure to be addressed by each country in COP16 and COP17. The government of Madagascar has not submitted NAP to the UNFCCC; however, the studies are underway to develop a basis for the NAP, which will be compiled and submitted to the UN in the future. The following are some of the issues that are currently identified.

- Strategic Area 1: Strengthening governance and mainstreaming of adaptation
- Strategic Area 2: Implementing a priority sectoral action programme
- Strategic Area 3: Financing adaptation to climate change

To mainstream climate action into a development of Madagascar, the NAP focuses on seven sectors: agriculture, livestock and fisheries, water resources, public health, biodiversity and forestry, coastal zone, infrastructure, and climate risk and disaster management/reduction. This prioritization is consistent with the sectors addressed in the NDCs being submitted to the UNFCCC. The document also proposes ten sectoral approaches, listed below, with strategic directions and priority actions for each sector at the national and regional levels, and a set of structured programs. This is intended to link the strategic prioritization and actions raised in the NAP for effective, cross-cutting, and time-bound implementation in the targeted regions

- Strengthening the adaptation of the agricultural sector and the resilience of rural populations in the South
- Strengthening the resilience of rural populations through the development and structuring of export sectors
- Strengthening the adaptation of the fisheries sector and developing warning systems and associated action plans
- Improving access to drinking water in urban and rural areas
- Strengthening early warning systems for the resilience of the health sector to climate change
- Accelerating reforestation through the operationalization of the REDD+ mechanism and the development of ecosystem services
- Improved conservation of natural forests and management of protected areas including the development of climate refuge areas in the interior and in the periphery
- Protection of coastal infrastructure and economic activities (including tourism) from sea level rise
- Improving cyclone early warning systems, as part of a regional effort in the Indian Ocean
- Development of resilient and less methane-emitting rice fields

2） Regional level

According to Madagascar's Climate Change Adaptation Plan, the adaptation programs are underway in the following area with support from various donors.

Table 3-88 List of the adaptation programs in Madagascar

PROJECT	SECTOR OR DOMAIN BENEFICIARY	SOURCES OF FINANCING	POPULATION/ SECTOR/ TARGET REGION	EXPECTED IMPACTS
Improving adaptation and resilience to climate change in rural communities in Madagascar (PACARC)	Agriculture Water	LCDF/ GEF	Regions of Androy, Anosy, Atsinanana, Analamanga and Atsimo-Andrefaana	-Food security -Agricultural techniques adapted to climate change -Improving livelihoods
Promoting the climate resilience of rice farming through investments pilots in the AlaotraMangoro Region	Rice growing	Adaptation Fund	Regions of Alaotra Mangoro, then extension in Itasy, Middle West area and in the Vakinankaratra Region	-Increasing Rice production -Improved Agricultural practice -Food security
Adaptation of coastal zone management to climate change considering ecosystems and livelihoods	Fishing Coastal areas	LCDF	Institutions at national and regional level: Menabe, Boeny, Atsinanana and Vatovavy Fitovinany	Institutions strengthened by: - Systematic integration of climate change into policy and planning - Concrete adaptation measures for coastal areas
Programme for Strengthening Conditions and Capacities for Sustainable Adaptation to Climate Change	Multisectoral	Union European/ AMCC BMZ	CPC: Municipalities and Regions: Analamanga, Boeny, DIANA, DGM, Education, Development of the territory, Infrastructure and equipment, Health, Biomass energy, Artisanal mining	Regions and Municipalities resilient through the implementation of SRAT and SAC integrating CC
Adaptation of agricultural value chains to climate change Madagascar	Agriculture	Union European/ BMZ	Anosy, Androy, Atsimo Andrefana	Increasing the resilience of farms operating in selected agricultural value chains to climate change risks

Source: National Adaptation Plan

(3) Supports from Other Donors

In Madagascar, a number of international organizations and national donors have been providing various types of support for climate change-related policy formulation and project formation. In particular, the UN-led NAP-GSP (Environment National Adaptation Plan Global Support Programme) has provided support in a wide range of areas.

Table 3-89 Support from donors (as of 2021)

Donor	Sector	Project name
World Bank	Disaster risk reduction	Climate Risk and Adaptation Country Profile: Madagascar (2011)44 2016 Madagascar Disaster Risk Profile (2016)45
UNISDR		Disaster Risk Reduction Review of Madagascar (2015)46
GERICS	Disaster risk reduction	Climate Fact Sheet, Madagascar (2015)
USAID	Climate risk analysis	Climate Risk Profile Mozambique47
	Coastal protection	Mozambique Coastal City Adaptation Project (2014-2019)

[44] http://sdwebx.worldbank.org/climateportalb/doc/GFDRRCountryProfiles/wb_gfdrr_climate_change_country_profile_for_MDG.pdf
[45] https://www.gfdrr.org/sites/default/files/publication/drp_madagascar.pdf
[46] http://www.unisdr.org/files/43522_2.reviewofmadagascar.pdf
[47] https://www.climatelinks.org/resources/climate-risk-profile-mozambique

3.2.3 National and Urban Development

(1) National Axis and Strategic Cities

The capital Antananarivo is located at the intersection of the national highways running north-south and east-west. Since Antananarivo is located in the center of the country, all cities in Madagascar are within 1200 km of Antananarivo. The Antananarivo-Toamasina Economic and Urban Axis (TaToM) Comprehensive Development Plan, formulated in 2019 by the support of JICA, established urban development plan (PUDi) for two urban areas, namely: the capital Antananarivo metropolitan area and the Toamasina metropolitan area, and formulated a development plan for the areas connecting these two cities.

The TaToM economic axis is the most important transportation axis of the country, consisting of National Highway No. 2 and a railroad, connecting Antananarivo and Toamasina. This transportation axis not only plays a role of connecting the capital and the port of Toamasina, Madagascar's largest international port, but also plays a major role in forming the spatial structure of the nation because of the location of these two cities. Antananarivo is also connected by routes to major tourist destinations such as Toamasina, Taolagnaro, Mahajanga, Antsiranana, Fort Dauphin, and Nosy Be, St. Mary and Morondava. Other cities such as Antsirabe (170 km from Antananarivo), Fianarantsoa (405 km from Antananarivo) and Moramanga (115 km from Antananarivo) can be reached by national highway from Antananarivo.

The figure below shows Madagascar's economic corridors.

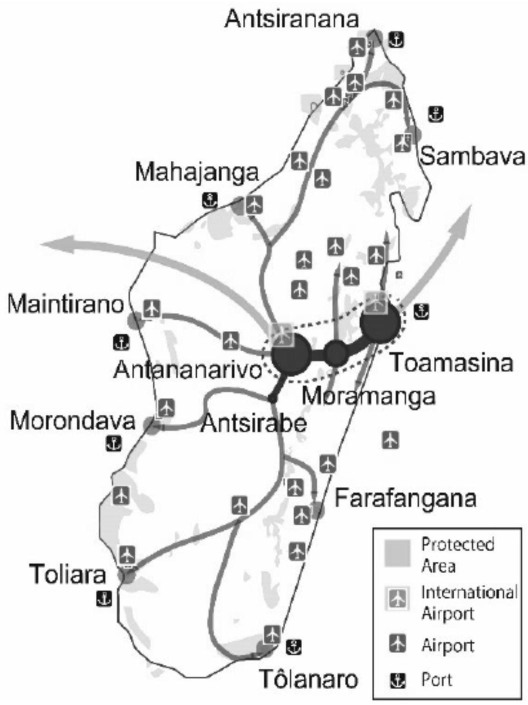


Figure 3-111 Corridors in Madagascar

Source: JICA TATOM

As for the railway network, Antananarivo and Toamasina is connected by a railroad laid during the French colonial era. A branch line of this connects to Ambatondrazaka and Antsirabe. Apart from these, there is also a line connecting Fiana Lantua and Namakara on the east coast.

Madagascar has a number of small regional airports, but at the moment there are only nine airports used for regular flights other than Antananarivo. Air Madagascar, which operates them, is the only practical means of transportation to access rural areas away from the capital during the rainy season, when roads can even be washed away by rain.

(2) Cross-border infrastructure

Since Madagascar is an island country, international transportation is carried by air and sea. The most important seaport in Madagascar is Toamasina, which carries about 90% of international cargo. It is being expanded by Japanese yen loans which expects year 2026 for completion. Ports in Mahajanga and Antsiranana are not often used due to factors such as the distance from the metropolitan area and poor connections. The port of Ehoala, privately built by Rio Tinto in 2008, is the newest port in Madagascar, but will be controlled by the government when the company's mining project near Fort Dauphin ends around 2038.

(3) Location of Important Industries

Madagascar's main industry is the tertiary industry, which accounted for 55.8% of GDP as of 2014. Looking at the GDP of the tertiary industry, the trade, transportation, and service industries are prominent. The primary industry accounts for 25.4% of GDP, but its share has been declining gradually since 2010. Among the primary industries, agriculture is the most important industry that contributes to GDP. The share of the secondary industry has increased slightly since 2010. In the secondary industry, the Export Processing Zone (EPZ), which includes export-oriented industries such as the clothing industry, is the largest, followed by the food, beverage, and energy industries. The EPZ was introduced in 1990 and facilitated the transition from agricultural-dependent economies such as vanilla and coffee to more diverse economies. The two major mining sites; Rio Tinto's Illuminate mine in the south-eastern part of the country and Ambatby's nickel-cobalt mine in the eastern part, are increasing the importance of the mining and industrial sector, but their contribution to GDP is small.

As for Madagascar's industrial development, the following industries are seen as promising from the perspective of expanding exports to neighboring countries in Africa and the Indian Ocean.

- Agriculture and food industry (agricultural processing)
- Textile and apparel industry
- Light industry
- Essential oils, perfumes, cosmetics

The mining, tourism and information and communication (ICT) sectors are also attracting foreign investments and have development opportunities due to global market expansion. Because of the population growth in Africa and the Indian Ocean, urbanization, and changes in lifestyles and consumption patterns of middle-income earners, the agricultural processing industry, textile and apparel industry, and light industrial products are expected to grow.

The three provinces of Analamanga, Azinanana, and Arocha Mangle, including the entire TaToM region, currently generate about half of the country's GDP. Most of this GRDP is generated in the Antananarivo metropolitan area accounting for about 80% of the GRDP generated in the above three prefectures. It also contributes to about 40% of Madagascar's GDP. The Antananarivo metropolitan area is the driving force of Madagascar's economy. Therefore, economic activities, employment opportunities and labor force in Madagascar are concentrated in the Antananarivo metropolitan area.

Although the Toamasina metropolitan area is much smaller than the Antananarivo metropolitan area, it accounts for 3.7% of the GRDP produced in the three prefectures mentioned above. In addition to Ambatby, the major economic activities in the Toamasina metropolitan area are agricultural processing, textiles, logistics, and tourism.

Cities and villages along the TaToM economic axis have not been promoted for economic activity at present, and thus, their development is limited. In some cities and villages, the main source of income for residents is retailing and car repairs for road users on National Highway No. 2.

(4) Key Cities in Terms of Urban Development

In the National Development Plan (2015-2019) (hereafter referred to as the PND), the following features of Madagascar's national territory are identified as relevant to the content of this study.

- It is very rich in hydrology, with a total of 3,000 km of rivers, surface water and groundwater.
- The climate varies greatly from region to region, with rainfall ranging from 400 mm per year in the dry southern region to 3,700 mm per year in the rainy eastern region. This makes it difficult to control the risk of flooding and drying.
- Disasters are often caused by cyclones, and of the 63 major disasters between 1990 and 2013 (about 17.13 million people affected), about 50 (about 9 million people affected) were cyclones.

In addition, 22 issues have been identified in the General National Policy (PEG). The background can be summarized as follows.

- Unstable personal income due to informal employment or informal private business
- Disparities between urban and rural areas
- Disparities within urban areas
- Low economic capacity of female head of household
- Fragility of educational healthcare

One of the reasons for this is the lack of effective and efficient development of the country's potential due to weak governance and the absence of a vision and plan.

In terms of issues related to disaster risk reduction, cyclones and floods can damage infrastructure and delay recovery, which in turn can halt distribution and thereby worsen the economic situation (including employment situation). This will set off a chain of events that will reduce the economic strength of parents, which will reduce the schooling rate of their children and lead to low-wage workers. Another reason is the limited educational opportunities for young people in rural areas where the transportation system is not well developed.

The priority sectors listed in the PND are mining operations, development of tourism reserves, infrastructure and social housing development including urban areas, fisheries and business, and intensive large-scale agriculture including free zones. The 12 growth areas identified so far include the following 12 areas.

- 1-E Tolagnaro: development of ilmenite ore and construction of the Great Port of Jehora
- 2-AA Antsirabe: potential of the agro-industry
- 3-TE Nosy Be: tourism development
- 4-ME Toamasina: Port functions and import/export related economic development
- 5-H-E1 Lake Alaotra: potential for hydro-agricultural development, especially rice farming
- 6-LD Fianarantsoa: human and physical capital, products of the land.
- 7-T Antananarivo-Toliara Route: a growth region built by RN7 due to abundant resources and transportation opportunities.
- 8-Met Metropolitan Growth Region: generates 30.0% of GDP, constituting a major economic hub
- 9-BV Betsiboka Basin: development is inappropriate due to agro-pastoral and fisheries environmental potential
- 10-A Menabe Region: national-regional growth space, agro-pastoral potential of the west coast of Antsirabe-Antananarivo.
- 11-MTA Atsimo Andrefana: mining investment opportunities and development benefits to local governments
- 12-EM Entire sea area of Madagascar: Sea area as a development tool due to its abundant wealth and strategic geographical location.

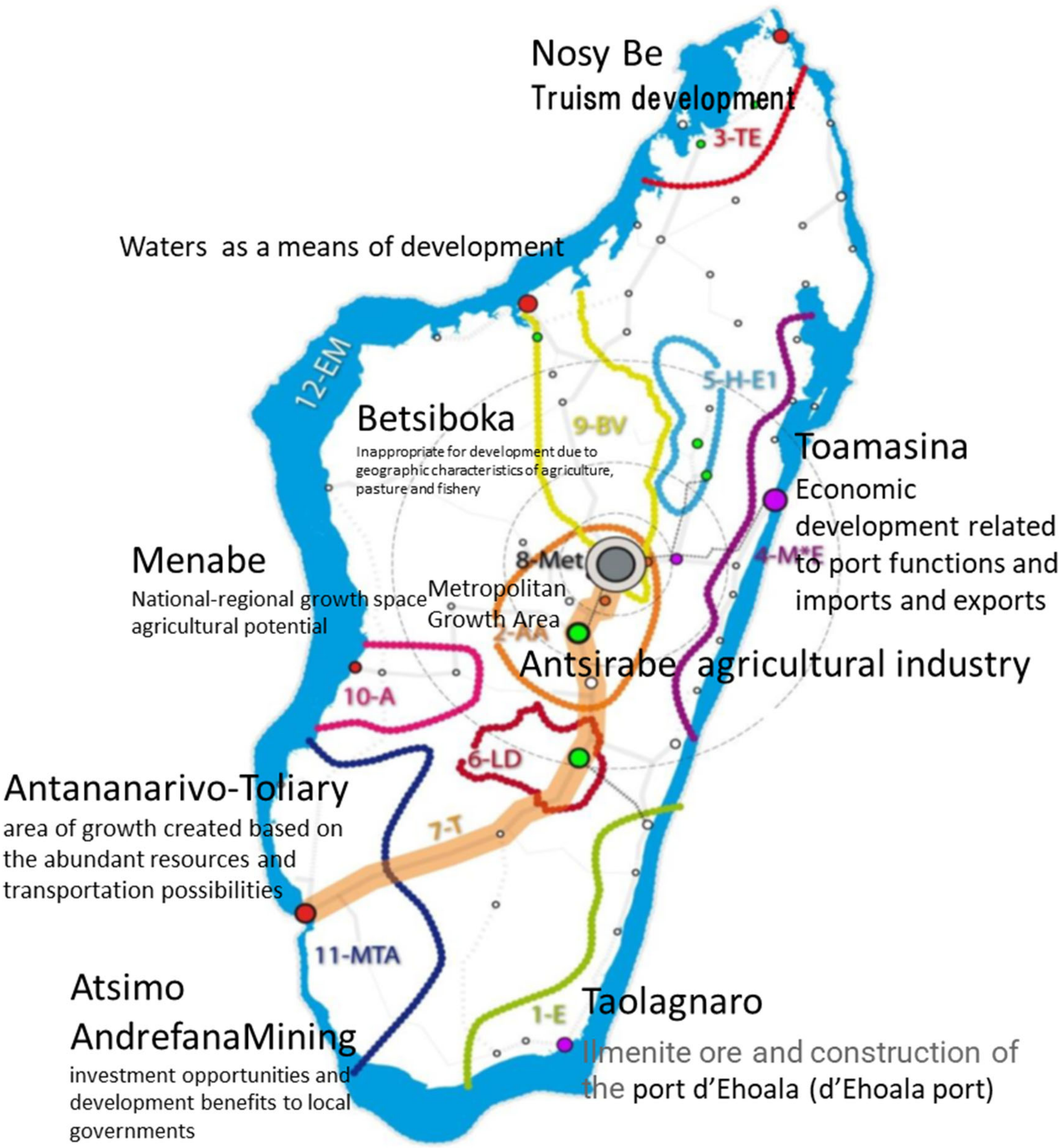


Figure 3-112 Identified 12 Growth Areas

Source : Prepared by JICA Study Team based on National Development Plan (2015-2019).

On the other hand, according to the JICA Madagascar office, the implementation of the Antananarivo-Toamasina Economic and Urban Axis (TaToM) Comprehensive Development Planning Project is positioned as the first priority project.

[Future vision for the entire TaToM region]

- To rebuild the Malagasy economy and restore stability to Malagasy society through the development of the entire TaToM region.

- In addition to pursuing the sustainable development of industry throughout TaToM, we will promote the economic development of Madagascar and contribute to the stability of Malagasy society.
- Strengthening the transportation function of the TaToM economic axis will also enhance the connectivity of the ports of Antananarivo and Toamasina to the surrounding areas of TaToM, thereby supporting the economic development of these surrounding areas.

[Current status and issues in Madagascar and the entire TaToM region]

- Madagascar has an abundant and relatively low wage labour force. Madagascar's wage level belongs to the group of 25 countries with the lowest minimum wage. Workers are industrious and dexterous, and a large workforce is concentrated in the Antananarivo metropolitan area, the capital of Madagascar.
- The export-oriented textile industry is one of the major industries in Madagascar and is integrated into the global value chain.
- Madagascar is also an internationally famous tourist destination for its rare flora and fauna.
- On the other hand, due to repeated political crises over the past 25 years, economic infrastructure such as electricity, water supply, and roads are in poor condition.
- As a result, it is difficult to attract investment in industry and industrial development promotion has not progressed.
- There is a significant shortage of government funds for infrastructure development.
- The school education system is deteriorating, and the basic academic skills of young people are declining.

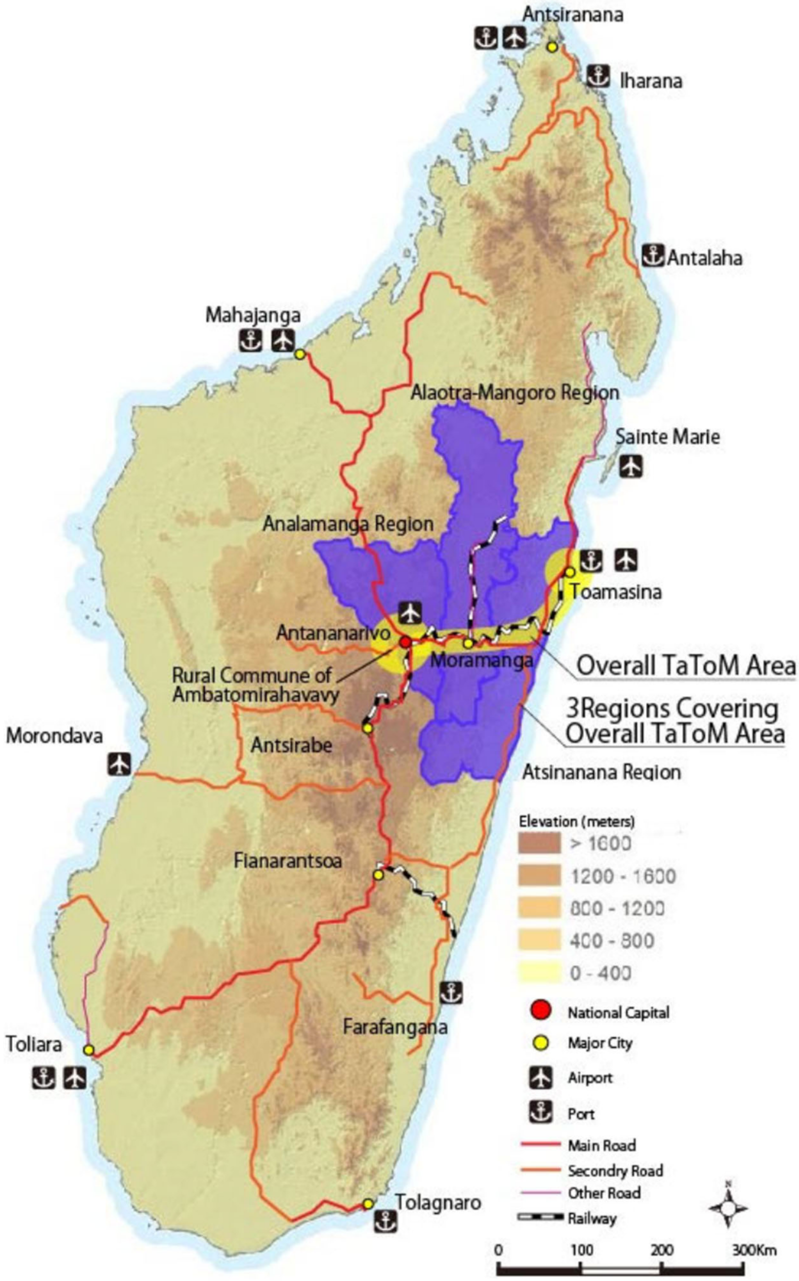


Figure 3-113 Location of the entire TaToM region in Madagascar

Source: JICA Antananarivo-Toamasina Economic and Urban Axis (TaToM) Comprehensive Development Planning Project

Overlaying the location map of major cities, priority project areas and hazard distribution, it can be seen that the 12 development potentials identified, both from cyclone risk and sediment disaster, are 3-TE: Nosy Be (tourism development), 4-ME: Toamasina (port functions and import/export related), 5-H-E1: Lake Alaotra (hydro-agricultural development), and the TaToM target area. (port functions and import/export related), 5-H-E1: Lake Alaotra (hydro-agricultural development), and also the TaToM target area is found to be at high risk.

In addition, in order to consider a target city based on the concept of advance disaster risk reduction "investment," a certain city size is necessary. Simply based on the size of the population, Antananarivo has 3.37 million people, while Toamasina and Toliara have 430,000 and 110,000, respectively, and it can be assumed that in the event of a disaster, Antananarivo will suffer by far the most damage. From the perspective of national land use and the national axis, National Road RN2, which connects the first and second cities, is an important route in the national growth strategy, while traffic disruptions during the rainy season and cyclones will have a significant impact on the urban and regional economy.

Therefore, in terms of disaster risk, city size, and project priority, the potential for investment in disaster risk reduction in the TaToM target area is high. National Road RN7 is the north-south urban axis. Although it is a lower priority compared to National Road RN2, as another route connecting the capital city and the port, a single north-south axis would be well-balanced from the perspective of national land development.

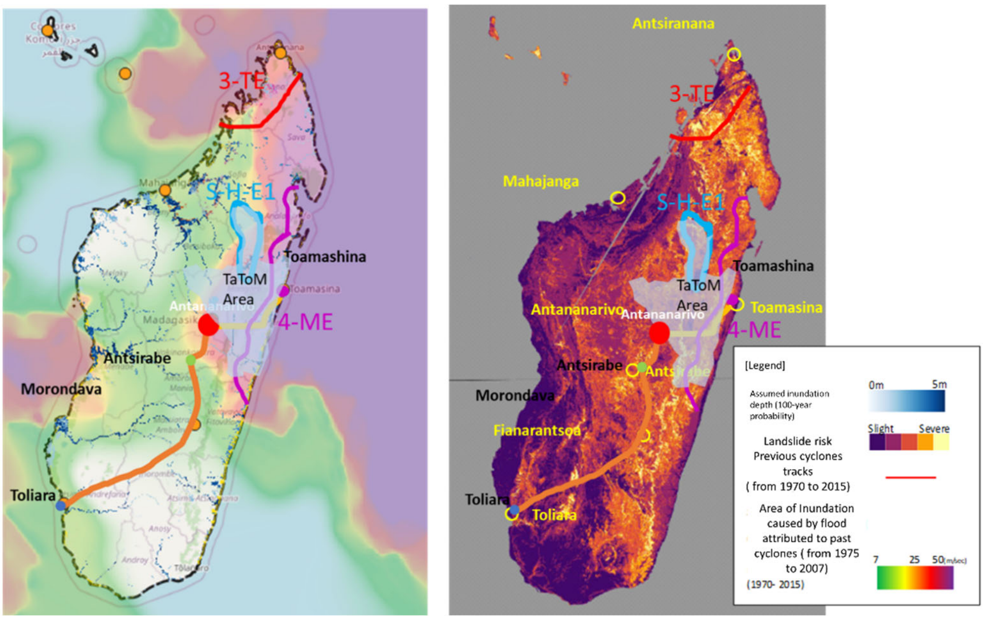


Figure 3-114 Cities and hazard distribution

Source: Prepared by JICA Study Team based on UNEP Global Risk Data Platform and Open Street Map (background map).

3.2.4 Disaster Management Plan and Implementation Structure

(1) Legal Framework and Planning for Disaster Management

In Madagascar, the law on disaster management was established in 1972 with the establishment of the Decree on the Emergency National Council (CNS), and subsequent laws on disaster management policies have been enacted and revised based on changes in social conditions and other factors. Based on these laws and regulations, the National Disaster Management Policy (PNGRC) (2003) was established as a framework that includes responsible agencies and financial mechanisms for disaster management. On top of that, in 2006, laws and regulations were enacted for the CPGU (Prevention and Response Unit), which is responsible for reviewing national disaster management policies, and the BNGRC (National Disaster Management Office), which is the agency responsible for implementing disaster management policies. The current law has been revised based on the Sendai Framework for Disaster Risk Reduction. Along with the development of these legal systems and implementation systems, national level disaster management plans such as the SNGRC (National Strategy for Disaster Management) and the National Contingency Plan have been formulated.

The National Strategy for Disaster Management was first formulated in 2003 and has since been revised with the support of UNDP and other organizations, with the latest plan being the National Strategy for Disaster Management (2020-2030). The strategy outlines a vision for disaster management in Madagascar during the period under review, as well as priorities for implementation, and indicates that CPGU and BNGRC will basically take the lead in promoting these activities. The strategy calls for the promotion of effective disaster risk reduction and mitigation measures based on the Sendai Framework for Disaster Risk Reduction, as well as the strengthening of technical and financial systems and the promotion of understanding of disaster risks. Four pillars of the strategy are listed, including strengthening the capacity for inter-sectoral cooperation, and a budget plan for each of these pillars is presented until 2030.

Regarding disaster management plans at the local government level, we checked with BNGRC and the cities of Antananarivo and Toamasina, but basically no local government has formulated a disaster management plan. On the other hand, some municipalities have developed emergency response plans, for example, Antananarivo City is in the process of updating its plan with the support of the Red Cross and UN-OCHA. As for early warning systems, there are some efforts being promoted at the municipal level. Other disaster hazard maps at the municipal level have been studied in some specific areas with the support of AFD and BNGRC, but due to technical and human resource problems, they have basically not been prepared. In Antananarivo City, the number of households in the landslide danger zone and the danger zone was surveyed and discussed based on the residents' workshop and field survey, but the status of disaster management measures varies from municipality to municipality.

(2) Implementation Structure of Disaster Risk Reduction and Management

According to the results of interviews with the BNGRC, the CPGU (Prevention and Emergency Response Unit) and the BNGRC (National Disaster Management Office) basically play the major roles in disaster management in Madagascar, with the CPGU responsible for policy-level strategy and the BNGRC playing a central role in practical aspects such as disaster response. The BNGRC coordinates and implements disaster management and emergency response in collaboration with all disaster management related agencies. Support and coordination with UN agencies and international donors are also the responsibility of the BNGRC, which promotes efforts in accordance with the disaster management cycle, including disaster prevention, preparedness, emergency response, and recovery and reconstruction. The coordination of disaster management is being handled by organizing the competent ministries and international organizations in each cluster.

In terms of disaster prevention infrastructure development, etc., BNGRC has opportunities to discuss with relevant agencies (e.g., Ministry of Public Works, etc.), but the actual budget acquisition and project implementation are under the jurisdiction of the respective ministries. For example, in the event of a sediment disaster on a road, the BNGRC is responsible for collecting disaster information and working with the Ministry of Public Works to respond to recovery efforts. While soft measures for disaster prevention have been studied and developed mainly by the BNGRC and other organizations, for example, hazard mapping and disaster risk analysis have not been carried out to prioritize disaster prevention infrastructure.

3.2.5 Trends in donor support

(1) Overview of Donor Support

According to the Ministry of Foreign Affairs of Japan's International Cooperation Bureau's Official Development Assistance (ODA) Country Data Collection, totals for the period 2000-2017, donor aid to Madagascar is dominated by the World Bank Group's International Development Association (IDA), the European Commission, the European Investment Bank, and other European Union (EU) institutions. In terms of major donors, aid from France and the U.S. is the largest.

Table 3-90 Top five donor economic cooperation achievements (in millions of dollars)

Achievements in economic cooperation with international organizations		**Achievements in economic cooperation of major donors**	
IDA	2,538.4	France	1,927.6
EU Institutions	1,614.6	U.S.	1,239.5
AfDF	606.4	Japan	550.2
IMF-CTF	500.9	Germany	292.0
GFATM	246.73	Norway	143.1

Source: Compiled by the research team from Official Development Assistance Country Data Collection (2000-2017), International Cooperation Bureau, Ministry of Foreign Affairs of Japan

According to the table of focus sectors of development partners shown in the COUNTRY STRATEGY PAPER (CSP) 2017-2021 of the African Development Bank, support on rural development is high on a sectorial basis.

Table 3-91 Main areas of support by donor

Partners of Madagascar	Focus sectors of Madagascar's development partners							
	Infrastructure	Rural development	Environment	development	Governance	Education	Health	Solidarity
IMF					x			
World Bank	x	x	x	x	x	x	x	x
European Union	x	x	x		x	x	x	
United Nations		x	x		x	x	x	x
United States		x			x	x	x	
African Development Bank Group	x	x	x	x	x			
IFAD		x	x					
AFD (France)	x	x	x	x	x	x		
Global Alliance for Vaccines and Immunizations							x	
Germany (GIZ)	x	x			x			
GFATM (Global Fund - AIDS - Tuberculosis - Malaria)							x	
JICA	x	x			x	x		
South Korea	x							
Norway		x				x	x	

Source: AfDB COUNTRY STRATEGY PAPER (CSP) 2017-2021

(2) Trends in Aid from World Bank (WB)

The WB states that the unplanned urbanization that is spreading in Madagascar is leading to poor storm water drainage, transportation, and management capacity for natural disasters, and that the national and local governments need to strengthen their disaster risk management policies and practices, as the population is concentrated in cities that are highly vulnerable to cyclones and floods. Madagascar has historically focused on post-disaster response and recovery, but there is a growing awareness that disaster prevention needs to be given the same attention. With technical assistance from the World Bank, the national disaster risk reduction agencies have developed new construction standards for major infrastructure such as irrigation, roads, and schools. Going forward, the nation will require local authorities to adapt rural and urban development strategies to be more resilient to disasters and climate change, and the World Bank will continue to support efforts to make infrastructure investments more disaster resilient. In addition, the World Bank is consulting on the development of a disaster risk financing instrument that is based on an ongoing assessment of disaster risks and adapted to the country's financial capacity and risk pattern. They are considering including a “Catastrophic Deferred Drawdown Option (CAT-DDO)” in the Development Policy Operations (DPO) on inclusive and resilient growth, and financing participation in regional insurance schemes.

The COUNTRY PARTNERSHIP FRAMEWORK (CPF) 2017-2021, which sets out the World Bank's aid policy, identifies "improving resilience and reducing vulnerability" and "promoting inclusive growth" as two priority areas. The "Enhancing Resilience and Reducing Vulnerability" section of the report includes efforts in the area of disaster risk reduction, which aims to increase the resilience of rural and urban livelihoods and expand the country's ability to mobilize resources and deliver services at the local level with greater accountability. In the past, Madagascar has tended to experience periodic crises in which services provided by the central government and the central government cease and local communities are left to fend for themselves. By intervening on multiple fronts, we aim to build greater social cohesion at the local level, reduce the risk of vulnerability, and maintain basic services. The WB states that through its activities, it will strengthen the human capital of the younger generation and promote transparency and accountability through citizen participation for more relevant and efficient public policies. Specifically, in addition to post-disaster emergency response, the project intends to support the development of infrastructure such as irrigation and water supply and sewage to cope with the urbanization of the Antananarivo metropolitan area, as well as mixed-use urban development and land use planning to reduce vulnerability.

Table 3-92 List of relevant projects in the area of disaster response / disaster risk reduction

Project Name	Project Objective	Financier	Approval Year
Madagascar Disaster Risk Management Development Policy Financing with a Catastrophe Deferred Drawdown Option (Cat DDO)	The development objective of the proposed operation is to strengthen the Government of Madagascar's institutional, technical, and financial capacity to manage disaster and climate-related risks.	AFD	2019
Integrated Urban Development and Resilience Project for Greater Antananarivo	The Project Development Objective is to enhance urban living conditions and flood resilience in selected low-income neighborhoods of Greater Antananarivo; and to improve the Recipient's capacity to respond promptly and effectively to an Eligible Crisis or Emergency.	IDA	2018
Emergency Food Security and Reconstruction Project	The Project Development Objectives are to: (i) increase access to short-term employment in targeted food-insecure areas; and (ii) restore access to social and economic services following natural disasters in targeted communities.	IDA	2008
Mainstreaming Climate Change and Disaster Risk Management into Economic Development	To promote the use of innovative ICTs such as geo-spatial mapping and open-source technology, as well as more mainstream technology like the BNGRC SMS system.	Global Facility for Disaster Reduction and Recovery	2007
Post-Cyclone Emergency Supplemental to SAC 2	Project Development Objective (Note: will be disclosed in the MOS) to support the next phase of the adjustment reform. Board Schedule Comments	IDA	2000
Cyclone Emergency Social Fund III Supplemental	To finance demand driven community development activities in rural areas and empower beneficiaries.	IDA	2000

Source: Extracted from WB Projects & Operations

(3) Trends in Aid from the African Development Bank (AfDB)

The objective of the COUNTRY STRATEGY PAPER (CSP) 2017-2021, which sets out the AfDB's aid policy, is to help reduce poverty and improve the living conditions of the population by creating more value-added jobs through structural transformation and accelerated industrialization. The two pillars of the program are "Development of Energy and Transportation Infrastructure to Support Inclusive Growth" and "Support for Agricultural Transformation and Industrial Development." As for disaster risk reduction efforts, they are positioned as one of the measures in developing the agricultural sector in the "Support for Agricultural Transformation and Industrial Development" section, with few specific descriptions.

As for specific projects, many of the disaster-related projects are post-disaster responses to cyclone damage.

Table 3-93 List of relevant projects in the area of disaster response / disaster risk reduction

Project Name	Project Objective	Financier	Approval Year
Africa Disaster Risks Financing Programme (ADRIFI)	To build Madagascar's capacity in disaster risk assessment, early warning systems and contingency plans, and support the country's participation in the sovereign risk transfer mechanism of the African Risk Capacity (ARC).	Fragile States Facility	2019
Effectiveness Improvement for Disaster Risk Reduction Project	To repair the protective dam of the Bas Mangoky irrigated area,	Fragile States Facility	2016
Emergency humanitarian aid to restore social infrastructure damaged by Cyclone	To restore classrooms and basic health centers damaged by the cyclones. -Cyclone Chedza (2015) -Cyclone Haruna (2013) -Cyclone Giovanna and Irina (2012)	Special Relief Funds	2015 2013 2012
Humanitarian assistance to victims of damage caused by Cyclone Bingiza	The rehabilitation of damaged infrastructure and the restoration of traffic on the national network by repairing the damage caused by the passage of Cyclone Bingiza.	Special Relief Funds	2011
Emergency humanitarian aid for the victims of the floods caused by Cyclone Fanele	To repair the dike protecting the Bas Mangoky rice-growing perimeter, by filling the gap created by the overflow of the Mangoky River, following the passage of cyclone Fanele.	Special Relief Fund	2009
Emergency Humanitarian Aid - Cyclone Gafilo	To contribute to alleviating the sufferings of the victims of Gafilo.	Special Relief Fund	2004
Cyclones Eline, Gloria and Hudah Damage Repairs Project	To restore the links on 1767 km of roads and 153 km of railways with a view to restoring the levels of service prior to the cyclones.	African Development Fund	2000

Source: Extracted from AfDB Projects & Operations

3.2.6 Selection of Key Cities

Based on the above overview of disaster risk, climate change, land development and urban development in Madagascar, as well as the trend of donor support, we have decided to focus on Antananarivo and Toamasina as important cities for this study, and to investigate the issues of disaster risk reduction and the possibility of support projects at the city level. As for the inter-city infrastructure, it was decided to focus on the Antananarivo-Toamasina Economic City Axis, etc. The study will focus particularly on these important cities and inter-city infrastructure, but the study of potential support projects will not be limited to these but will be conducted flexibly as appropriate based on sectoral conditions, local needs, and issues related to regional disaster risk reduction.

3.2.7 Information Collection and Analysis for Cooperation in the Field of Disaster Risk Reduction in Each Sector

(1) Urban Development and Disaster Risk Reduction

1) TaToM Area: National Road RN2

Antananarivo, the capital of Madagascar is an inland city. In order to maintain the functions of the capital city, it is important to cooperate with port cities in terms of logistics. The nearest port from Antananarivo is Toamasina, which is about 355 km away via National Road RN2. However, as mentioned above, this area is mountainous and has a high risk of sediment disaster. It is also susceptible to cyclones, which is a characteristic of disaster risk. Therefore, from the perspective of maintaining the functions of the capital city, it is essential to protect the national road that serves as the logistics axis. This is why it is important to implement the ToTaM plan.

The National Road RN2 between Antananarivo and Toamasina has many landslide spots, and the steep slopes frequently slow down large vehicles and cause traffic congestion. In addition, there is a high need for maintenance and improvement due to the poor driving environment of the roads (road pavement deterioration, etc.) The route crosses a mountain pass, which is only 3m wide in one lane and 6m wide in two lanes, making it dangerous for large trucks to curve or pass each other, and posing a high risk of sediment disaster. In particular, the pass on the Toamasina side route, where trucks and trailers loaded with goods from the port of Toamasina climb, has a higher priority.

2) Antananarivo City

Antananarivo developed from pre-colonial times with the city center located on a slightly higher elevation hill in the center of the city, and the area was the center of the city. As a hill, the risk of sediment disaster originally existed, but as the population grew, the city developed down the hill, increasing the risk of flooding in addition to sediment disasters. During cyclones and other heavy rains, many areas of the city are flooded.

According to the "Antananarivo-Toamasina Economic and Urban Axis (TaToM) Comprehensive Development Planning Project in Madagascar", the characteristics and problems of disaster risk reduction are analysed as follows.

- The increased inundation risk caused by rainfall-induced flooding is attributed to the deprivation of water retention functions due to the reduction of wetlands and paddy fields, and the reduced drainage capacity due to poor maintenance of drainage facilities. The government has been reclaiming and using the wetlands to enhance urban functions and to build roads and other urban infrastructures. At the same time, the wetlands continue to be gradually reclaimed as the population grows.

- As for the causes of increased risk of river flooding, irrigation facilities are not well maintained and water is not properly managed, which tends to reduce the productivity of paddy fields. The irrigated paddy fields are gradually being converted to urban land use. As a result, there is an increased risk of river flooding outside the city of Antananarivo.

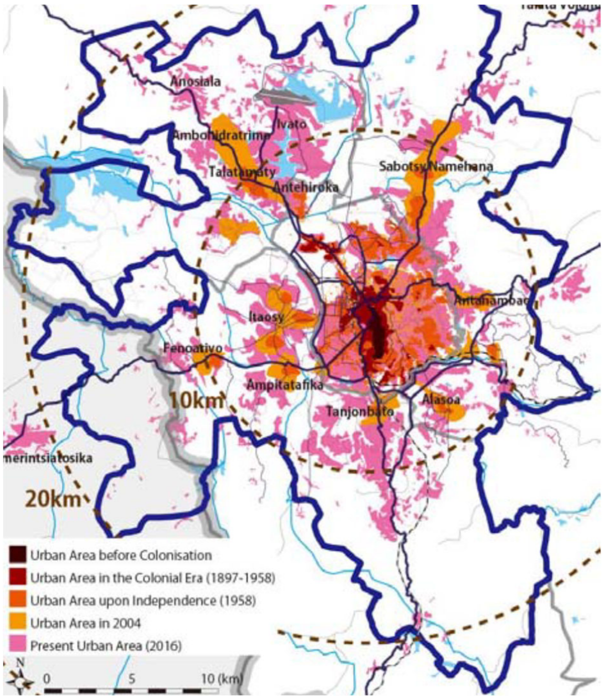


Figure 3-115 Expansion of cities in the Antananarivo metropolitan area

Source: JICA Study Team

Various international cooperation organizations have been supporting non-structure measures for disaster risk reduction (Contingency Plan: Red Cross/UNOCHA, Programme Intégré d'Assainissement d'Antananarivo (PIAA): AFD, Study on Measures for Flooded Areas: WB). Antananarivo (PIAA): AFD, Study on Flooded Areas: WB). However, hazard mapping based on scientific evidence for the entire city has not been implemented due to technical and budgetary constraints. In addition, many donors and NGOs target only specific areas (fokontany) in the city, so there is a strong need to study disaster risk reduction measures on a comprehensive basis.

Thus, infrastructure investment and measures related to disaster risk reduction in Antananarivo are quite limited, and fundamental solutions need to be considered.

Figure 3-116　Urban expansion in Antananarivo (photo)

Source: JICA Study Team

(2) Transportation

According to AfDB data (Madagascar 2017-2021 Country Strategy Paper, AfDB, Nov. 2017), Madagascar's transportation infrastructure is underdeveloped, and aging infrastructure is a constraint to transportation sector reform, industrialization of the country, and job creation. In particular, inadequate infrastructure maintenance is accelerating the deterioration of infrastructure conditions. Madagascar's transportation infrastructure is poorly rated, ranking 39th out of 54 African countries. In addition to accessibility issues, high transportation costs are also a major challenge. The challenges of Madagascar's transportation sector are manifested in all areas of administration, regulation, planning, operations, and finance. Due to the topographical constraints of an island nation and the challenges of improving the road network, it is important to ensure safe and low transportation cost access to regional, national, and international markets through sustained investment in the aviation and railroad sectors.

1) Overview of Relevant Organizations and Legal systems

Table 3-94, shows the main relevant organizations, including the ministries and agencies that have jurisdiction over the transportation sector in Madagascar, and the organizations that manage or operate each subsector.

Table 3-94 Key Institutions in the Transportation Sector in Madagascar

Subsector	Key Institutions
Road	Ministry of Public Works (Ministère des Travaux Publics)
	Madagascar Roads Authority (Autorité Routière de Madagascar)
	Madagascar Road Fund (Fonds Routier de Madagasikara)
Railroad	Ministry of Transport and Meteorology of Madagascar (Ministre des Transports et de la Météorologie)
	Madarail company
	Fianarantsoa-Côte-Est railway
Port	Ministry of Transport and Meteorology of Madagascar (Ministre des Transports et de la Météorologie)
	Port, Maritime and River Agency (Agence Portuaire Maritime et Fluviale)
	Société du Port à Gestion Autonome de Toamasina
	Madagascar International Container Terminal Services Ltd. (Madagascar International Container Terminal Services Ltd.)
	Société de Manutention des Marchandises Conventionnelles (Société de Manutention des Marchandises Conventionnelles)
Airport	Ministry of Transport and Meteorology of Madagascar (Ministre des Transports et de la Météorologie)
	Aviation Civile de Madagascar
	Aéroports de Madagascar

Source: JICA Study Team

a) Road

The ministry responsible for road infrastructure in Madagascar is the Ministry of Public Works (Ministère des Travaux Publics, "MTP"). However, it is the state-owned Madagascar Roads Authority (Autorité Routière de Madagascar, “ARM”) that is responsible for the maintenance, operation, and other management of the national roads.

The main roads are located in a radial pattern around the capital city, Antananarivo, which is located inland in the middle of the country. Most imports and exports take place at the Port of Toamasina, the largest port in the country (responsible for about 90% of international cargo), and goods from various regions are often collected in Antananarivo by road and transported to the Port of Toamasina from there. Due to this situation, the most important intercity road infrastructure is the National Road RN2 connecting Antananarivo and Toamasina. However, the trip from Antananarivo to Toamasina, which is about 350 km, is said to take 8 hours by passenger car and 2 days by cargo truck, which is a main bottleneck in the country's economic activities. The pavement condition of National Road RN2 is relatively good, but other roads, including national roads, are in poor condition. There are many major national road sections that are difficult to travel, especially during the rainy season. Since the national road network is formed mainly by radial roads, the role of ring road is important for inter-regional exchanges and economic activities, but their development is considered to be lagging behind.

According to a JICA document (Preparatory Study for the Bridge Rehabilitation Project on the Antananarivo-Toamasina Economic Axis in the Republic of Madagascar Report (Pre-release Version), May 2019), 75% of the cargo unloaded at the Port of Toamasina, which handles about 90% of international cargo, is transported to Antananarivo City, the political and economic center of the country, via National Road RN2 (one lane in each direction, total length 354 km). According to another JICA document (The project on Master Plan Formulation for Economic Axis of TaToM (Antananarivo-Toamasina, Madagasikara) Final Report (summary), JICA, October 2019), despite National Road RN2 and the railroad connecting Antananarivo and Toamasina are the most important transportation corridors in Madagascar, the daily traffic volume of National Road RN2 is about 1,700 vehicles/day in 2018, and the rail freight traffic volume is only about 96,000 tons/year in 2017. The difference in elevation between Antananarivo and Toamasina is about 1,400 meters, and because it passes through a mountainous area, improving the alignment of the road and the railroad to increase the volume and speed of transportation would be very expensive.

According to AfDB data (Madagascar 2017-2021 Country Strategy Paper, AfDB, Nov. 2017), Madagascar's transportation infrastructure is underdeveloped and there has been little investment in the road network since the 2009 political crisis. As a result, the total road length has decreased from about 50,000 km in the 1960s to 31,640 km in 2016, and only 10% of the roads have good road surface conditions (only 26% of national roads are "good"). Furthermore, inadequate maintenance is accelerating the deterioration of infrastructure conditions. Madagascar's transportation infrastructure is poorly rated, ranking 39th out of 54 African countries. Therefore, not only accessibility issues, but also high transportation costs are a major challenge. As an example, the above AfDB data shows that the average cost of driving a heavy-duty cargo vehicle on the Analamisampy-Manja road in southwestern Madagascar is 2,644 MGA/km in 2016 (about 74 yen/km *exchange rate as of October 1, 2021).

Table 3-95 shows the total road length and road surface condition by road classification in Madagascar. The total length in the country is 31,612 km. The road surface condition survey does not cover the entire total road length, so that the sum of road length values by road surface condition in the table is not the same as the total road length.

Table 3-95 Road Length and Surface Condition of Madagascar's National Road Network by Road Classification

Road classification	Total length (km)	Road surface conditions		
		Good (km)	Fair (km)	Poor (km)
Primary National roads (RNP)	2,560	1,339	912	309
Secondary National road (RNS)	4,753	1,094	1,188	2,241
Temporary National road (RNT)	4,549	602	753	2,578
Provincial Road (RP)	12,250	537	1,387	4,768
Communal roads (RC)	7,500	0	0	223
Total	31,612	3,572	4,240	10,119

Source: Preparatory Study for the Bridge Rehabilitation Project on the Antananarivo-Toamasina Economic Axis in the Republic of Madagascar Report (Pre-release Version), May 2019.

b) Railroad

There are two railroad lines in Madagascar: Tananarive-Côte Est Railway (TCE) and Fianarantsoa-Côte-Est Railway (FCE). The TCE line is 732 km long and connects the Port of Toamasina with Antananarivo and Antsirabe. The TCE line was privatized in 2003 and is operated by Madarail under a concession contract with the Ministry of Transport and Meteorology (Ministre des Transports et de la Météorologie, "MTM"). The freight trains are mainly used to transport fuel cargo and run twice a day between the oil storage facilities near the port of Toamasina and the two oil storage facilities in Antananarivo. Passenger trains, on the other hand, run only once or twice a week between Moramanga and Toamasina. Railroad infrastructure is deteriorating due to heavy rains, lack of budget for maintenance and rehabilitation. It is also necessary to partially improve the alignment to ensure sufficient functionality. The FCE line operated by a Province is 163 km long and connects Fianarantsoa and Port of Manakara. There is a passenger train service on the FCE line twice every week. The cyclone in 2000 caused major damage due to sediment disasters and flooding, and even today, the aging infrastructure makes the country extremely vulnerable to disasters.

According to the WB document (Madagascar Road Connectivity (P166526): Project Information Document/Integrated Safeguards Data Sheet (PID/ISDS), The World Bank, 26-Apr-2018) 2018), Madarail's line between the capital city of Antananarivo and the port of Toamasina has been assessed as economically and financially promising, provided that proper investment and maintenance is made. However, due to aging infrastructure and cyclone damage, the annual cargo transportation performance has decreased from 430,000 tons in 2010 to 220,000 tons in 2015. If the infrastructure is properly upgraded and maintained, it has been assessed that it could be raised to 600,000 tons per year, or 60% of the total cargo traffic between Antananarivo and Toamasina, by 2023.

c) Port

There are 16 major ports managed by the government of Madagascar. Among these, four ports of Toamasina, Antsiranana, Mahajanga, and Toliara handle international cargo, and other ports handle domestic and feeder cargoes. According to a JICA document (Preparatory Study for the Bridge Rehabilitation Project on the Antananarivo-Toamasina Economic Axis in the Republic of Madagascar Report (Pre-release Version), May 2019), the Port of Toamasina, located in the eastern part of Madagascar, handles about 75 percent of domestic cargo and 90 percent of international cargo. It is the largest commercial port in the country.

Madagascar's ports are under the jurisdiction of the Port, Maritime and River Agency (Agence Portuaire Maritime et Fluviale, “APMF”), which is responsible for related planning, regulation, administration, and operations. However, the Port of Toamasina is under the jurisdiction of the Société du Port à Gestion Autonome de Toamasina (SPAT), and under the concession plan, it is operated by Madagascar International Container Terminal Services Ltd. (MICTS) and the general cargo handling company (Société de Manutention des Marchandises Conventionnelles, SMMC). SPAT and SMMC are private companies with 100% government ownership.

The Port of Toamasina forms a bay in the shadow of two reefs, with area of 2.0 km × 1.5 km. The port of Toamasina is the only one in Madagascar with a large quay (-12m) and a large quiet anchorage. The Port of Toamasina handles a variety of cargo, including marine containers, bulk cargo, general cargo, petroleum products, and mining products. According to a JICA document (Toamasina Port Development Project Ex-Ante Evaluation Report, JICA, 2016), the annual container handling volume is estimated to be 459,887 TEU in 2027, compared to the actual value of 206.990 TEU in 2014, According to another JICA document (Preparatory Study for the Bridge Rehabilitation Project on the Antananarivo-Toamasina Economic Axis in the Republic of Madagascar Report (Pre-release Version), May 2019), through the "Toamasina Port Expansion Project," which is currently being implemented through yen loans, the volume of domestic container cargo unloaded at the port is expected to quadruple by 2035 from the current level. WB document (Madagascar Road Connectivity (P166526): Project Information Document/Integrated Safeguards Data Sheet (PID/ISDS), The World Bank, 26-Apr-2018), points out that while the four ports - Antsiranana, Ehoala, Toliara, and Mahajanga - have the potential to contribute significantly to Madagascar's national economy as international ports, their inadequate transportation infrastructure to and from the hinterland limits the potential of Madagascar's ports.

d) Airport

The government agency responsible for civil aviation sector in Madagascar is the Aviation Civile de Madagascar (ACM). The main airports are managed and operated by Aéroports de Madagascar (ADEMA), while Ivato International Airport in Antananarivo, the capital of Madagascar, and Fascene Airport, located on Nosy Be, a small island in the north of Madagascar, are managed and operated by another private company (consortium) under a recent concession agreement.

Ivato and Fascene airports are developed and operated by Ravinala Airports. According to the website of Bouygues Construction of France, Ravinala Airports is a consortium consisting of Groupe ADP, Bouygues Bâtiment International, Colas, and Meridiam Africa. According to the Ravinala Airports website, the 28-year concession contract calls for the design and construction of a new international terminal at Ivato Airport, the renovation of runways and terminal buildings at both airports respectively, and the achievement of technical and environmental standards for airport facilities.

ADEMA, which had had jurisdiction over Ivato and Fascene airports until they were handed over to Ravinala Airports, has been given additional responsibility for the operation and management of secondary airports and is promoting business development through the development of secondary airports. According to the ADEMA website (https://adema.mg/), it manages and operates 10 major airports, including 6 international airports, and 44 secondary airports (aerodromes) open to public air traffic, which in 2018 handled a total of about 495, 000 passengers and over 2,000 tons of cargo were handled in 2018. Table 3-96 shows an overview of the 10 major airports.

Table 3-96 Ten major ADEA-operated airports in Madagascar

Position	**Classification**	**Transportation results (2018)**	
		Passenger (persons)	**Cargo (tons)**
Antsiranana	International	68,505	179
Sambava	Domestic	80,170	955
Mahajanga	International	39,450	9
Sainte Marie	International	25,334	19
Toamasina	International	80,781	87
Morondava	Domestic	14,755	1
Fianarantsoa	Domestic	NC	NC
Mananjary	Domestic	NC	NC
Toliara	International	77,547	323
Taolagnaro	International	62,740	433

Source: Data from ADEMA website (https://adema.mg/)

Due to insufficient maintenance works on roads and the poor road network, airports are an important transportation infrastructure for domestic travel. For the Antananarivo-Toamasina route, Air Madagascar operates flights using small aircrafts twice every week. In July 2018, Air Madagascar established a new domestic-only airline, Tsaradia, which began operating new flights.

2） Overview of Related Plans and Development Status

Plan National de Developpement (2015-2019) (PND) places the highest priority on the development of key infrastructure for economic growth, and the area along the National Road RN2 connecting Antananarivo and Toamasina is positioned as a strategic region to drive economic growth. The specific action plan is presented in the National Action Plan (Paritra Malagasy zary Ohabolana (2015-2019), "PMO") formulated in April 2015. In this action plan, five strategic axes for implementing PND are defined. One of the contents that is particularly relevant to the transportation sector is "Strategic Axis 3: Comprehensive and Harmonious Territorial Development," which includes the elaboration and strengthening of the road network. Indicators for assessing development status include the rate of preservation of the national asphalt road network, the annual growth rate of marine freight traffic, and the annual growth rate of passenger traffic.

A development plan for the transportation sector is the Plan National de Transport (PNT), which was prepared in 2004. The planning period is from 2004 to 2020, and a total of about 1,200 km of the following three types of roads are planned.

- Links between regional hubs: 3,537 km
- Links between local poles and relay poles, or between local poles: 5,116 km
- Links to allow access between local poles and local areas: 3,227 km

Currently, the most important economic axis in Madagascar is the National Road RN2, which connects the two metropolitan areas of Antananarivo and Toamasina, as well as the railroad and the area along the railroad (hereinafter, “TaToM economic axis”), and development is underway.

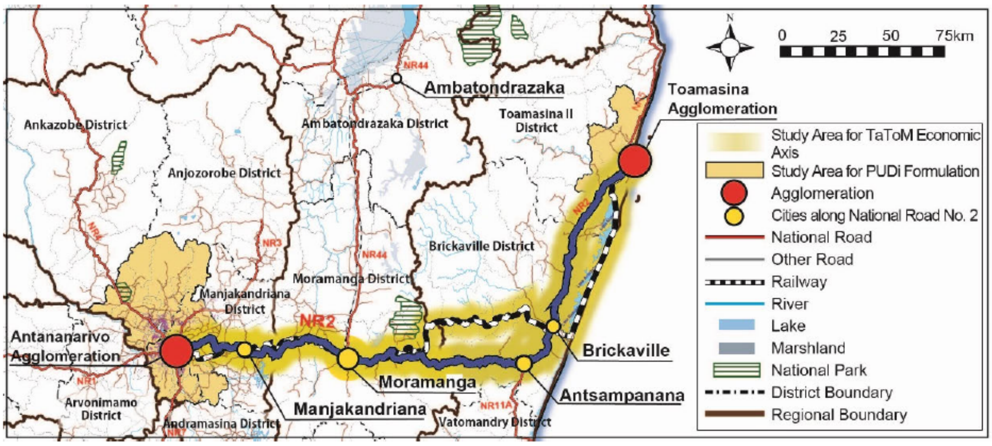


Figure 3-117 Antananarivo-Toamasina Economic and Urban Axis (TaToM) Comprehensive Development Plan

Source: The project on Master Plan Formulation for Economic Axis of TaToM (Antananarivo-Toamasina, Madagasikara) Final Report (summary), JICA, October 2019.

The transportation function of the TaToM economic axis needs to be enhanced (upgraded) to promote industrial development in the Antananarivo and Toamasina metropolitan areas. In the selected growth scenario, the following two initiatives will be implemented in the development of the transportation system of the TaToM economic axis for the economic development of both metropolitan areas.

- Improving freight transportation capacity for industrial development in the Antananarivo metropolitan area
- Increase transportation speed for industrial development in the Toamasina metropolitan area

For the development of each urban area, it is essential to strengthen (upgrade) the transportation system of the TaToM economic axis. However, since the cost of improving the transportation system of the TaToM economic axis is not cheap, measures to improve the transportation system should not only benefit individual urban areas but should also benefit both urban areas for the sustainable development of the TaToM economic axis. The TaToM economic axis development will be implemented in three phases (Phase 1: 2019-2023, Phase 2: 2024-2028, Phase 3: 2029-2033). Regarding transportation between the Port of Toamasina and the Antananarivo metropolitan area, the TaToM economic axis needs firstly to improve safety and resilience, secondly to increase cargo volume, and thirdly to increase speed. The growth scenario selected for the Toamasina metropolitan area is aimed at developing the industrial sector of the Toamasina metropolitan area, in addition to strengthening the logistical capabilities of the Port of Toamasina.

Table 3-97 Status of donor support for TaToM economic axis development

Project	Doner	Year	Status
National Road RN2 Improvement Project	WB, EU	2018	The WB's project for the construction of a weighting station and the EU's project for the improvement of the urban area. The loading and unloading operations near Tana and Toamasina have been completed and are in operation. Upgrading work on facilities near Muramanga is underway.
Toamasina Airport Expansion Project (Presidential initiative)	AFD (under consideration)	unknown	The Toamasina Airport is mainly used for passenger transportation. However, if its runway is rehabilitated, Boeing 737 class aircraft will be able to operate there, which is expected to increase the transportation capacity, including cargo transportation
Antananarivo-Toamasina Expressway Construction Project	Chinese Government	unknown	As a PPP project, a Chinese company proposed a route that would shorten the distance between the two cities by about 100 km compared to National Road RN2. The impact of this project on the TaToM Axis will be great if it is completed, but there are many issues to be solved in terms of high project costs (around 200 billion USD) and environmental considerations. As of February 2022, this project is not in progress, since there is no private company expressing interest in the bidding for the PPP project.
Urban Ring Road（La Rocade）	AFD、EIB、EU	2018~2021	Rocade Est & Nord-Est, a ring road project connecting National Roads RN2 and RN3 in the eastern part of the city, is under construction with funding from AFD, EIB, EU, and the Government of Madagascar.
National Road RN44 Improvement Project (project formation study)	WB	2018	Improvement project of National Road RN 44 (Moramanga～Ambatondrazaka) starting from the district of Moramannga on National Road RN2.

Source: Preparatory Study for the Bridge Rehabilitation Project on the Antananarivo-Toamasina Economic Axis in the Republic of Madagascar Report (Pre-release Version), May 2019.

a) Road

According to JICA documents (The project on Master Plan Formulation for Economic Axis of TaToM (Antananarivo-Toamasina, Madagasikara) Final Report (summary), JICA, October 2019), the Ministry of Public Works (MTP: Ministère des Travaux Publics) and the Ministry of Transport and Meteorology (MTM: Ministre des Transports et de la Météorologie) proposed a highway project connecting Antananarivo and Toamasina, and the government of Madagascar signed a Memorandum of Understanding (MOU) with a private Chinese company in 2016 for cooperation in the construction of this highway. However, as of February 2022, this expressway construction project is not in progress, since there has been no private company expressing interest in the bidding announced by the Government of Madagascar in 2020.

Table 3-98 TaToM Economic Axis Transportation System Growth Scenarios

Development Phase	Transportation-related scenarios
Phase 1 (2019-2023)	Establish safe and disaster risk reduction functions connectivity between Antananarivo and Toamasina by installing traffic safety facilities and strengthening disaster prevention functions on National Road RN2.
Phase 2 (2024-2028)	The increase in passenger vehicle speed will be ensured by the construction of an uphill lane on the priority section between Antananarivo and Moramanga. This construction project will begin in the middle of Phase 1 and continue through Phase 2.
Phase 3 (2029-2033)	The partial opening of the Antananarivo-Toamasina highway and the ongoing rehabilitation of rail facilities will increase the volume of freight traffic.

Source: The project on Master Plan Formulation for Economic Axis of TaToM (Antananarivo-Toamasina, Madagasikara) Final Report (summary), JICA, October 2019.

As part of the development of the TaToM economic axis, the document proposes the construction of an outer ring road to the Antananarivo metropolitan area and the development of industrial areas along this road and to the north of the Ivato airport. In addition, the expansion of radial roads connecting the city of Antananarivo to the outskirts of the city has been proposed to disperse the population and urban functions to the suburbs. The outer ring road is designed to strengthen the connection between National Road RN2, which connects the Port of Toamasina and the city of Antananarivo. Figure 3-118 illustrates the cross-sectoral development directions outlined in the TaToM economic axis concept. According to this document, the transportation route between Tuliara and the capital, Antananarivo, is emphasized, and the National Road RN7 corresponds to this transportation axis.

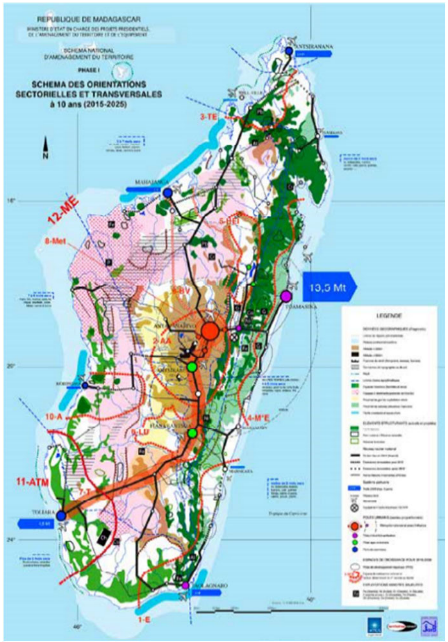


Figure 3-118 Cross-sectoral orientation diagram for the TaToM economic axis initiative

Source: The project on Master Plan Formulation for Economic Axis of TaToM (Antananarivo-Toamasina, Madagasikara) Final Report (summary), JICA, October 2019

b) Port

Since the political crisis of 2009, the country's GDP growth rate had been below 3 percent, but since the new government took office in 2014, the economy has recovered and turned to positive growth. With economic growth, demand for domestic cargo is expected to increase due to rapid population growth, but the container terminal at the Port of Toamasina is too narrow and the quay walls are not long enough or deep enough to allow large container cargo ships to dock. The Toamasina Port Expansion Project (total project cost: 70.207 billion yen), which began in April 2018 under a 45.214 billion yen loan agreement signed in March 2017, is expanding and upgrading the Port of Toamasina. This will enhance the port's ability to meet the increasing demand for cargo, promote investment and private sector development, and contribute to the country's economic development. According to JICA document (Toamasina Port Development Project Ex-Ante Evaluation Report, JICA, 2016), the expansion of the Port of Toamasina will allow the world's largest container ships to call at the Port of Toamasina for transshipment, just like Port Louis Harbour in Mauritius. This will increase the number of feeder ships sailing from the port of Toamasina to East and Southern Africa. As a result, access to cargo ships connecting markets in the Indian Ocean and African continental countries will become easier, reducing transportation costs to those regions and increasing the potential for industrial development aimed at intra-regional consumer markets.

c) Airport

Madagascar's largest airport, Ivato International Airport in the capital city of Antananarivo, has recently changed its governing body from ADEMA to Ravinala Airport Company. According to the website of Bouygues Construction, a major French construction company (https://mediaroom.bouygues-construction.com/ravinala-airports-the-concession-company-for-) the-antananarivo-and-nosy-be-airports-in-madagascar-formed-by-groupe-adp-bouygues-batiment-international-colas-and-meridiam-africa-finalises-its-fundi-2/), Ravinala Airport company has signed a 28-year concession contract to design and build a new international terminal at Ivato Airport, renovate runways and terminal buildings at Ivato and Fascene airports, respectively, and achieve technical and environmental standards for airport facilities.

According to ADEMA's website (https://adema.mg/infrastructures-aeroportuaires-quatre-hubs-dans-lair-avec-adema/), ADEMA has a plan to build a hub airport centered on the Ivato International Airport in the capital city of Antananarivo. The four airports listed for hubs are Toamasina, Antsiranana, Mahajanga, and Toliara airports. In order to realize this hub airport concept, first of all, the Toamasina Airport will be improved and modernized. In Phase 1, US$58 million will be invested in the renovation of the terminal building and runway. Phase 2 will involve the construction of a new international terminal and cargo terminal building at a cost of US$56 million.

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Madagascar, the fourth largest island in the world, is about 1.6 times the size of Japan's land area. Madagascar is in the path of many cyclones that originate in the Indian Ocean and make landfall on the African continent. Thus, cyclones are particularly damaging in Madagascar, causing widespread damage. Figure 3-119 shows the risk of sediment disasters and floods in Madagascar.

The risk of cyclone damage is particularly high in the northeast and east-central parts of Madagascar. Among the international ports in Madagascar, the Ports of Toamasina and the Port of Antsiranana are located in this region. Although the risk of cyclone is relatively low in the Port of Mahajanga, the surrounding areas are at high risk of flooding, so damage to the National Road RN4, the main access route to the Port of Mahajanga running near the port, is expected. The risk of sediment disaster is higher in the eastern and north-eastern parts of Madagascar, so there is concern about damage to the National Road RN2 and the TCE railroad line connecting the capital Antananarivo and the port of Toamasina, as well as the FCE line, National Road RN4, and National Road RN7.

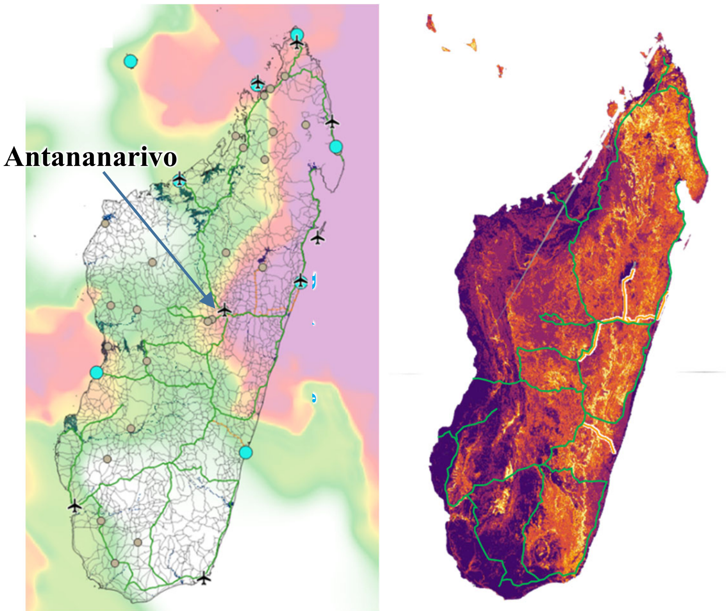


Figure 3-119 Risk of cyclones, floods and sediment disasters in Madagascar

Source: JICA Study Team

The FCE lines are vulnerable to natural disasters. The cyclone in 2000 caused sediment disaster in 280 locations and washed away four locations, shutting down operations for several months. It was restored by donors from Switzerland and others and is still in operation, however, due to the aging infrastructure including rails and vehicles, and the high risk of sediment disaster caused by the cyclone, the service could be suspended again at any time. The FCE line also affects air safety as it crosses the runway of Manakara Airport on a flat surface.

In order to identify critical transportation infrastructures with a high risk of damage, it is necessary to collect information through on-site hearings. Based on the above discussion, Table 3-99 summarizes the important transportation infrastructures for disaster risk reduction that can be considered at present. As mentioned above, 90% of international cargo in Madagascar is processed at the Port of Toamasina. As the closest international port to the capital, it is inevitable, and its expansion project will contribute greatly to the national economy. However, considering the high risk of damage from cyclones and the significant risk of sediment disaster on the transportation corridor between Antananarivo and Toamasina, the concentration of 90% of international cargo in one port is also considered a major risk to Madagascar's economic development. Therefore, although the risk of natural disasters is relatively low, Table 3-99 lists the Ports of Toliara and Mahajanga as international ports that back up the Port of Toamasina. National Road RN4 and National Road RN7, which connect Antananarivo to these two ports, should also be treated as important transportation routes regardless of natural disasters.

Table 3-99 Critical Transportation Infrastructure for Disaster Management in Madagascar

Subsector	Critical infrastructure for disaster risk reduction	High-risk disaster
Road	National Road RN4	Floods, sediment disasters
	National Roads RN2, RN5, RN6, RN7, RN25, RN27, RN34, and RN35	Sediment Disasters
Railroad	TCE Line, FCE Line	Sediment Disasters
Port	Port of Toamasina, Port of Antsiranana	Cyclones
	Port of Toliara, Port of Mahajanga	-
Airport	Ivato Airport, Toamasina Airport, Antsiranana Airport	Cyclones

Source: JICA Study Team

4) Consideration of Disaster Risk Reduction Measures

a) Antananarivo-Toamasina Urban Economic Axis Disaster Risk Reduction and enhancement (sediment disaster countermeasures and functional enhancement of National Road RN2)

Importance and route characteristics of the National Road NR2 in Madagascar

The National Road NR2 is a 353.4 km route connecting the capital city of Antananarivo and the port of Toamasina as the Antananarivo-Toamasina urban economic axis. The daily traffic is approximately 1,700 vehicles/day (2018), with a high proportion of heavy vehicles. The volume of freight transported by the railroad connecting the two cities is 96,000 tons/year (2017), and considering that the total logistics volume estimated for the cities' economic axis is 4,509,000 tons/year (2017) [48], most of the logistics between Antananarivo and Toamasina is transported by truck freight on the National Road NR2. In addition, as mentioned above, 75% of the domestic outbound freights from the Port of Toamasina, which handles about 90% of international freights, is transported to Antananarivo via the National Road NR2[49], which is required to function as an essential artery for the economic development of the country.

[48] The Project on Master Plan Formulation for Economic Axis of TaToM Final Report, JICA, 2019
[49] The Project for Rehabilitation of Bridges on the Economic Axis Antananarivo-Toamasina, Study Report, JICA, 2019

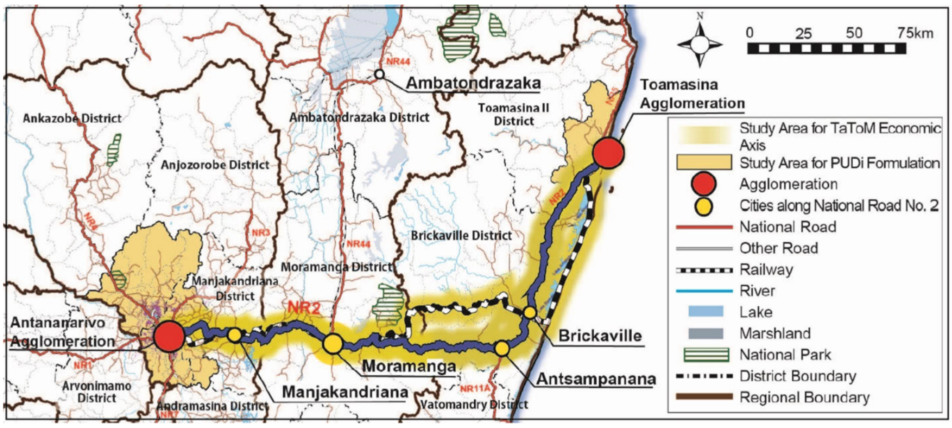


Figure 3-120 Antananarivo-Toamasina economic axis (repeat of previous information)
Source: The Project on Master Plan Formulation for Economic Axis of TaToM Final Report, JICA, 2019

On the other hand, the current National Road NR2 has many problems in terms of its geometric structure. Except for the intra-city section, the standard width of the road is only about 6 meters. Although it is a two-lane road with one lane on each side, it is difficult for large vehicles to pass each other smoothly. In addition, sidewalks, shoulders, center line and center divider, road signs, and drainages are basically not in place. As a result, safe and smooth traffic functions have not been ensured.

The altitudes of Antananarivo and Toamasina differ by about 1,400 meters, and as the National Road NR2 passes through a mountainous area, it has many sharp curves and steep slopes. Container freight vehicles and large logistics vehicles slow down significantly in the intermittent uphill sections, causing the vehicles behind them to slow down and causing traffic congestions. The road surface condition is also poor outside of the urban area, with many torn pavements and uneven sections, which constitutes a problem in terms of traffic performance and safety. During the field survey, many heavy vehicles were found to be stopped due to malfunctioning on the road.

Figure 3-121　Current situation of the National Road NR2

Source: JICA Study Team

Expansion of the Port of Toamasina and development and future traffic demand

The Port of Toamasina has been undergoing expansion work since 2018 under the finance and investment cooperation of JICA, aiming to complete the construction of a new berth that can accommodate the largest container ships, improvement of the existing berths, and expansion of the container yards by 2026. The expansion work will greatly expand the port's functions, and is expected to increase the number of international freight ships making calls at the port and rapidly enhance the freight volume handled at the port. This will rapidly increase the traffic on the National Road NR2, which carries most of the import and export freights of the Port of Toamasina, making the role of the road as an urban economic axis even greater. The table below shows the projected future traffic demand for the National Road NR2 based on the TaToM Economic Axis Study. While the current traffic volume is about 1,700 vehicles/day, it will more than triple to 6,240 vehicles/day in 2033. It is also predicted that heavy trucks will be 3,680 vehicles/day, constituting a high percentage (approximately 60%) of the total.

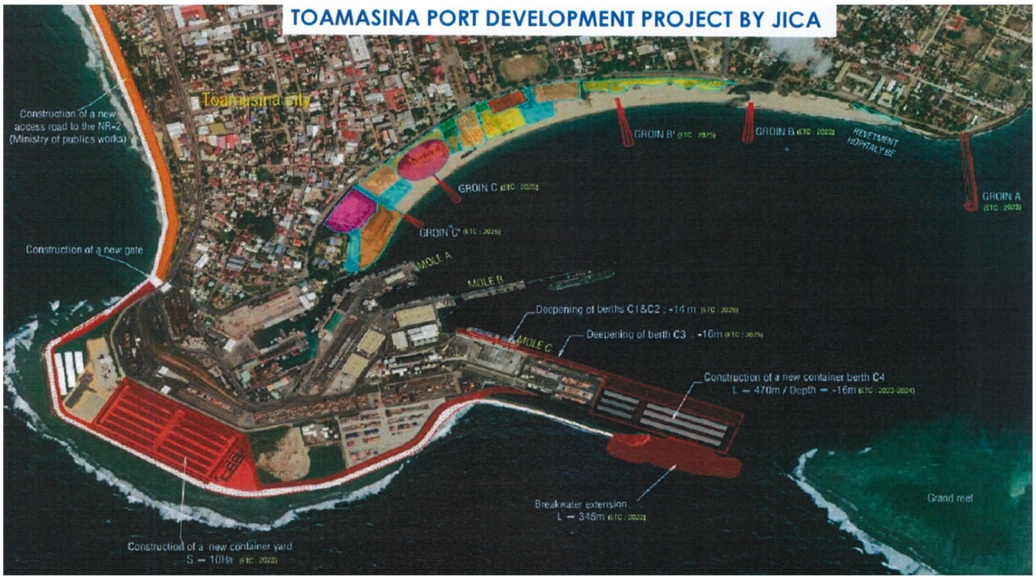


Figure 3-122 Toamasina Port expansion and development plan (project on-going)

Source: SPAT (Toamasina Autonomous Port Authority)

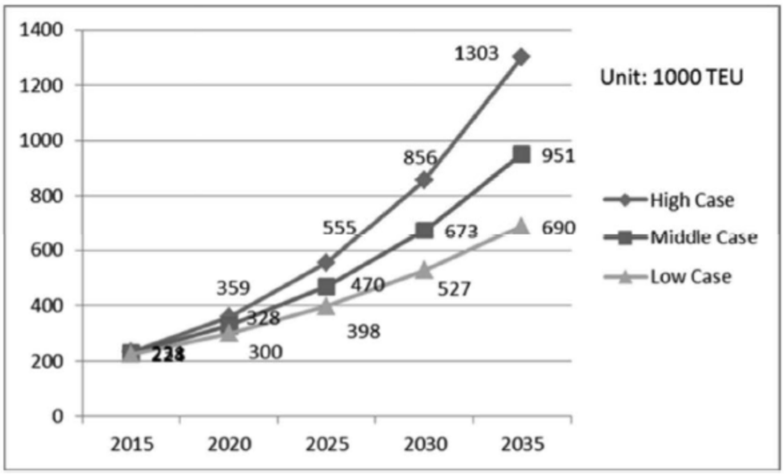


Figure 3-123 Future demand forecast for container freight handling volume at the Port of Toamasina

Source: Madarail (The Project on Master Plan Formulation for Economic Axis of TaToM Final Report, JICA, 2019)

Table 3-100 Future demand forecast for passenger and freight volume using the TaToM economic axis

	2017	2033	2033/2017	Annual average growth rate
Number of passengers ('000 persons)	3,702	6,812	1.8	3.9%
Freight volume ('000 tons)	4,509	14,829	3.3	7.7%

Source: The Project on Master Plan Formulation for Economic Axis of TaToM Final Report, JICA, 2019

Table 3-101 Future demand forecast for traffic on National Road NR2

Vehicle Type	Daily Traffic Volume 2033	Share
Passenger car	1,830	29%
Bus (Taxi-Brousse, etc.)	730	12%
Large Truck	3,680	59%
Total	6,240	100%

Source: The Project on Master Plan Formulation for Economic Axis of TaToM Final Report, JICA, 2019

Development plan for the TaToM economic axis on the National Road NR2

The Master Plan for the Economic Axis of TaToM outlines a strategy for the TaToM economic axis, which requires the enhancement of transportation on the National Road NR2 for economic development. To achieve this, first, safety and resilience enhancement is required, second, freight volume needs to be increased, and third, speed needs to be improved[50]. Furthermore, 17 priority projects have been formulated in the plan regarding the functional enhancement of the TaToM economic axis (National Road NR2), from which 7 high priority projects have been proposed. One of them is the "Project for Construction of Climbing Lane in Steep Slope" between Antananarivo-Moramanga-Brickaville on the National Road NR2, and the proposal for the project section is also under consideration. The countermeasures for collapse of artificial slopes facing of the road are also recommended to be partially implemented along with the climbing lane construction. Among the high-priority projects, for two bridges where passages of vehicles are difficult, the "Rehabilitation Project for Mangoro Bridge and Antsapazana Bridge on the National Road NR2" is underway with grant aid and is scheduled for completion around 2024-2025.

[50] The Project on Master Plan Formulation for Economic Axis of TaToM Final Report, JICA, 2019

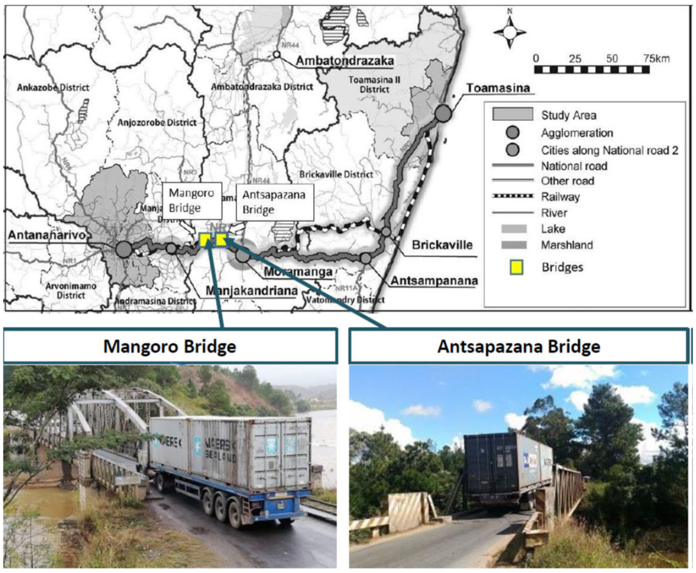


Figure 3-124 Rehabilitation of Mangoro Bridge and Antsapazana Bridge on National Road NR2 (in progress)

Source: The Project on Master Plan Formulation for Economic Axis of TaToM Final Report, JICA, 2019

Support by donors for the National Road NR2

In terms of donor support for the National Road NR2, road improvements within the urban areas of Antananarivo and Toamasina as well as development of load and weight inspection facilities for freight vehicles are being implemented in 2018 with support from the World Bank and the EU. On the other hand, there are not many donor-supported projects for most of the inter-city sections. Although China seems to have considered the construction of an expressway and shorter routes connecting Antananarivo and Toamasina, no specific policies or donor support have been determined, and there are no concrete plans or prospects at present.

Disaster risk and vulnerability

As mentioned above, Madagascar is highly vulnerable to damages caused by cyclones occurring in the Indian Ocean, and the national highway network at various locations suffers from damage such as collapse of slopes facing the roads and stone fall, flooding, and road damage as well as road runoff due to rising rivers in the vicinity during heavy rains and cyclones every year. According to the interviews with the Ministry of Housing and Public Works (Ministère de l'Aménagement du Territoire, de l'Habitat et des Travaux Publics, MAHTP) and the Prevention and Emergency Management Unit, as well as the confirmation of the data on damage to the National Road NR2, there seems to be no precise data on damage history. On the one hand, there are annually one to ten times landslides on the National Road NR2 recently, according to BNGRC.

In addition, the data of damage caused by cyclones to national roads and the photographic data include the information on damages to many routes such as the National Roads No.2, 4, 6, 7, 11, 12, 16, 23, and 24, suggesting that cyclones caused widespread road disruptions and closures due to landslides and flooding.

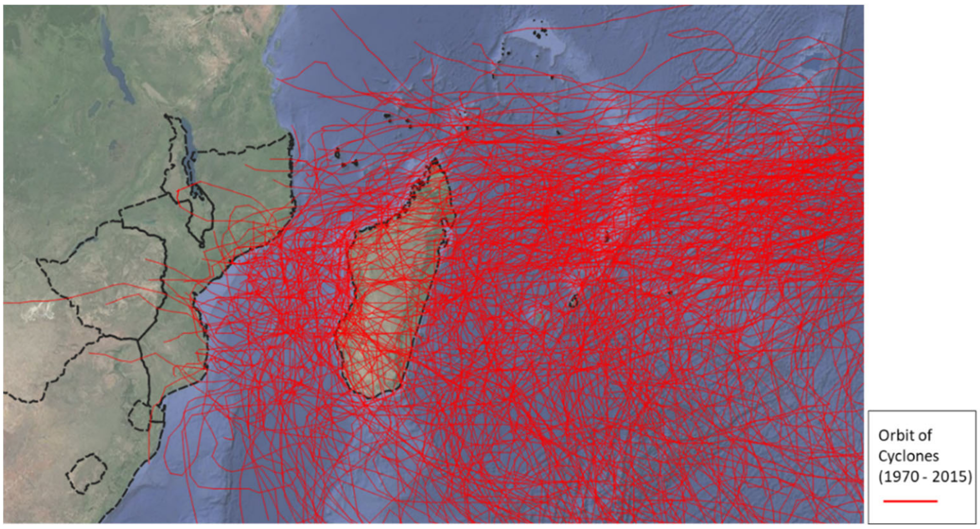


Figure 3-125　Historical cyclone tracks around Madagascar (1970-2015): Repeat of previous information

Source: UNEP, Global Risk Data Platform (https://preview.grid.unep.ch/index.php?preview=data&events=cyclones&evcat=3&lang=eng)

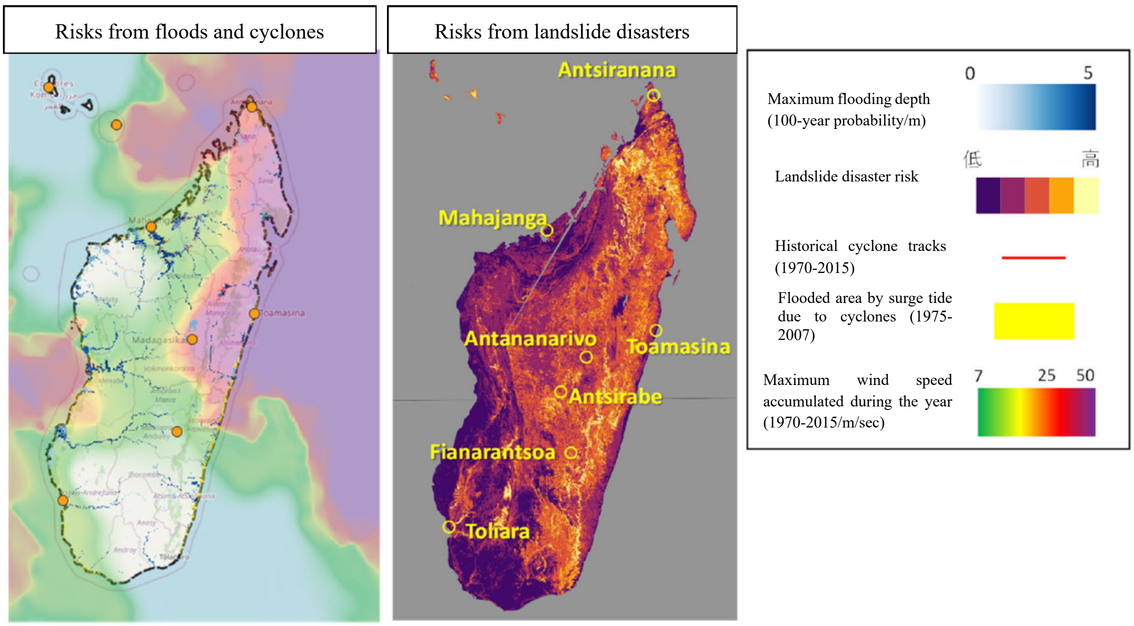


Figure 3-126　Hazard analysis in Madagascar

(Left: flood/cyclone, right: landslide disasters): Repeat of previous information

Source: Sources of each data are listed in Chapter 2 of this report.

Figure 3-127 Landslide disaster and flood damage occurrences on National Road NR2 (2018)

Source: The Ministry of Housing and Public Works (MAHTP)

As illustrated in the figure below, in January 2022, Cyclone ANA caused extensive damage in Madagascar, with flooding occurring near the TaToM economic axis. According to the MAHTP, the damage caused by Cyclone ANA resulted in the closure of the National Road NR2 for 36 hours, and even after the traffic resumed on some sections of the road following the establishment of an emergency alternative route, recovery work continued on the damaged sections.

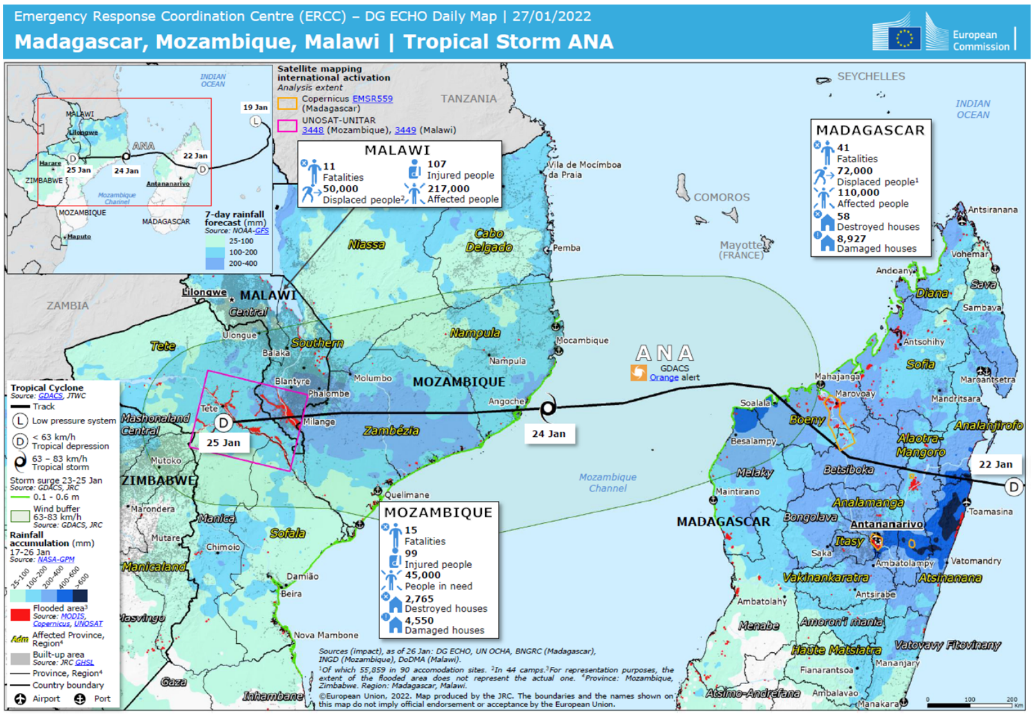


Figure 3-128 Track of Cyclone ANA (January 2022) and occurrence of heavy rain and floods

Source: European Commission

Figure 3-129 Landslide disasters and flood damages on National Road NR2 due to Cyclone ANA (January 2022)

Source: The Ministry of Housing and Public Works (MAHTP)

According to the MAHTP, although there is no precise statistical data on how long it took for the said roads to be closed in the event of a disaster, it can be 6 to 12 hours at the shortest, and in some cases, it can take a day or two. The MAHTP also said that, if the scale of damage is large, it may be difficult to restore the road in a few days. When the National Road NR2 is closed, there is basically no alternative route between Toamasina and Antananarivo that is accessible by large freight vehicles. When the National Road NR2 is available, the journey between Antananarivo and Toamasina is said to take about 8 hours for ordinary vehicles and 2 days for freight vehicles. If the mountainous section of the National Road NR2 near Moramanga, etc. is closed to traffic and a detour is needed on the southern route (via the National Roads No.11, No.25 and No.7), it is expected to take 5-6 days.

If the road is closed for two days, the costs of economic losses are estimated to be approximately JPY 1.8 billion, based on the projected traffic volume for the year 2033 (estimated by multiplying the road closure time by the number of vehicles affected by the closure and the time value of each vehicle type[51]). If the road is frequently closed due to landslide disasters, etc., economic loss could be that much greater. According to BNGRC, there are annually about one to ten times landslides on the National Road NR2 recently. If there are three times of 2days road closure in a year, the economic loss could be estimated as approximately JPY 5.4 billion.

<u>Outline of the proposal for the National Road NR2 disaster risk reduction and resilience enhancement project</u>

Promoting disaster risk reduction measures and functional resilience enhancement for the TaToM economic axis (National Road NR2), the primary engine for economic development in Madagascar, are important in order to reduce disaster risks and to improve transportation functions of the country. Therefore, we propose a project to implement the countermeasures for collapse of artificial slopes and ground reinforcement for roads in areas with high risk of landslide disasters (slope collapse and falling rocks) in the event of the cyclone, and a project to improve climbing lanes on steep sections of the road, which should be carried out in a coordinated manner.

In order to implement countermeasures for collapse of artificial slopes and improve road structure

[51] The estimation of economic loss is based on the concept of "Manual for measuring the effects of improving the functions for disaster risk reduction of road networks (draft), Ministry of Land, Infrastructure, Transport and Tourism, 2016", and the figures obtained by multiplying the time value by vehicle type in the "Cost-Benefit Analysis Manual, Ministry of Land, Infrastructure, Transport and Tourism (MLIT), 2018" by a correction factor of 0.7 were applied as the time value. Although the correction factor is not defined based on the clear rationale, it is assumed to be around 70% given the assumption that not only the drivers but also the opportunity cost of the vehicle is affected.

to reduce disaster risks, it is important to select priority sections by identifying the areas with high concentration of landslides in the past through the confirmation of disaster history, field survey and analysis, and consultation with relevant organizations, and study the details of the countermeasures. The construction of a climbing lane is considered to be a high priority in the section from the Port of Toamasina to Antananarivo, where the traffic demand of large freight vehicles loaded with freight from the Port of Toamasina is high, and where the steep gradient sections causing significant speed reduction exist. The figure below shows the difference in altitude between Antananarivo and Toamasina and the longitudinal gradient.

As it will be difficult to implement countermeasures for all the issues with the budget size of the grant aid, the approach of the project may be to identify the priority areas for countermeasures after conducting surveys and analysis, and to implement the project as a pilot project in combination with capacity building of relevant government agencies. Since there are few sections with countermeasures for landslides and climbing lanes in Madagascar, it seems that the related governmental agencies do not have sufficient experiences and knowledges for the implementation of those projects. By developing the capacity of related governmental agencies in terms of technical aspects such as planning, design and construction management and project management aspects, it is expected that the pilot projects will contribute to promotion of similar type of road projects in other road sections in Madagascar.

Figure 3-130 Concept of the construction for artificial slope protection

Source: The Project on Master Plan Formulation for Economic Axis of TaToM Final Report, JICA, 2019)

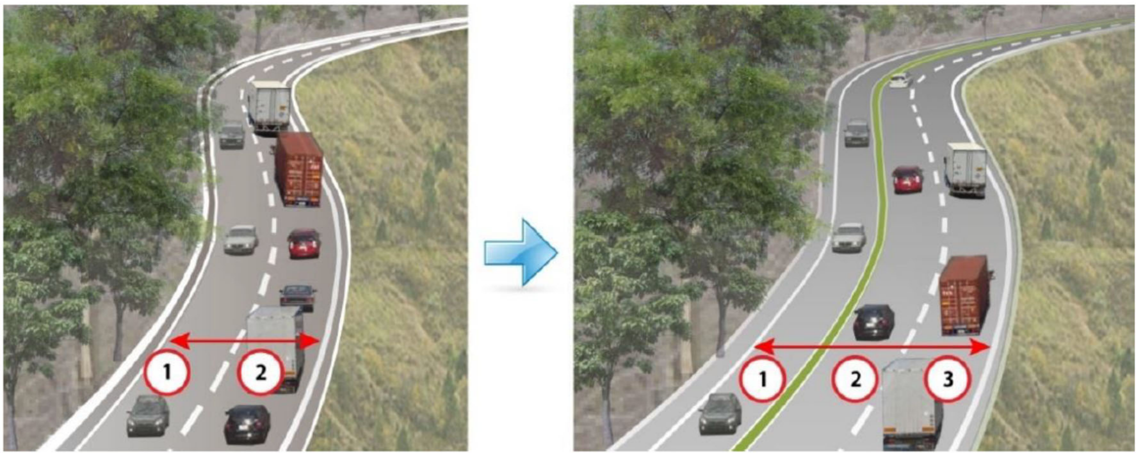


Figure 3-131 Concept for the climbing lane construction for the National Road NR2

Source: Madarail (The Project on Master Plan Formulation for Economic Axis of TaToM Final Report, JICA, 2019); The Project on Master Plan Formulation for Economic Axis of TaToM Final Report, JICA, 2019)

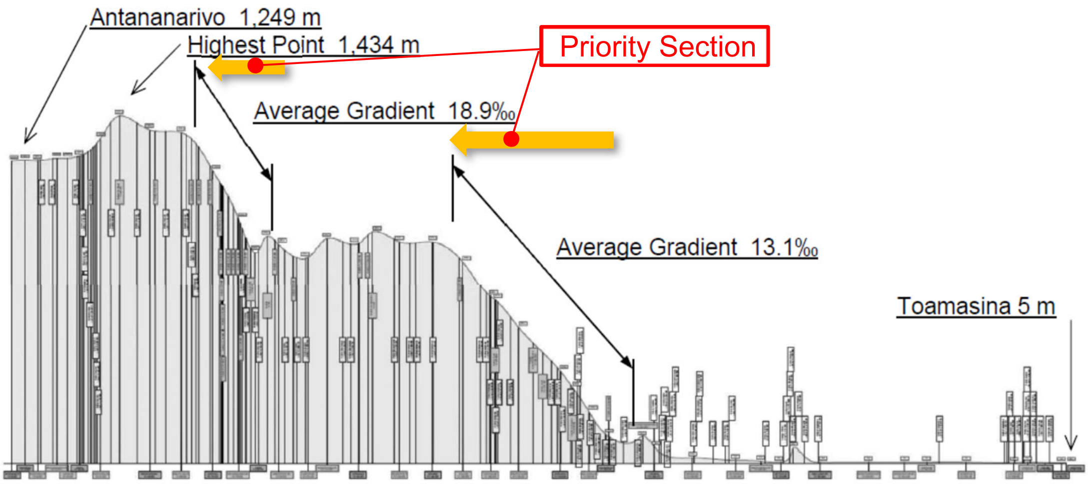


Figure 3-132 Altitude difference and longitudinal gradient of the Antananarivo-Toamasina Intercity Railway (TCE Line) (reference)

Source: Madarail (The Project on Master Plan Formulation for Economic Axis of TaToM Final Report, JICA, 2019) Additional description is provided by the JICA Study Team

For example, in the TaToM economic axis survey, the areas that need to be improved were identified from the past cyclone damage records and longitudinal gradients, as shown in the figure below. Further review of the latest disaster and problem areas, such as the damage caused by Cyclone ANA, and selection of priority sections for grant aid projects and support for study of countermeasures to serve as model activity for other sections, in particular, are expected to trigger subsequent support from other donors and the provision of ODA loans.

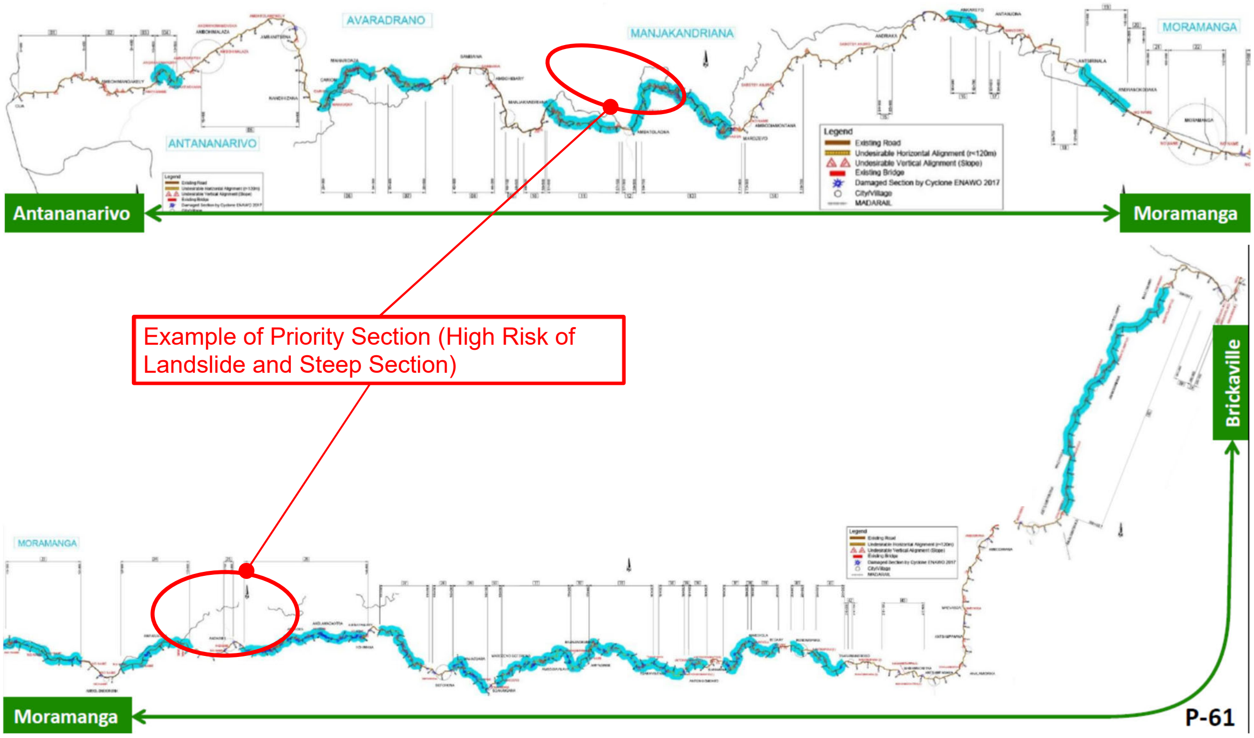


Figure 3-133 Priority section for countermeasures for the collapse of artificial slopes and climbing lane construction on National Road NR2 (concept)

Source: Additional description is provided by the JICA Study Team to the Project on Master Plan Formulation for Economic Axis of TaToM Final Report, JICA, 2019

As mentioned above, if the National Road NR2 is closed for two days, the economic loss (opportunity cost) would be about JPY 1.8 billion according to the projected traffic volume for 2033. For example, if a similar road closure occurs every year for 30 years, the loss would be JPY 54 billion. There are one to ten times road closure by landslides on the National Road NR2 in recent years. If there are three times of 2days road closure every year for 30 years, the economic loss could be approximately JPY 162 billion. If the road is no longer closed after the disaster risk reduction for slopes and the countermeasures for collapse of artificial slopes, the elimination of the relevant loss will be deemed as the project effect (benefit). In addition to this, construction of climbing lanes will provide further benefit of shorter travel time.

b) Disaster risk reduction and resilience enhancement for National Road NR7

The National Road NR7 is also highlighted in the concept of the TaToM economic axis as a transportation axis connecting the southwestern cities of Turriana and Antananarivo[52]. This route is also an important link between the capital city and the southern region of Madagascar, but some sections are prone to landslides in the event of a cyclone. The following figure shows the damage caused by the cyclone on the National Road NR7, inferred from the data provided by the MAHTP. For the purpose of preventing and mitigating such damages, it is important to evaluate and study the entire route from the perspective of disaster risk reduction, and further, to implement landslide countermeasures and projects for the National Road NR7 as in the case of the National Road NR2. On the other hand, since the importance of the route and the priority of the countermeasures are relatively higher for National Road NR2, collaboration and capacity building with local government agencies for implementation of countermeasures on National Road NR2 are considered to require higher priority, and then expanding the efforts to other regions and routes should be considered.

Figure 3-134 Damages suffered by National Road NR7 (in the event of Cyclone CHEDZA in 2015)

Source: The Ministry of Housing and Public Works (MAHTP)

[52] The Project on Master Plan Formulation for Economic Axis of TaToM Final Report, JICA, 2019

(3) Power

1） Overview of Relevant Organizations and Legal systems

In Madagascar, the Ministry of Energy and Hydrocarbons oversees the legal system and policies for electricity supply, and JIRAMA, under its supervision, develops and operates a vertically integrated grid for generation, transmission, and distribution. Rural electrification that is not grid-connected is supervised by ADER, which is subordinate to the Ministry of Energy, and implemented by PIU.

Madagascar's power sources are hydropower and diesel power, which are scattered near the demand areas. A chronic shortage of power generation is an issue, and in addition to the lack of capacity, aging and lack of maintenance are also major factors. The country is heavily dependent on hydropower and is prone to power shortages during the dry season from October to December.

The only grid system is the fragmented Antananarivo-Toamasina-Finalanzoa. The Antananarivo system is almost a loop.

The cost of electricity generation is about 25cent/kWh, which is higher than the cost of electricity. For this reason, subsidies in the electricity and fuel sectors are necessary, putting pressure on government finances. There is a need to increase RE in order to reduce fuel consumption. Also, the rate of uncollected charges is high. Transmission loss is 5%, but distribution is not included, and JICA report says 22% for transmission and distribution. Most of the power supply is handled by JIRAMA, a vertically integrated power utility with 511 MW of installed capacity in 2017, of which 389 MW was available. 1,702 GWh of total power generation is equivalent to 86% of the country's power generation. Of the power generated by JIRAMA, 459 GWh is supplied by the heavy oil plant of an IPP that has a purchase agreement with JIRAMA.

Madagascar has not been able to supply enough electricity to meet the demand before securing backup capacity. Hydropower potential is abundant, but progress has not been made due to lack of data and rights issues.

A comprehensive power master plan has not been confirmed. In the future, it is expected that the three systems will be interconnected, power supply will be developed, and PV will be used for rural electrification.

The hydropower potential is estimated to be 7.8 GW, but detailed hydrological data is not yet available. Candidate sites for hydropower are scattered throughout the country, and grid maintenance is also an issue (securing RoW, etc.). The distribution of solar radiation across the country has been surveyed, and there is great potential for the introduction of PV. On the other hand, wind and geothermal power have almost no potential.

2） Overview of Related Plans and Development Status

The PEMC is implementing a power development plan, and there is an energy MP for 2015-30 and a rural electrification plan; there is a target to electrify all households by 2030, but rural areas are poor and have low population density, so electrification will not proceed. Capacity building of relevant institutions is also needed.

In addition, the conversion from light to heavy oil and the introduction of PV is underway with World Bank support. In addition, the World Bank has presented a proposal to expand the grid for electrification between major cities and rural areas. Other support from China is also increasing.

Madagascar has set the following targets for power development within the framework of the IEM through the PEM horizon 2023 (plan de continuite des services essentiels energie en cas de catastrophe).

- 50% of Madagascar's population will have access to electricity at an acceptable price (USAID says current electrification rate is 25% as nationwide, 46% in urban and 12% in rural area.)
- Double the current electricity production capacity to 820 MW by 2023
- Achieve an electricity mix that is 70% renewable energy
- Develop five priority hydropower projects (600 MW) and medium capacity projects (350 sites ranging from 2 to 20 MW)
- Construction of solar power (150 MW), wind power (150 MW), and coal power (60 MW in Imaroto)
- Development of strategies to achieve zero-economical load shedding
- Hybridization of JIRAMA's thermal power plants (119 districts)
- Review of connection fees to reduce initial costs
- Implementation of JIRAMA debt restructuring plan
- Assessment of the needs of the Tanamasoandro project and planning of the power supply
- Develop a national energy plan for crisis situations and acquire relevant equipment
- Provide solar kits to households without access to electricity and easy payment
- Updating the medium- and long-term master plan, especially to meet new needs in the development sector

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

In Madagascar, only JIRAMA has a contingency plan for the electricity sector (plan de continuite des services essentiels energie en cas de catastrophe). It is stated that JIRAMA ensures power supply in all districts of the country and covers the areas at risk. It is a member of the Committee for Essential Services (CSE) established by the 2011 National BCP and works with the ministry in charge of electrical energy.

The Ministry in charge of electrical energy has developed sector plans such as the "Madagascar National Electrification Plan" (PNE-SNE) and the "Least Cost Development Plan" (PDMC). Another priority action of PEM30 is the development of a national energy plan for the crisis situation and the acquisition of relevant equipment. In order to implement this plan, MEH has developed a plan in its Public Investment Program (PIP) entitled "Emergency Intervention and Electricity Supply Continuity Program", which runs until 2020. This PIP includes the following

- Emergency intervention and continuity of supply program for electrical energy
- Procurement of materials and equipment for electrical emergency response
- Electrification of hospitals to respond to the COVID 19 pandemic and various other situations that may disrupt the country
- Solar kit mass distribution project

In addition, Madagascar experiences three to four cyclones and associated floods per year, one or two of which are very damaging. Every year, a multi-risk and multi-hazard crisis management plan (GRC) is developed for risk and disaster management, including an emergency and relief organization plan. In addition, as part of the Pilot Program for Climate Resilience (PPCR) funded by the Climate Investment Fund (CIF) with the support of the World Bank (Grant Agreement TF0A5362) and implemented by the Prevention and Crisis Management Support Unit (CPGU) attached to the Office of the Prime Minister, a basic A continuity plan for services has been developed.

In particular, for the energy sector, a continuity plan has been developed to ensure continuity of basic services related to electricity, wood energy, petroleum products and gas distribution during disasters. The plan provides for preventive, disaster, and recovery measures for each of the three subsectors: electricity, wood energy, and oil and gas products.

For electricity, the first preventive measure is to prevent blackouts in the transmission and distribution network and damage to substations. Second, in the event of a disaster, diesel generators, PV SSDs, and pico-PV kits will be used to provide electricity services to specific affected areas as needed. Third, the power transmission and distribution networks and power plants in the affected areas are being restored; spare generators, PV SSDs, and pico-PV kits are being removed, transported, and stored; and standards for the installation of electrical equipment are being revised so as to increase disaster resistance.

Considering that electrical and telecommunication installations are vulnerable to cyclones and are a strategic issue for the functioning of the population and the economy, technical and organizational provisions have been made to optimize the durability, especially strength and stability, of structures against cyclones (Reference Guidelines for Disaster Resistant Electrical and Telecommunications Installations in Madagascar). The design standards for civil and structural engineering in this field are based on Eurocode or former French standards.

These provisions relate to the design, construction, and operation of new electrical and telecommunication installations, but can also be applied to existing structures, especially in the case of retrofitting works. The facilities that are specifically considered are as follows

- HV (high voltage) transmission lines and supports, LV and MV (low and medium voltage) distribution lines and supports (this includes towers, poles, their foundations, cables, and accessories (e.g., insulators))
- Power plants: external components of power plants (thermal and hydroelectric)
- Related buildings, buildings that house dedicated electrical and communication equipment

In Madagascar, other facilities, such as solar power plants, wind farms, and biomass, are also used as sources of electrical energy. This regulation does not take into account the particularities of these facilities, but sets out a number of general provisions that can be applied to these facilities. The development of this regulation is based on the following research

- Organizing meetings with the organizations responsible for the facilities involved
- Gathering information in the field on the condition of typical facilities, including conditions during cyclone damage

<hazard map>

As for landslides, both the power supply and the power grid are located in medium-risk areas, so appropriate civil engineering design needs to be carried out.

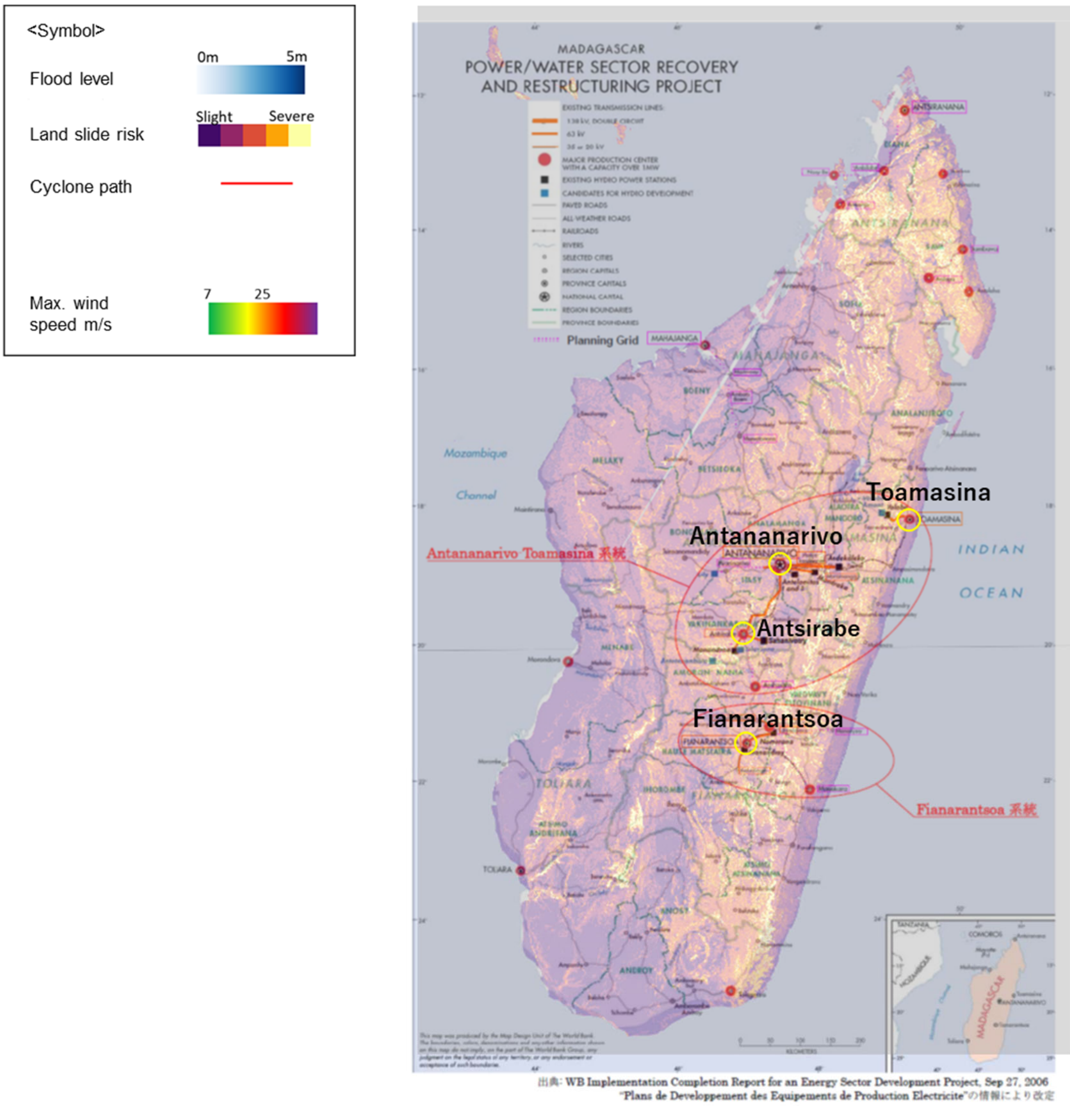


Figure 3-135 Madagascar Power Facilities and Landslide Risk Map

Source: Prepared by the study team based on Integrated Master Plan Mozambique Power System Development Final Report (2018, JICA).

As for floods and cyclones, wind damage to facilities is expected due to the large wind speed records in Toamasina and Antananarivo. Appropriate design standards need to be adopted, and in some cases, underground cables should be used.

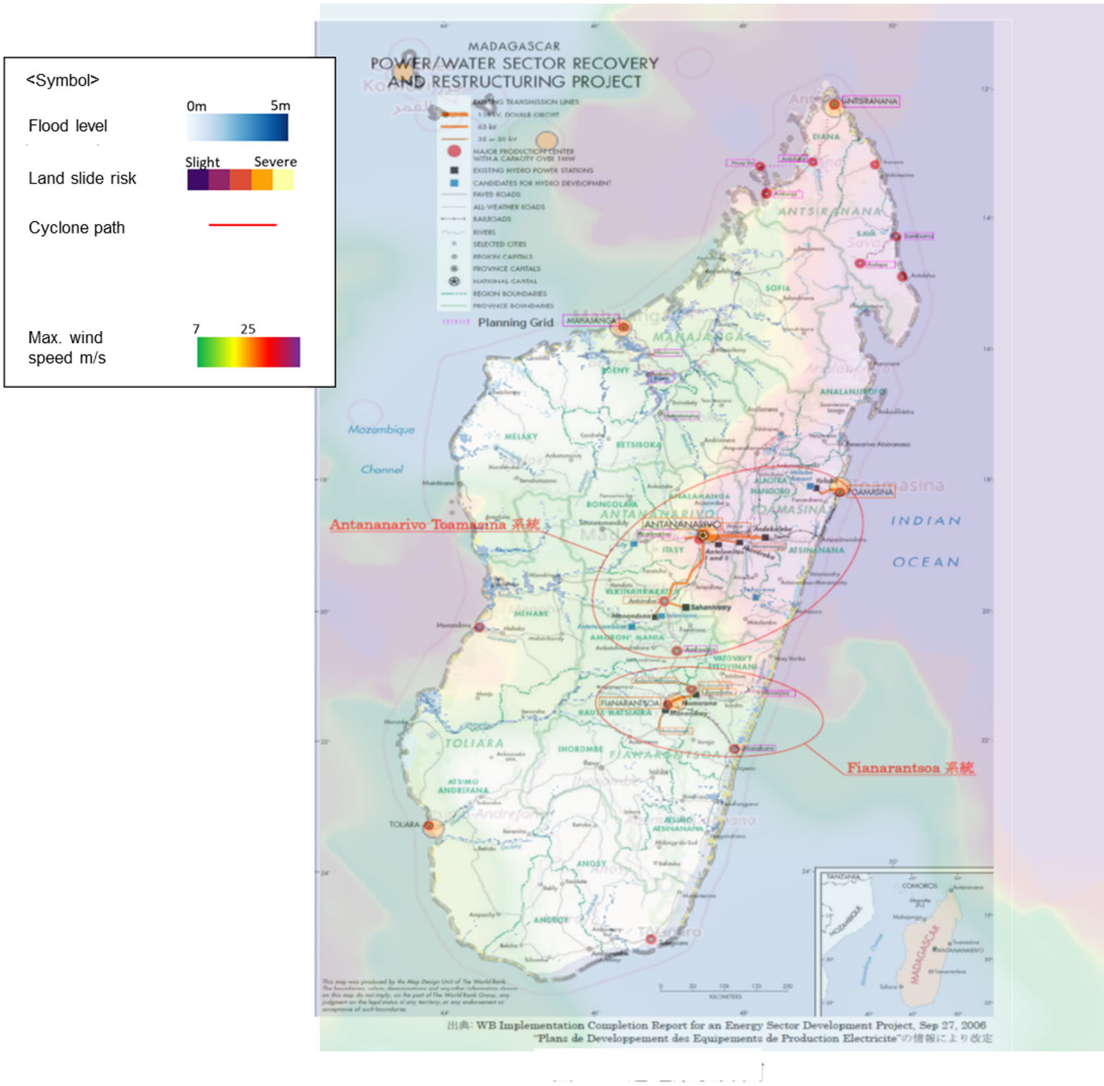


Figure 3-136　Madagascar Power Facilities and Cyclone and Flood Risk Map

Source: Prepared by the study team based on Integrated Master Plan Mozambique Power System Development Final Report (2018, JICA).

4） Consideration of Disaster Risk Reduction Measures

The challenges for the power sector in Madagascar include the development and strengthening of the power supply, transmission, and distribution networks and rural electrification, but there are many factors that hinder development, including political instability, financial difficulties for JIRAMA, sparse population distribution in rural areas, rights issues during development, and poor English language skills. Projects such as hybrid power generation, which can provide reliable power in the event of a power outage or disaster, for important public sectors, companies, and industrial parks in urban areas, may be beneficial, but it will take time to overcome these obstacles.

(4) Water and Sanitation

1) Overview of Relevant Organizations and Legal systems

The institutions involved in water supply and sanitation in Madagascar are as follows (Table 3-102).

Since 2008, the Ministry of Water (Ministère de l'Eau) was responsible for water supply and sanitation, and the Ministry of Public Health (Ministère de la Santé Publique, "MSANP") for hygiene. In 2017, the Ministry of Water was replaced by the Ministry of Water, Energy and Hydrocarbons (Ministère de l'Eau, de l'Energie et des Hydrocarbures) and in 2018 by the Ministry of Water, Sanitation and Hygiene (Ministère de l'Eau, de l'Assainissement et de l'Hygiène, "MEAH") in 2018 and added a hygiene department to further strengthen the WASH regime.

Table 3-102 Water and sanitation relative institutions in Madagascar

Institutions	Summary
Ministry of Water, Sanitation and Hygiene / Ministère de l'Eau, de l'Assainissement et de l'Hygiène (MEAH)	Responsible for the supervision and regulation of governance and technology in the field of WASH.
Department of Water Supply / Direction de l'Alimentation en Eau (DAE)	MEAH's water supply department. It is responsible for ensuring drinking water supply, rational use of water resources, emergency response and environmental considerations.
Department of Sewage and Hygiene / Direction de l'Assainissement et de l'Hygiène (DAH)	The MEAH's department responsible for sewage and sanitation. It is responsible for the legislation of sewage and sanitation officials at the national level, the implementation of the PSNA, the promotion of hygiene activities for the prevention of infectious diseases, hygiene education, and the collaboration between the sewage and sanitation sector and the water supply sector.
National Water and Sanitation Authority / l'Autorité Nationale de l'Eau et de l'Assainissement (ANDEA)	It is the implementing body of the Integrated Water Resources Management Policy, supervised by MEAH.
Water and Sanitation Regulatory Company / Société de régulation de l'Eau et de l'Assainissement (SOREA)	It is the regulatory body that guarantees the quality of public water and sanitation services, and regulates the contracts and practices of the municipalities in which it operates, and is supervised by MEAH.
Water supply in the South / l'Alimentation en Eau dans le Sud (AES)	It is responsible for water supply in rural areas where JIRAMA does not operate, and is supervised by MEAH.
Autonomous Maintenance Service of the City of Antananarivo / Service Autonome de Maintenance de la Ville d'Antananarivo (SAMVA)	It is responsible for the maintenance of primary, secondary, and tertiary drainages and is supervised by the MEAH.

Institutions	Summary
Malagasy Electricity and Water / Jiro sy rano Malagasy (JIRAMA)	A public corporation that provides water and electricity services in cities including Antananarivo.

Source: JICA Study Team

The law relating to water supply and sanitation in Madagascar is the Water Code (Loi n° 98-029 du 20 janvier 1999 portant Code de l'Eau). The Water Code is the basis for water supply and sanitation services, but since its enactment in 1999, there have been no major revisions, and old organizations are left in the law.

2) Overview of Related Plans and Development Status

Madagascar urgently needs to improve the proportion of the population with access to water and sanitation services. Access to safe water is 86% in urban areas, 36% in rural areas and 54% nationally. Households with access to improved latrines is only 40% in urban areas, 15% in rural areas and 24% nationally, with 55% of households in rural areas forced open defecation (OD). (UNICEF/WHO Joint Program Monitoring, 2015)

- The Government of Madagascar has so far implemented its WASH policies in line with the following national plans.
- Madagascar Action Plan (MAP)
- National Programme for Access to Drinking Water and Sanitation 2008-2012 (Programme National d'Accès a l'Eau Potable et l'Assainissement 2008-2012, "PNAEPA")
- National Sanitation Policy and Strategy (Politique et Stratégie Nationale de l'Assainissement, "PSNA", 2008)
- National Water, Sanitation and Hygiene Strategy 2013-2018 (Strategie Nationale de L'eau, de 'Assainissement et de L'hygiene)
- JIRAMA Master Plan 2003
- Although MAP was not formally adopted due to political changes at the time, the water and sanitation goals set out in MAP continue to be referenced in PNAEPA, which is based on the MAP's "Development of a National Water and Sanitation Programme" and was developed as a three-year programme for 2005-2008. PNAEPA was developed as a five-year programme for the period 2008-2012, updating the three-year programme for 2005-2008. The main indicators are the proportion of the population with permanent access to drinking water will increase from 35% (2005) to 65% (2012) (urban: 61% to 95%; rural: 32% to 57%); the proportion of the population with permanent access to sanitation will increase from 54% (2005) to 71% (2012) (urban: 77% to 87%; rural: 32% to 57%). Although these figures have

improved, the targets have not been achieved.

PSNA contains policies and strategies related to the sanitation sector (drainage, rainwater, household waste and excreta) and the role of each ministry and agency related to sanitation. The National Water and Sanitation Strategy 2013-2018 sets out targets for access rates to water and sewerage services to be achieved by 2025, as follows.

Table 3-103 Goals of the National Water and Sanitation Strategy 2013-2018, Madagascar

	2015	2018	2025
Safe water supply	51.00%	63.00%	100.00%
Open Defecation Free	58.00%	99.00%	100.00%
Improved sanitation	50.00%	62.00%	100.00%

Sources: Document de stratégie du secteur EAH (Ministry of Water, 2013)

JICA has so far provided the following support for water and sanitation issues in Madagascar.

- Groundwater exploitation project in the south-west Madagascar (JICA, Phase I 1992, Phase II 1993-1994)
- Water supply facility maintenance capacity and sanitary behavior improvement plan in Atchimo Andrefana Region (JICA, 2012)
- Following-up cooperation of the groundwater exploitation project in the south-west region (study) (JICA, 2016)
- The Project on Master Plan Formulation for Economic Axis of TaToM (Antananarivo-Toamasina, Madagasikara) (JICA, 2019)

JICA supported the development of groundwater in south-west region of the country. JICA has currently supported the promotion of the development of the Economic Axis of TaToM (Antananarivo-Toamasina, Madagasikara) as a key point in the country's economic development, where population and assets are concentrated, and one of the key issues is the security of electricity and water in the Antananarivo and Toamasina metropolitan areas.

The Master Plan Formulation for Economic Axis of Antananarivo-Toamasina, Madagasikara (TaToM) indicates the suburbanisation of the city. On the other hand, the rapid population growth in the outskirts of Antananarivo, relative to JIRAMA's current water supply area and the water supply projections of the 2003 Water Supply Master Plan, is very different, making the extension of electricity and water infrastructure to the suburbs a challenge.

The following support programmes have been implemented by other international donors.

- Integrated Urban Development and Resilience Project for Greater Antananarivo (World Bank, on-going from 2018)

- Support for resilient livelihoods in the South of Madagascar (World Bank, on-going from 2020)
- JIRAMA Water III (European Investment Bank (EIB), on-going from 2014)
- Capacity enhancement of existing water treatment plants, construction of new water treatment plants, emergency response, construction of main pipelines, and remote management systems.
- Equipment providing to JIRAMA (KOICA, UNICEF and the Government of Norway, 2021)
- Integrated Sanitation Programme for Antananarivo (PIAA) (AFD, on-going from 2015)
- Protecting the Population from Flood Risks in Antananarivo (AFD, on-going from 2016)
- Strengthening the urban planning capacity of Antananarivo, repairing the sewage network and pumping facilities, and raising awareness of sanitation.
- Participatory Slum Upgrading Programme (PSUP Madagascar (EN), PPAB Madagascar (FR)) (UN-HABITAT, 2015)
- Improvement of the quality of water supply (water pressure, operation), expansion of public taps, and repair of JIRAMA house connected water supply.

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

The hazards on the water and sanitation infrastructure in Madagascar are cyclones, floods and droughts. In urban areas, such as the Antananarivo Agglomeration, there is an urgent need to expand water and sewerage service areas to cope with rapid population growth, while in rural areas, the challenge is to increase access to safe water and improved sanitation during normal times, and to build infrastructure that is less vulnerable to climate change.

From the perspective of DRR investment, it is desirable to promote the development and resilience of water and sewage infrastructure, especially in the Antananarivo Agglomeration, where there is a high concentration of population and assets.

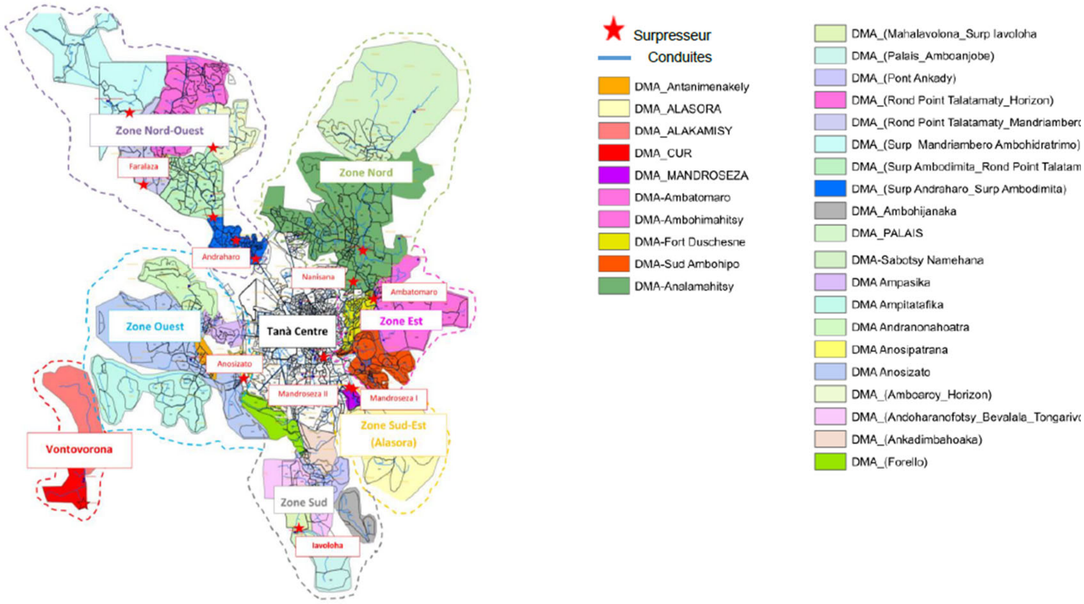


Figure 3-137 Water supply service area of JIRAMA

Source: RAKOTONDRASOA Herimirindra Larissa. 2016. Etude de l'adequation du besoin en eau potable d'antananarivo par rapport aux ressources mobilisees. Cas de mandroseza

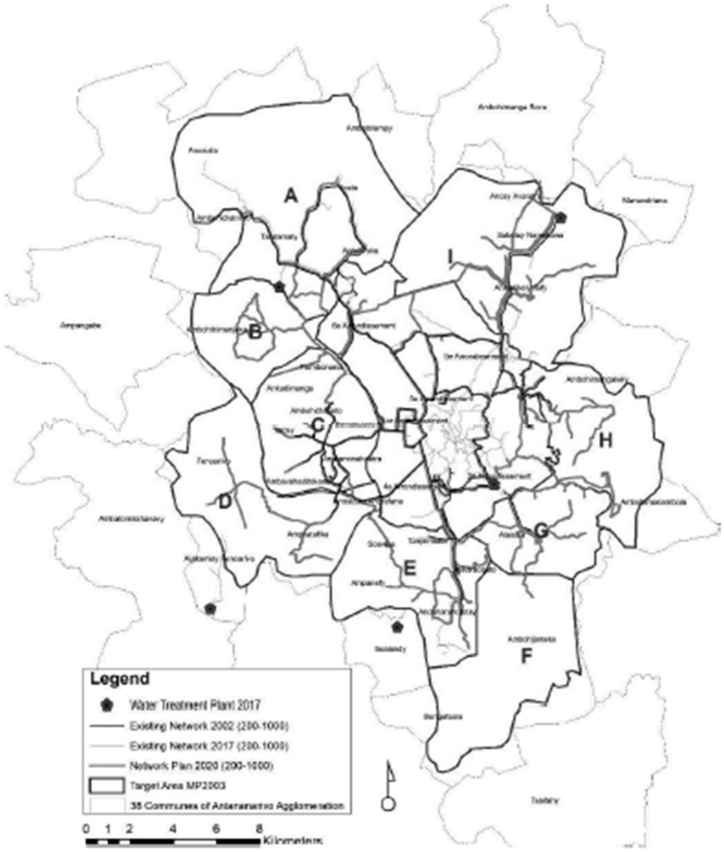


Figure 3-138 Expansion plan of water supply service area of JIRAMA (target year 2020)

Source: JIRAMA's Water Supply Master Plan for Antananarivo, 2003

The MEAH, with the support of the World Bank, has developed the Continuity Plan for Essential Water, Sanitation and Hygiene Services (Plan de Continuité des Services Essentiels d'Eau, d'Assainissement et d'Hygiène “PCEAH”) in 2020. PCEAH mentions heavy rains, droughts, cyclones, floods, heat waves and cold waves as the types of disasters to be considered. In cases of cyclones and floods and droughts, it also includes an institutional coordination chart in emergency (Figure 3-139), a list of responsibilities and emergency response activities, including the Prime Minister and relevant ministries, universities and press. The list of activities is divided into the following stages: before the disaster, immediately after the disaster, during the disaster - within 24 or 48 hours, until the effects of the disaster are over, and after the disaster. (Table 3-104)

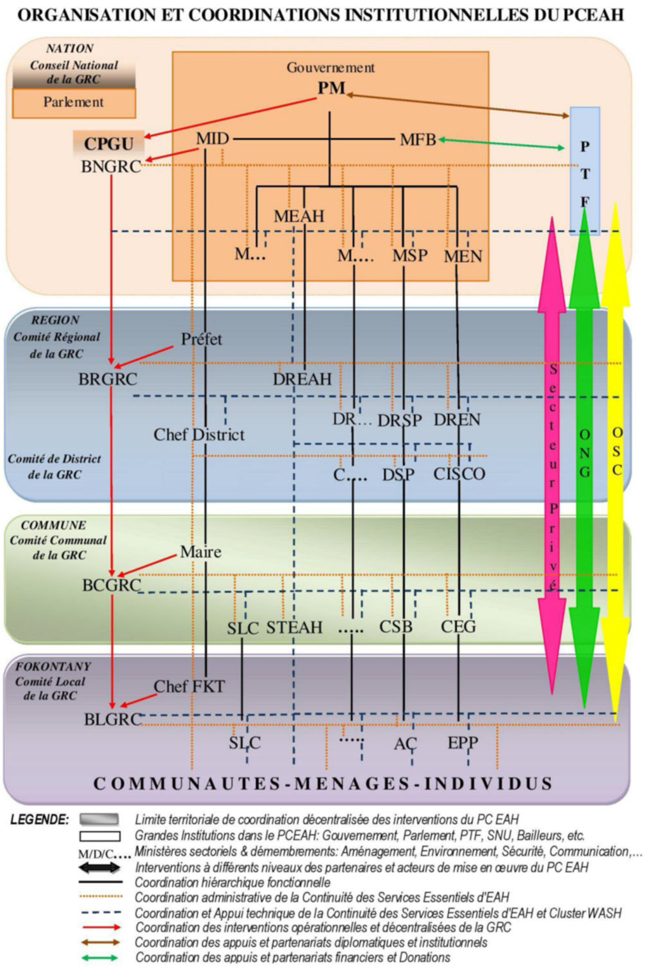


Figure 3-139 institutional coordination chart in emergency in PCEAU

Source: PCEAU. 2020.

Table 3-104 Activity list for service continuity in events of cyclone and floods

Activités	Approche	Résultats / IOV	Coordination / Supervision	Exécution	Appui technique	Appui financier
Quelques Mois avant la période des catastrophes	**Prévision des risques de discontinuité des SE/EAH en cas de catastrophe**					
Consultation des documents (rapports, études, bulletins, ATLAS, …) e Base de Données (BD) sur les catastrophes antérieures pour : • Tirer et capitaliser les leçons apprises sur les états des systèmes d'EAH et la continuité des Services Essentiels d'EAH (SE\EAH) • Prédéterminer et simuler les pires scénarii de catastrophes à venir • Élaborer le prochain Plan de Contingence et Pré-positionnement • Adopter les mesures de renforcement et d'adaptation des système d'EAH existants pour prévenir la continuité des SE\EAH.	Travail en équipe ou atelier sur les catastrophes antérieures Prestataires	Mémorandum ou fiche sur les leçons apprises et recommandations Manuel de procédures à jour	MEAH CPGU BNGRC	DGEAH, DREAH, Cluster WASH Acteurs GRC d'EAH	BNGRC, CERVO, DGM, UNICEF	MEAH, UNICEF, Co Lead de coordination WASH PTF
Diagnostics et évaluations des états de fonctionnement des Systèmes et Services d'EAH surtout pour les cas d'urgence pour : • Vérifier/tester la continuité des Services d'EAH en temps normal, • Étudier et prévenir les risques de discontinuités des Services Essentiels d'EAH en cas de nouvelle/pire catastrophe et simuler les réactions nécessaires pour leur continuité rapide et la MRR, • Adapter et/ou renforcer les capacités des systèmes d'EAH existants ou réhabilités pour supporter les pires risques et préparer les matériels d'interventions d'urgence en cas de panne.	Travail d'équipe et mission Prestataires	Rapport de synthèse Base de données Systèmes d'EAH adaptés et fonctionnels	MEAH, Communes	DGEAH, DREAH, STEAH, Gestionnaires des systèmes d'EAH	Cluster WASH, CTD	MEAH, Communes, Gestionnaires des systèmes d'EAH et PTF
Inventaire, remise à jour ou renforcement des capacités e responsabilisation des acteurs locaux à travers la réactivation e	Travail d'équipe	Acteurs aptes à la GRC et SE/EAH	MEAH, UNICEF, BNGRC	DGEAH, DREAH, PF Clusters	CERVO	MEAH et PTF

Source: PCEAH. 2020.

4) Consideration of Disaster Risk Reduction Measures

The PUDi (Urban Development Master Plan) of Antananarivo Agglomeration, PUDi for Toamasina Agglomeration and the Transport and Territorial Development Plan for TaToM Economic Axis, which JICA helped to revise, set out the following policies for development. One of the overall strategies of urban development for the Antananarivo Agglomeration is to "promote suburbanisation by developing urban centres outside the CUA and providing basic infrastructure (electricity and water)". One of the overall strategies for urban development for the Toamasina Agglomeration is to "establish an economic development zone and an industrial park to attract investment in light industry, targeting the free trade zone market of the regional economic community of which Madagascar is a member, and to provide economic infrastructure including access roads, electricity and water supply. TaToM has set out the following table of priority actions in the water supply sector.

Table 3-105 Priority actions in water supply sector in Antananarivo Agglomeration

Project	Contents	Remarks
JIRAMA III Water Supply Facility Construction Project (on going)	1) Doubling Mandroseza 2 WTP (Production: 60,000m³/day) 2) Construction of Two WTP from the Ikopa River (Production: 2 x 30,000 m³/day, Intake from subsoil water of Tana Plain) 3) Construction of a WTP at Laniera from the Ikopa River (Production: 30,000 m³/day) 4) Urgent Measures: Replacement existing pumps and connections, Installation of water meters and flowmeters 5) Replacement of Conduit: 17 km 6) Construction of Primary Pipelines (22 km) and Secondary Pipelines (354 km) 7) Remote Management System	This project is in the stage of the detailed design study which will determine the concrete contents of the project. Expected period of facility construction is for three to four years from 2021.
Water Supply Master Plan Formulation Project in Antananarivo Agglomeration	1) Social / Water Demand Survey 2) Existing Facility Survey 3) Water Supply Operation Study 4) Water Use Survey (Potable, Irrigation and Industrial Water) 5) Water Resources Development Plan (Surface Water in Ikopa sub-watershed) 6) Water Resources Development Plan (Surface Water in Mangoro, Tsiribihina and Betsiboka watersheds) 7) Water Resources Development Plan (Groundwater) 8) Outline Design and Cost Estimation (New Facility Construction) 9) Outline Design and Cost Estimation (Rehabilitation of Existing Facility) 10) Construction Plan 11) Water Supply Operation Plan 12) Social Environment Assessment	The objective of this project is to update the water supply master plan in order to fulfil the water demand in Antananarivo Agglomeration in 2033. Especially for grasp of the water resources development potential in order to select water source to be developed is a quite important issue for the water supply in Antananarivo Agglomeration.
Construction of New Retention Dam at Andavadaboara	Construction of a multi-purpose dam of which capacity is 53 million m³ at Andavadaboara, which is located between Mandroseza and Tsiazonpaliny. With this dam, the storage capacity against probable water shortage is expected to be reinforced.	Antananarivo Agglomeration experienced serious water shortage during the dry season in 2017. In order to reduce the water outage in such occasions in the future, this project is being planned by JIRAMA.
Construction of Water Aqueduct, Treatment and Transmission Facilities Using Water Source from the Onive River in Tsinjoarivo (Ambatolampy District)	1) Construction of intake and aqueduct facilities which intake 310,000 m³/day of water at Tsinjoarivo in Ambatolampy District, and an aqueduct to the water treatment plant in Bongatsara Commune in Antananarivo Agglomeration with 86 km of 1,600 mm aqueduct pipeline, 2) Construction of water treatment plant in Bongatasara Commune with treatment capacity of 310,000 m³/day, and 3) Construction of transmission facilities to provide treated water to each of seven new water supply areas proposed by TaToM, including an initial transmission pump station at the water treatment plant, a loop transmission pipeline to deliver treated water to each of water supply areas and seven transmission pump stations for each of seven water supply areas.	

Source: TaToM. 2019.

TaToM also proposed projects related to sewage and drainage to improve urban sanitation and reduce flood risk, and identified three priority projects as follows.

Table 3-106 Priority actions in sewage and drainage sector in Antananarivo Agglomeration

Item		2019-2023	2024-2028	2019-2033
1)	Implementation of the programmes and projects proposed by PIAA			
(1-1)	Implementation of the high-priority programmes identified by PIAA			
(1-2)	Construction of large scale facilities			
2)	Integration of drainage countermeasures into each individual development project			
(2-1)	Establishment of new frameworks and rules to develop new areas			
(2-2)	Construction of "compensatory" retention countermeasures integrated into individual development project			
(2-3)	Promotion and installation of compensatory water retention infrastructures in the existing urbanised areas			
3)	Planning and Implementation of comprehensive countermeasures enabling the improvement of Water Environment			
(3-1)	Establishment of new frameworks and rules			
(3-2)	Implementation of countermeasures to improve Water Environment			

Source: TaToM. 2019.

TaToM also planned zoning within the urban area, and while developing water and sewerage infrastructure in line with these plans, it is desirable to promote the mainstreaming of DRR in water and sanitation sector by examining disaster risks, designing appropriate facilities, and setting up inundation protection systems and organizations.

(5) Telecommunication

1) Overview of Relevant Organizations and Legal systems

Madagascar telecommunications sector is governed by ARTEC (Autorité de Régulation des Technologies de Communication) under the Ministère des Postes, des Télécommunications et du Développement Numérique (Ministry of Posts and Digital Development). ARTEC licenses telecom operators, both wired and wireless, to ensure regulatory compliance. ARTEC not only manages the frequency band of the country's wireless industry, but also promotes the development of new technologies to enhance communications. According to ARTEC's website, the country's telecommunications sector is regulated by the following laws.

- LAW NO. 2016-031, Law amending Article 20 of the Law on Combating Cybercrime
- LAW NO. 2014-038, Law on the Protection of Personal Data promulgated on 9 January 2015
- LAW NO. 2014-006, Law on combating cybercrime promulgated on 19 June 2014
- LAW NO. 2005-023, Act of 17 October 2005 on the recasting of Law 96-034 of 27 January 1997 on institutional reform of telecommunications

Among these, the most important law is Law No. 2005-023. The law finally came into effect in 2014, and this law has completely liberalized the telecommunications market in Madagascar. The license renewal fee paid by telecom operators to the authorities has been increased from the previous EUR 615,400 to EUR 5 million (US$ 6.35 million), and new entrants to the market will have to pay a minimum license fee of EUR 40 million. The law also mandated the sharing of telecommunications infrastructure, namely base transceiver stations (BTS), in order to reduce costs and environmental impact. These reforms ensured the budget of the authority that regulates telecommunication services, and the aforementioned ARTEC was also established under this law to replace the Office Malgache des Etudes et de Regulations (OMERT).

ARTEC enforces fair regulations for businesses while maintaining its independence. On the other hand, it is not entirely free of political influence. In January 2016, the government raised the tax rate on telecom services from 7% to 10% in an effort to raise revenue. In addition, fixed-lines (landlines), Internet, SMS, and data transfer are now subject to taxation, whereas previously only mobile services were taxable. On the other hand, since the income level in Madagascar is low, operators need to keep the price of their services at an affordable level. Business operators therefore cannot pass on the tax hike to consumer prices, leading to a situation where the operators' profits are undercut by the tax hike. As a result, the new taxation system having a negative impact on businesses, preventing them from expanding their investments.

The roles of ARTEC are as follows.

- Grant licenses to operators, prepare standards, receive declarations, and approve telecommunications terminals.
- Research, prepare and submit to the government proposals aimed at establishing, completing or modifying the legal and economic framework for telecommunications and other related activities. Within the scope of this authority, it prepares and submits draft laws, ministerial order, and ministerial ordinances to relevant ministries.
- Represent the minister in charge of telecommunications and ICT at international conferences dealing with frequency management and other regulatory and related matters, telecommunications, information technology, and telecommunications development and standardization.
- Participate in the activities of national and foreign organizations and others whose purpose is to study and improve the congruence of telecommunications, wireless communications, encryption, IP addressing, and various electronic services and standards, and to report and advise the government and the public on technological advances and good practices around the world that can inform government-level decision-making.
- Radio frequency management, taking into account the specific needs of the nation and to ensure the rational use of the frequency bands by users, as well as non-discriminatory treatment of the allocation of frequencies to private communications, ensuring transparency among competitors and preventing specific operators from gaining privileges in the use of these resources or retaining unused licenses for the purpose of monopoly.
- Encourage demonstrations of technological innovations and draw conclusions about the appropriateness of the directions and national policies.
- Develop a telephone numbering plan and assign numbers to operators, ensuring non-discriminatory and transparent treatment among competitors so that they are not privileged by any particular operator.
- Ensure the implementation of standards and other established rules, or send recommendations and formal notifications to operators to ensure respect for corresponding obligations.
- Ensure compliance with the technical regulations in force in the field of telecommunications and wireless communications, including broadcasting.
- Protect the interests of consumers and citizens as individual, corporate, group, and household users of telecommunications and ICT services, as well as users of e-government.
- Arbitrate disputes between operators in accordance with the procedures set forth in the Decree. Upon the decision of the regulatory authority, the concerned parties may file a dispute with the competent court. The regulatory authority will issue instructions to the relevant user within a maximum of two months after receiving a complaint from the user and,

if necessary, impose the penalties prescribed for the operator responsible for the fault by the implementing regulations.

- Conduct an investigation after receiving a formal complaint from a business regarding possible unfair competition.
- Conduct investigations into decisions of regulatory authorities.
- Ensure fairness in competition among businesses and, in particular, prevent and correct agreements that have the effect of restricting market functions, such as abuse of predominance, pricing that prevents competition, and agreements between two or more businesses.
- Ensure harmonization among the various domains involved in telecommunications, ICT, and e-governance, including IP addressing, encryption, domain names, rights related to intellectual or industrial property, and personal rights.
- Carry out tasks and missions as required by the competent ministries.
- Supervise the conditions for financial, administrative, and technical interconnection between operators to ensure that they do not become barriers to the provision of services.
- Maintain ground stations for personal use and allow changes to such ground stations.
- Controls the suitability of equipment and provides a professional opinion before the regulatory body responsible for communication via computer (mediated communications) grants a license.
- Manage frequencies to privately owned radio broadcasters, including stations on airplanes and ships (frequency allocation).
- Manage the network operator's frequency bands and site-to-site link services, and manage some of the connection licenses between the network and subscribers.

2） Overview of Related Plans and Development Status

In Madagascar, the pace of expanding broadband/Internet access has been slow, with only about 10% of the total population having access to the Internet.

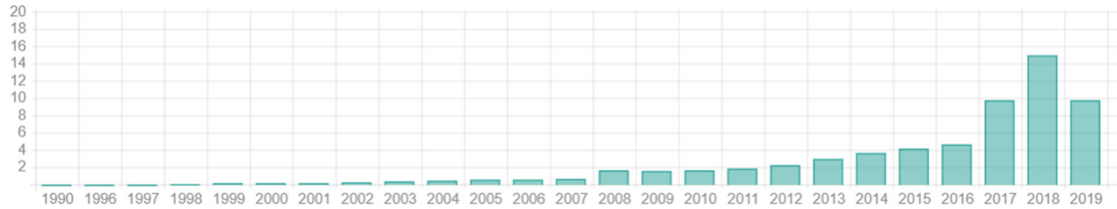


Figure 3-140 Percentage of Population with Access to the Internet (1990-2019)
Source: WorldData.info53

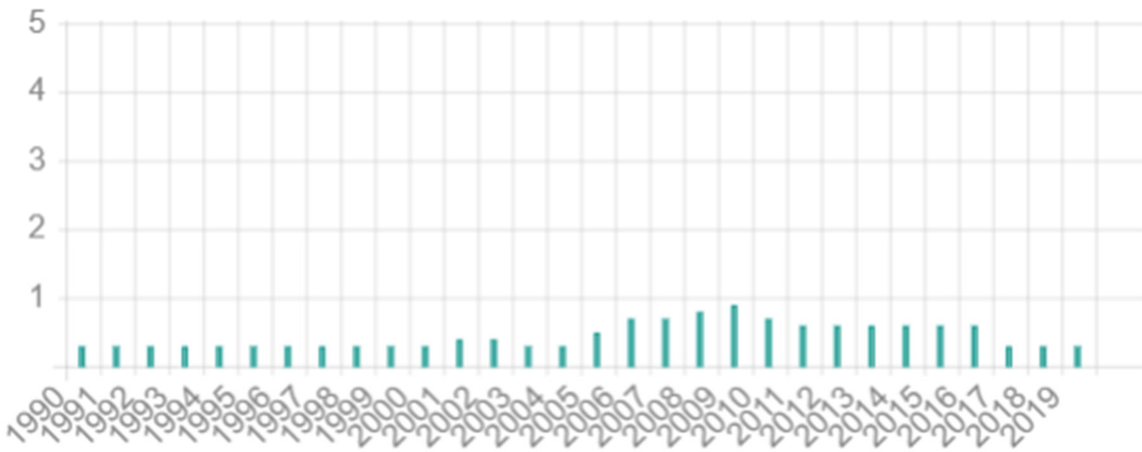


Figure 3-141 Percentage of Population with Fixed-line Subscriptions
Source: 33WorldData.info

[53] www.worlddata.info/africa/

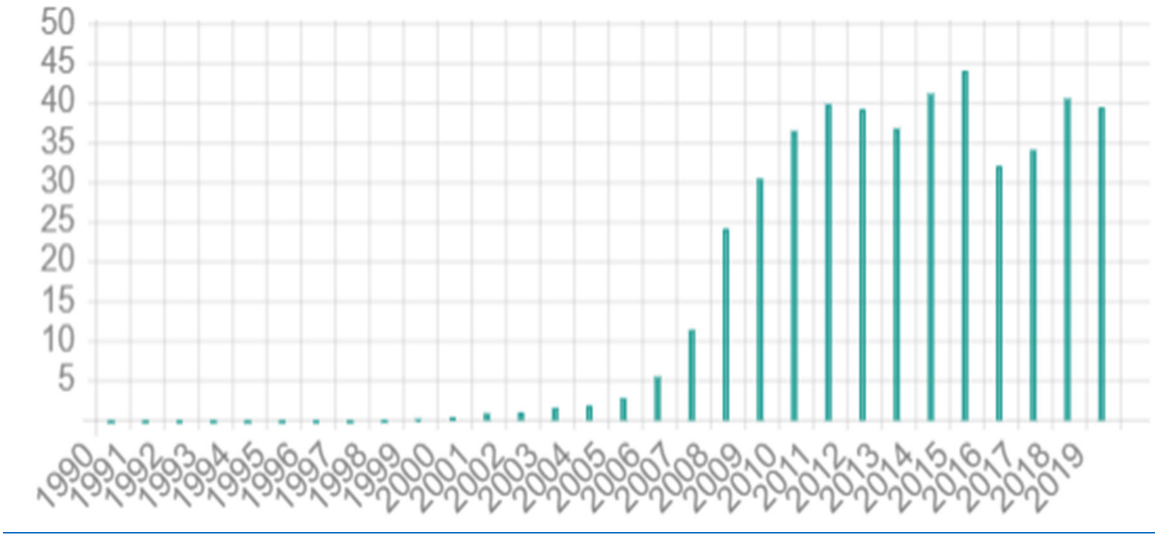


Figure 3-142 Percentage of Population with Mobile Line Subscriptions

Source: WorldData.info

Table 3-107 Key Indicators for Madagascar's Telecommunications Sector (ITU Estimation, 2017[54])

Indicator	Madagascar	Africa average	World average
Number of fixed-line subscribers (per 100 population)	0.3	0.9	13.0
Number of mobile subscribers (per 100 population)	34.1	74.4	103.6
Number of mobile broadband subscribers (per 100 population)	13.0	24.8	61.9
3G population coverage (%)	64.0	62.7	87.9
LTE/WiMAX population coverage (%)	25.0	28.4	76.3
Internet access population rate (%)	9.8	22.1	48.6
Percentage of households with PCs (%)	7.1	8.9	47.1
Percentage of households with Internet access (%)	8.2	19.4	54.7
Average Internet bandwidth per user (kbps)	8.9	11.2	76.6
Number of mobile broadband subscribers (per 100 population)	0.1	0.6	13.6

Source: ITU

Madagascar was connected to the first international submarine fiber optic cable, EASSy, in 2010. The cable, which is more than 10,000 km long, has landed in nine countries and connected Madagascar to the global ocean cable network. The Lion cable has been in operation since 2017

[54] https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2018/MISR-2018-Vol-2-E.pdf

to ensure full redundancy. It was followed by connection to Mauritius with METISS in 2019. METISS is 3,500 km long and was built using private investment funds of US$75 million. These connections to international submarine cable networks have made Madagascar the number one country in Africa for broadband speeds in 2018, according to a study by Cable.com. However, the cost of fixed broadband Internet services is higher than in other African countries, penetration rates are well below the competitors, and a significant proportion of the population is still not connected to mobile networks.

Madagascar's three mobile operators were French-owned Orange Madagascar, Indian-owned AirTel Madagascar, and government-owned Telma. But in 2016, Kuwaiti-owned Gulfsat Madagascar entered the market to build its own mobile network and obtained a license to build its own fiber network in mid-2020, ending Telma's longstanding monopoly on optical backbone networks.

Table 3-108 Telecommunications Operators and Market Share in Madagascar[55]

<table>
<tr><td>International connectivity</td><td>Core network</td><td>Middle mile</td><td colspan="3">Access network</td></tr>
<tr><td></td><td>National backbone</td><td>Backhaul</td><td colspan="3">Last mile</td></tr>
<tr><td rowspan="6">EASSy: Telma
LION: Orange</td><td colspan="2" rowspan="6">Fiber optic: Telma
Copper lines: Telma</td><td colspan="3">Fixed services:
Fixed wireline (ADSL and fiber): Telma
Fixed wireless (WiMAX, WiFi): Telma, Gulfast (Blueline), other ISPs
Mobile services: Market shares as at 2019</td></tr>
<tr><td></td><td>Share of 3G</td><td>Share of 4G</td></tr>
<tr><td>Airtel</td><td>16.9%</td><td>5.7%</td></tr>
<tr><td>Orange</td><td>19.6%</td><td>5.4%</td></tr>
<tr><td>Telma</td><td>63.5%</td><td>12.2%</td></tr>
<tr><td>Gulfsat (Blueline)</td><td>-</td><td>76.7%</td></tr>
</table>

Source: WB

[55] https://openknowledge.worldbank.org/bitstream/handle/10986/32794/Madagascar-Country-Economic-Memorandum-Scaling-Success-Building-a-Resilient-Economy.pdf

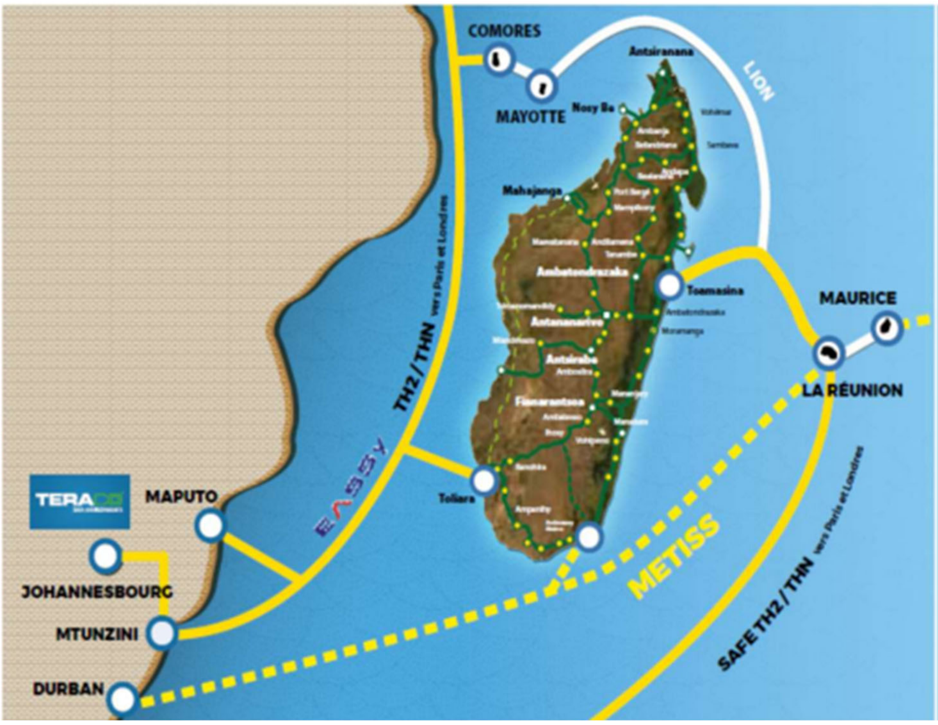


Figure 3-143 Submarine Optical Cable Network Connecting to Madagascar

Source: Telma

Table 3-109 Major Submarine Optical Cable Landing Stations in Africa

Country	*City*	*TEAMS 2009*	*SEACOM 2009*	*LION 2009*	*EaSSy 2010*	*SEAS 2012*	*BRICS 2014**
Djibouti	Djibouti				√		
Somalia	Mogadishu				√		
Kenya	Mombasa	√	√	√	√		
Tanzania	Dar es Salaam		√		√	√	
Seychelles	Beau Vallon					√	
Comoros	Moroni		√				
Mayotte	Kaweni			√			
Mauritius	Terre Rouge			√			√
Réunion	St Paul			√			
Madagascar	Tamatave			√			
Madagascar	Toliara		√		√		
Mozambique	Maputo		√		√		
South Africa	Mtunzini		√		√		
South Africa	Melkbosstrand						√

Source: Ewan Sutherland, Undersea cables and landing stations around Africa: Policy and regulatory issues, ITS Europe 25th Regional Conference, 2014

At the same time, a nationwide fiber backbone connecting major cities was also implemented. The government has invested in last mile fiber infrastructure to facilitate access to superfast broadband, and Telma, in which the government holds a 19.9% stake, has invested US$250 million to expand its backbone network from 5,000 km to 11,000 km. The country's fiber optic plan has been extended to the year 2020, with the aim of switching all existing subscribers to optical fiber contracts.

On the other hand, several donor initiatives have been undertaken in the past for digital connectivity in rural areas. For example, with the support of the WB, telecommunication infrastructure projects were implemented in three regions, mainly in rural areas, between 2007 and 2015. As a result, about 68 telecommunication towers were installed and the telecommunication infrastructure in more than 660 rural areas has been significantly improved, while other rural areas are still lagging behind in digitalization. Against this backdrop, the Economic and Social Commission for Asia and the Pacific (ESCAP), a UN organization, has proposed to leverage existing broadband connection infrastructure and services to complete the last mile fiber deployment and support the adoption of innovative digital solutions in targeted rural areas. This is based on the installation of high capacity fiber optic cables laid by the country's major telecom service providers along the two corridors in Madagascar (the most underdeveloped areas of telecom infrastructure in the country) since 2019.

Figure 3-144 Fiber Optic Network in Madagascar56

Source: ESCAP

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

As mentioned above, Madagascar's national telecommunications network is heavily dependent on international submarine fiber optic cables and the national optical backbone network connected to them. For this reason, the landing stations of the international submarine fiber optic cable in Triana, Tomasiana and Taolagnaro are extremely important for the country. When a disaster strikes, there is a risk that the entire country's Internet connection becomes unreliable. In Taiwan, for example, the 2006 Hengchun earthquake damaged the cable landing station and ruptured the submarine cable, which took 49 days to restore. Toamasina, in particular, is frequently damaged by inland flooding and storm surges due to cyclones, and the international submarine optical cable landing station is estimated to be at risk of damage due to flooding and strong winds. However,

56 https://www.unescap.org/sites/default/files/Rural%20Digital%20Connectivity%2C%20Deployment%20of%20Fiber%20Optic-International%20Experience%2C%20The%20Case%20of%20Madagascar%2C%20ESCAP.pdf

as we were unable to conduct a site visit, we do not know the exact location of the landing station and it is difficult to accurately assess the risk at this stage.

In addition, the domestic optical cable network is mainly laid along national highways, but as mentioned in the Transport and Traffic Sector, many national highways, especially National Highways No. 2 and No. 7, have problems with road conditions and are vulnerable to landslides. This means that in addition to the road infrastructure, it is important to strengthen the domestic optical cable network that is being laid in parallel with the road infrastructure, and to take measures against landslides.

4) Consideration of Disaster Risk Reduction Measures

In order to mitigate the digital divide between rural and urban areas, the government of Madagascar is working with ESCAP, a UN organization as mentioned earlier, to digitize rural areas in the vicinity of two corridors in Madagascar (see below for specific areas). However, the project does not consider any particular disaster risk. In the aftermath of the Cyclone Idai and Cyclone Kenneth in Mozambique, the communication network was cut off for a long period of time due to the collapse of towers caused by strong winds and the disconnection of the fiber optic cable network caused by flooding. It would therefore be effective to review the wind resistance of towers and secure backup routes for the fiber optic cable network, and make recommendations to ESCAP.

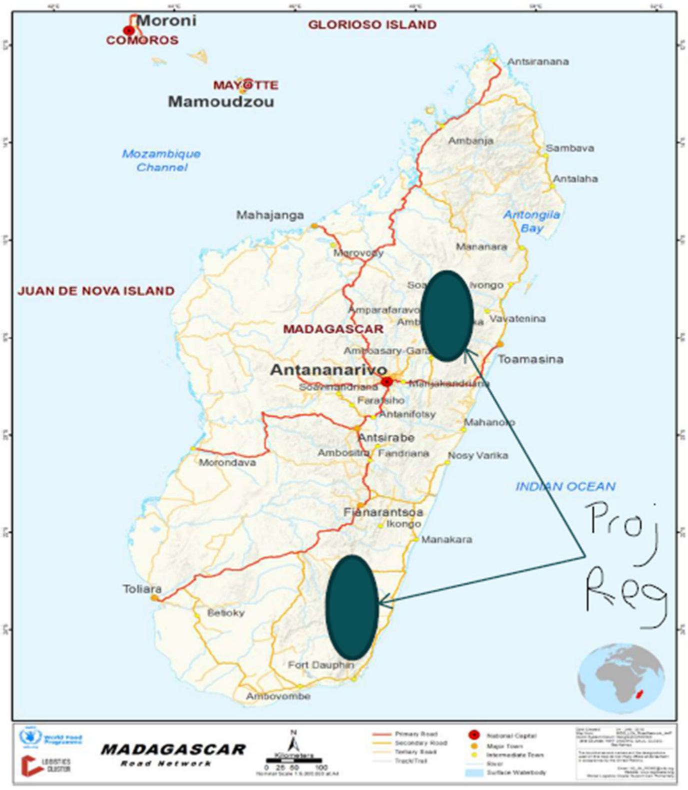


Figure 3-145 Area Covered by ESCAP's Project to Improve Telecommunications Infrastructure Along the Corridors

Source: ESCAP

In addition, as described below, the country's meteorological radar is aging, and the Direction Générale de Météorologie (DGM) has requested that the radar equipment be upgraded. Since communication from the observation points can only be made by mobile phone lines and low-speed VHF radio communication lines, it is believed that upgrading the communication network along with the upgrading of the meteorological radar will help reduce the disaster risk in the country. In concrete terms, it is desirable to establish a dedicated microwave wireless network.

(6) Education

1) Overview of Relevant Organizations and Legal systems

Currently, the Ministry of National Education (MEN33, Le Ministère de l'Education Nationale) is responsible for basic education (primary and early secondary), late secondary education, pre-school education, literacy, and non-formal education. The Ministry of Higher Education, Science and Technology (MESUPRS34) is responsible for higher education, and the Ministry of Employment, Technical Education and Vocational Training (MEETFP35) is responsible for technical education and vocational training.

As for the local level, it is organized by the Ministry of Education (MEN) at the central level, the Provincial Department of Education (DREN), the School District Office (CISCO) at the county level, and the District Affairs (ZAP) at the commune level.

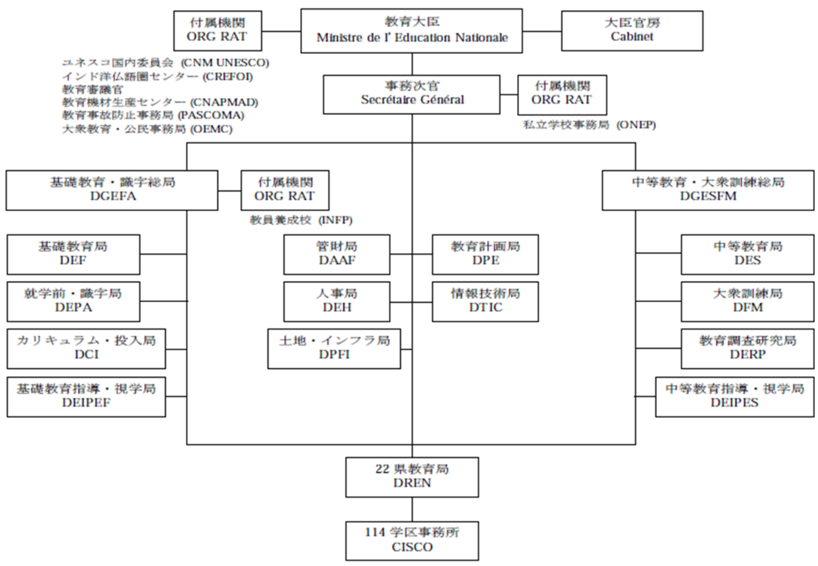


Figure 3-146 Structure of education-related organizations

Source: MEN (2012). Plan intermédiaire pour l`éducation 2013-2015 (PIE 2013-2015)

Just as the organizational chart of the School District Office (CISCO) has all the departments necessary to manage and administer basic education, the clarification of the number of teacher posts per school, teacher recruitment and hiring, and in-service teacher training and mentoring are all under the authority of this level. However, this is subject to prior approval through the Provincial Department of Education (DREN) and budgeting through the annual plan (PTA) described below. On the other hand, in terms of classroom construction, the Ministry of Education still tends to implement the project directly, although a post of Infrastructure and Land Section has been established in the Administration Division and decentralization through the use of a

Procurement Agent (MOD) to provide technical support has been tried, as it is expected to reduce costs through the use of local companies.

Madagascar considers the impact of natural disasters and other factors on education to be important, and has developed the SECTOR RESPONSE PLAN 2020-2021 as a strategy to realize the right of all students to a quality education and to have a safe learning environment protected. The Plan is divided into three parts: disaster prevention, disaster response, and recovery support, and includes the promotion of contingency planning, the strengthening of cooperation among sector stakeholders, teachers, students, and community members to ensure efficient and integrated disaster response, and support for the return to school.

Since the 1990s, education spending has ranged from 1.8% to 3.6% of GDP, with significant ups and downs due to political and economic conditions. After the political change in 2009, the rate remained below 3%. The drop in investment spending, which is heavily dependent on foreign aid, was particularly large. As for government spending, it has been stable at around 18% in recent years. In terms of expenditure by subsector, primary education accounts for a majority of the total expenditure (around 55%), followed by early secondary education and higher education, which both account for around 16%.

Table 3-110 Education recurrent expenditure by subsector (billion MGA: 2011 value)

Year	Pre-school Literacy education	Primary school	Early secondary	Late secondary	Vocational Training	Higher education	Total
2004	10.4	2,197.7	641.0	301.2	199.5	573.5	3,923.3
	0.3%	56.0%	16.3%	7.7%	5.1%	14.6%	100.0%
2005	11.2	2,458.8	785.3	384.8	185.7	635.6	4,461.3
	0.3%	55.1%	17.6%	8.6%	4.2%	14.2%	100.0%
2006	10.2	2,234.5	680.3	317.5	148.3	812.3	4,203.2
	0.2%	53.2%	16.2%	7.6%	3.5%	19.3%	100.0%
2007	10.7	2,533.8	805.1	367.0	162.5	804.1	4,683.2
	0.2%	54.1%	17.2%	7.8%	3.5%	17.2%	100.0%
2008	18.8	55.1%	941.8	385.8	173.9	839.3	5,258.9
	0.4%	2,899.3	17.9%	7.3%	3.3%	16.0%	100.0%
2009	17.7	56.0%	888.3	369.2	137.2	818.9	5,071.1
	0.3%	2,839.9	17.5%	7.3%	2.7%	16.1%	100.0%
2010	14.6	53.8%	830.7	355.9	168.3	898.6	4,696.0
	0.3%	2,527.8	17.7%	7.6%	3.6%	17.0%	100.0%
2011	19.2	55.3%	928.3	368.6	175.6	763.0	5,049.4
	0.4%	2,794.8	18.4%	7.3%	3.5%	15.1%	100.0%

Source: MEN (2012). Plan intermédiaire pour l`éducation 2013-2015 (PIE 2013-2015)

Education-related laws and regulations in Madagascar were not identified through the Internet research. In contrast, building codes are known to exist and include methods for verifying structural strength (Concrete Structural Limit Design Criteria (BAEL 91), seismic structural criteria (Règles parasismiques PS 69, addenda 1982), snow and wind load structural design criteria (Règles Neige (Règles Neige et Vent 65), etc. However, they have not been updated to meet the current construction technology and demand, and the country often seems to use the current French building code as a French Commonwealth. While the existing building codes have not been updated or improved, in 2010, in light of the repeated damage caused by cyclones, a building standard specifically designed to deal with cyclones was formulated, requiring schools, hospitals and other facilities that perform important functions such as evacuation centers and disaster centers to comply with the standard. However, its details could not be confirmed.

2） Overview of Related Plans and Development Status

Madagascar is an island located on the east coast side of the African continent and is often in the orbit of multiple cyclones each year. This has resulted in repeated damage from strong winds and high water caused by cyclones, mainly damage to roofs and windows. Although the number of damaged educational facilities is decreasing due to the cyclone preparedness standards introduced after 2003, it is not clear whether any of the existing educational facilities have been renovated or constructed in accordance with the cyclone preparedness standards.

Prior to the political change in 2009, donors in the education sector shared and supported the activity matrix of the EFA plan under the initiative of the Ministry of Education. Joint reviews were held twice a year for a week to ensure smooth aid coordination. After the political change, in addition to the inability to provide support to an unrecognized government, there was an exodus of talented people from the Ministry of Education. Donors used UAT, the implementation management agency created by UNICEF and the World Bank, to approach the target directly through the School District Office (CISCO). With the formation of the new government in January 2014, there has been a gradual recovery, but it has not returned to previous levels. UNICEF, the World Bank, the EU, France, Norway, AFD, the African Development Bank, and the World Food Program are all involved in the education sector.

The cyclone preparedness standards provide architectural cyclone preparedness rules for each of the four types of areas considered for cyclone risk. Although details are still being verified, it is known that as many as 2,041 educational facilities have been newly built or renovated to meet the cyclone preparedness standards with support from the International Development Fund IV (FID IV). However, their effectiveness could not be confirmed by the Internet survey. UNICEF is also implementing soft measures for disaster risk reduction, such as education in times of disaster and disaster risk reduction education for students and the community.

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

In Madagascar, more than 2,300 classrooms collapsed, and more than 3,900 classrooms were partially damaged during the 2017 Cyclone Enawo [57]. "Education Cannot Wait" was established to provide emergency support for educational facilities, and approximately 1.8 billion USD was provided. Based on interviews with JICA field offices, it is assumed that the 2010 cyclone preparedness standards itself guarantees sufficient strength against cyclones, but it is unclear to what extent these standards have been widely adopted. There may be factors that could not be confirmed in this survey, such as the management system associated with the construction and renovation of facilities and the degree of difficulty in applying the standards to existing facilities in the area.

4） Consideration of Disaster Risk Reduction Measures

In the case of educational facilities, it was confirmed that there were no design standards specific to educational facilities and that the cyclone preparedness standards were in place for buildings in general. However, it is still unclear to what extent the standards have been adopted in existing and newly constructed facilities, and there are still many uncertainties, such as whether they are designed to be used as evacuation centers in the event of a cyclone.

In addition, it has been confirmed that the government of Madagascar would like to build more inexpensive schools rather than constructing a small number of strong schools with disaster countermeasures (based on JICA field office interviews), so it is desirable to make the schools stronger and more suitable for local schools. Therefore, the formulation of guidelines on the combination of the cyclone preparedness standards and other relevant laws and regulations with the existing local school buildings can be considered as a proposal case.

[57] https://reliefweb.int/report/madagascar/building-back-better

(7) Health Service

1) Overview of Relevant Organizations and Legal systems

In Madagascar, the Ministry of Public Health, which is responsible for the healthcare sector, is under the umbrella of the Essential Services Commission. The Ministry of Public Health has established disaster and epidemic preparedness organizations at each regional level, and at the central level, Service des Urgences et de Réponses aux Epidémies et Catastrophes (SURECA) is in charge of the epidemic and disaster emergency preparedness services. It carries out pre-positioning of medicines and materials in the regions and districts, provide training on risk and disaster management, and support affected areas through on-the-ground interventions. At the county level, the District Public Health Board (DRSP) and the District Training and Sanitation Department (SDSP) have mobile disaster monitoring and response units and sections that use the ORSEC Plan (Organisation of Relief) as their working tool. At the commune level, the Basic Health Center is in charge of crisis response and is responsible for disseminating disaster response strategies to the community and encouraging participation.

Madagascar's insurance healthcare services are based on the "Basic Strategy for Hospital Reform" (Reforme Hospitaliere les Axes Strategiques) formulated in 2007, and has a healthcare system composed of four levels. A summary of each level is shown in the table below.

Table 3-111 Madagascar's healthcare system by level

Level	Overview
Healthcare center (CSB: Centre de Sante de Base)	A primary medical facility established in each commune CSB1 are run by nurses and midwives, and CSB2 are staffed by doctors. The main cases to be handled are limited to first aid and initial treatment, antenatal check-ups, normal delivery assistance, and preventive activities (tetanus, malaria, STDs/AIDS, nutritional support, etc.).
District Hospital (CHD: Centre de Hospitalier de District)	A secondary medical facility established in each district It is equipped with an operating room to perform basic surgical procedures, normal deliveries, obstetric emergencies, external abortions, and referrals to tertiary medical facilities
Provincial Referral Hospital (CHRR: Centre de Hospitalier de Reference Regional)	A tertiary medical facility with multiple specialized departments and medical specialists as of 2008, 19 facilities belonged to this group, and the actual status of hospital facilities is only at the level of county hospitals, so there is an urgent need to expand facilities and personnel. The hospital revolution strategy seeks to improve them to a level where they can provide advanced medical care as a tertiary medical facility.
University Hospital (CHU: Centre de Hospitalier Universitaire)	As of 2008, two locations have been established in Antananarivo, the capital city, and Majunga, the provincial capital, with new locations planned for Toamasina and Fianarantsoa, the provincial capital. A quaternary medical facility equipped with multiple specialized departments and medical specialists to treat patients with severe illnesses as a specialized medical facility It also functions as a regional referral hospital and trains physicians and allied health professionals.

Source: JICA, Report on the Basic Design of the Expansion and Equipment Improvement Project for the Medical Assistant Training School in Antananarivo, Republic of Madagascar, 2008.

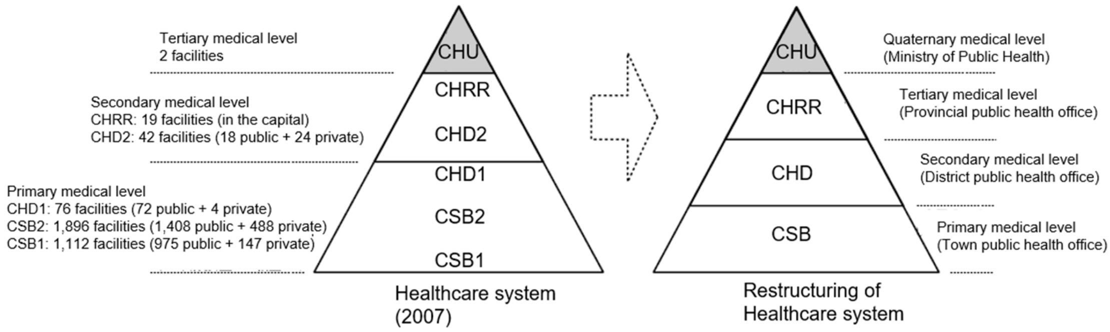


Figure 3-147 Referral system in Madagascar

Source: JICA, Report on the Basic Design of the Expansion and Equipment Improvement Project for the Medical Assistant Training School in Antananarivo, Republic of Madagascar, 2008.

The proportion of primary medical facilities (CSB1 and CSB2) that residents first contact is 50.7% for general diseases and 70.6% for antenatal care nationally (75.8% in rural areas). On the other hand, the number of medical professionals per 1,000 people is much lower than the standard of 2.5, and the number of doctors is only 0.29, making the absolute shortage of medical professionals an issue. In addition, medical professionals in Madagascar tend to be unevenly distributed in urban areas throughout the 22 provinces, with the province of Antananarivo alone accounting for 36% of the national total. It is reported that less than 50% of facilities are adequately staffed with qualified medical professionals, facing inefficiencies as well as personnel shortages. [58]

The number of existing insured medical facilities (2005) is shown in the following table, and it is known that 2,383 new CSBs have been established as of 2008. The Ministry of Health is working on a restructuring and strengthening plan to raise CSB1 to CSB2 and CHD1 to CHD2. The national healthcare policy and wired insurance sector programs focus on expanding basic healthcare services, including;

- For the time being, 525 CSB1s will be raised to the rank of CSB2 so that there will be one CSB2 per 10,000 citizens.
- Consider raising 72 CHD1s in the public sector CHD2.
- Expand facilities and personnel for 15 CHRRs as a tertiary referral hospital.
- Construct two university hospitals (Toamasina and Fianarantsoa).

[58] Final Report of the Health Sector Human Resource Development Programme PDRH August 2007

Table 3-112 Number of medical facilities in Madagascar (2005)

Facilities / Province	Primary						Secondary			Tertiary
	CSB1		CSB2		CHD1		CHD2		CHRR	CHU
	Public	Private	Public	Private	Public	Private	Public	Private	Public	Public
Antananarivo	132	19	312	265	13	0	4	10	2	1
Antsiranana	83	9	123	28	4	1	2	4	2	0
Fianarantsoa	189	36	346	65	14	0	4	4	5	0
Majunga	199	6	187	46	15	3	2	3	3	1
Toamasina	197	46	208	39	10	0	5	0	3	0
Toliara	175	31	232	45	16	0	1	3	4	0
Total	975	147	1,408	488	72	4	18	24	19	2
	3,084						61			2

Source: JICA, Report on the Basic Design of the Expansion and Equipment Improvement Project for the Medical Assistant Training School in Antananarivo, Republic of Madagascar, 2008.

In July 2003, the government of Madagascar published a Poverty Reduction Strategy Paper (PRSP) to achieve the MDGs, and in November 2004, the president's national vision, Madagascar Naturellement, was announced as the top development principle. In November 2006, the National Action Plan for Madagascar 2007-2012 (Plan d'Action Madagascar, MAP) was formulated as a medium- to long-term development strategy. Its goals are listed in the table below.

Table 3-113 MAP2007-2021 13 major goals

Index	2005	2012
1. UN human development index (rank)	146 / 177	100
2. Poverty rate	85.1% (2003)	50%
3. Total fertility rate	5.4%	3~4%
4. Life expectancy	55.5	58~61
5. Literacy rate	63%	80%
6. Percentage of children who have completed secondary school	Secondary: 19% High school: 7%	Secondary: 56% High school: 40%
7. literacy rate	4.6%	8~10%
8. GDP (US$)	5 Billion US$	12 Billion US$
9. GDP per capita (US$)	309 US$	476 USD
10. Foreign Direct Investment (FDI)	84 Million US$	500 Million US$
11. World Bank Business Environment Ranking	131	80
12. Corruption perception index (CPI)	2.8	5.2
13. Percentage of households with land ownership	10%	75%

Source: JICA_Provision of Special Medical Equipment "Health Measures for Mothers and Children" Equipment Planning Study Report 2008

The section "5. Healthcare, Family Planning and HIV/AIDS Control" lists eight sub-tasks: (1) Provide quality healthcare services to all citizens, (2) Eradicate major infectious diseases, (3) Successfully combat HIV/AIDS, (4) Implement effective strategies for family planning, (5) Reduce infant and juvenile mortality, (6) Reduce maternal and neonatal mortality, 7) Improve nutritional intake and food safety conditions 8) Provide safe drinking water and promote health and hygiene practices.

In the healthcare sector, the "Healthcare Sector Development Plan 2007-2011 (Plan de Developpement du Secteur Sante (PDSS)" has been formulated with five main objectives: 1) strengthening the national healthcare system, 2) improving the maternal and child survival rate, 3) strengthening the eradication of major diseases, 4) strengthening health protection and promoting public sanitation, and 5) ensuring and promoting the living conditions of the vulnerable groups. We know that the Healthcare Sector Development Plan 2015-2019 and the Healthcare Sector Development Plan 2020-201249 have been subsequently formulated and their contents are being studied now.

In addition, laws and regulations related to medical services facilities include the following.

Table 3-114 Laws and regulations related to medical services and facilities

Law No.	Title (French)	Title (Japanese translation)
Decret n°1963 -192	Fixant Le Code De L'urbanisme Et De L'habitat	Amendments to Urban and Housing Standards
Decret n°2003-1162	Organisant la Médecine d'Entreprise	Drug company management laws and regulations
Loi n°1994–027	portant code d'hygiène, de sécurité et d'environnement du travail	Occupational Health, Safety and Environment Law
Decret n°1999-130	portant organisation et fonctionnement du Comité technique consultatif en matière de santé, d'hygiène, de sécurité et de l'environnement du travail	Organization and functions of the Technical Advisory Committee related to health, sanitation, safety and working environment
Decret n°2005-215	portant organisation et fonctionnement de l'Autorité de Régulation des Marchés Publics	Organization and functions of the Public Procurement Supervision Bureau

Source : JICA Study Team

2） Overview of Related Plans and Development Status

Madagascar has ratified the loan agreement for the financing of the Fifth Poverty Reduction Assistance Loan (CARP5) concluded between Madagascar and the International Development Association (IDA) in Loi n°2008-017 as an international cooperation system, and is actively accepting foreign assistance. Looking at the details of donor assistance in the healthcare sector in the table below, it appears that upper level planning of healthcare services and development of healthcare service systems and facilities are underway.

Table 3-115 Summary of healthcare sector assistance from other donors

Donor	Overview
WB	The Health Sector Assistance Project (2000-2006) was established to support the health sector. Madagascar government has been providing support for the higher-level plan developed and implemented by the government of Madagascar. Amount implemented 44.38 million dollars. In addition, individual areas such as nutrition improvement, sexually transmitted disease control, HIV/AIDS control, etc.
WHO	A wide range of initiatives are being developed to address specific issues such as improvement of health care systems and services, promotion of infectious disease control and child and adolescent health.
UNFPA	Based on the "Fifth Support Plan" (2005-2009), the Japan Reproductive Health Center (JRC) has been working to promote awareness in the field of reproductive health. promotion of development activities, strengthening of local service systems, and promotion of cooperation with traditional midwives.
France	The French Ministry of Foreign Affairs' Bureau for Development and Technical Cooperation (CF) and the Regional Organization for Development Cooperation in Alsace (IRCOD) are providing assistance for the development and improvement of the health care service system in Majunga Province. Japan's technical cooperation project "Comprehensive Improvement Plan for the University Hospital Center of Majunga (1999-2003) was implemented in collaboration with CF and IRCOD.
GTZ	The "Majunga Provincial Health Care Improvement Plan" (1996-2001) was established to provide primary and secondary level health care services. The development of institutions, etc., has already been implemented. The amount of implementation is approximately US$1.13 million.
US	The U.S. Agency for International Development (USAID) is focusing on maternal and child health, nutritional improvement, and HIV/AIDS. The company is currently developing local-level initiatives through NGOs in these sectors.
AfBD	Planning to build a blood center in CHUA. Originally planned to be constructed at the proposed site, another site within the CHUA site will be used. Construction site: Planned for the northwest side of the IFIRPA project site. Facility size: 2-story RC building with a total floor area of approximately 1,000 ㎡, Construction schedule: Construction is scheduled to begin in October 2008 with a construction period of about 18 months.
IAEA	As part of the agency's Cancer Treatment Action Program, the CHUA has established a Cancer Center within the CHUA. The plan to establish a new facility has been formulated and is being coordinated with the relevant agencies.
CBM	Plans have been developed to establish an ophthalmology center within the CHUA, and The BfDB is currently developing the facility behind the blood transfusion center.

Source: JICA, Report on the Basic Design of the Expansion and Equipment Improvement Project for the Medical Assistant Training School in Antananarivo, Republic of Madagascar, 2008.

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

International assistance in Madagascar is mainly focused on policies related to healthcare systems and service improvement, and there were no laws or regulations for strengthening facilities other than the cyclone preparedness standards. During the Cyclone Enawo, eight hospitals were damaged and 104 healthcare centers (CSBs) were damaged (16 of which were completely destroyed). Therefore, due to a lack of information, it was not possible to reach a detailed examination of the extent to which the cyclone preparedness standards have been disseminated among medical facilities, the reasons for their lack of dissemination, and whether the standards are designed to serve important functions such as shelters and disaster centers in the event of a disaster.

(8) Agriculture

1） Overview of Relevant Organizations and Legal systems

a) Ministry of Agriculture and Livestock / Ministère de l'Agriculture et de l'Elevage, MAE

The Ministry of Agriculture and Livestock (MAE), reorganised and launched under the new government in 2019, aims to accelerate economic growth in the rural world through a transformative vision for agriculture and livestock. Under the MAE, there is the Directrate of Rural Engineering (La Direction du Génie Rural, DGR), which is in charge of implementing strategies such as the expansion of rural areas and the promotion of new agricultural zones, agricultural mechanisation, the modernisation of equipment in partnership with investors and the private sector, and the development of irrigation; the Derectrate of Support for Producer Organisations and Agro-Business (La Direction d'appui à l'Organisation des Producteurs et à l'Agro-business, DOPAB), which supports the structuring and professionalisation of producer organisations and strengthens the foundations for agro-business development, and the Regional Directorate of Agriculture and Livestock (Les Directions Régionales de l'Agriculture et de l'Elevage, DRAE), which implements policies at the regional level, in line with the standards and objectives set by the Ministry of Agriculture and Livestock taking into account the characteristics of each region.

b) Agencies related to MAEP

The following agencies are under MAEP.

Table 3-116 Agencies under MAEP

Agency	Overview
National Centre for Applied Research in Rural Development Centre National de la Recherche Appliquée au Développement Rural (FOFIFA)	Implements the national research policy for rural development and defines, guides, promotes and coordinates all research activities related to i) agricultural production: food crops such as rice, traditional export crops and non-traditional crops (e.g. fruit and vegetables); ii) forestry and natural resource management; iii) animal production, fish farming and animal health; iv) conservation and post-harvest handling; and v) economics and social sciences as applied to rural development.
National Centre for Water, Sanitation and Rural Engineering / Centre National de l'Eau, de l'Assainissement et du Génie Rural (CNEAGR)	i) Research and surveys in the field of water, sanitation and rural engineering, initial and continuous training leading to diplomas, ii) training of technical cadres capable of carrying out tasks related to water, sanitation and rural engineering, iii) dissemination and valorisation of research and survey results, iv) construction, development and rehabilitation related to water, sanitation and rural engineering projects; v) carrying out the necessary work, management, monitoring and follow-up; and vi) organising seminars and workshops.
Agricultural Development Fund Fonds de Développement Agricole (FDA)	Rreceives and manages funds aimed at facilitating producers' access to agricultural services in order to enable them to increase production, improve productivity and generate income.
Fund for Rehabilitation of Hydro-Agriculture Networks Fonds de Remise en Etat des Réseaux Hydro-Agricoles (FRERHA)	It was set up to secure funds for the rehabilitation, maintenance, conservation and policing of non-transferable commodities and infrastructure. FRERHAs in each region contribute to the necessary repairs in the event of flood damage, cyclone damage and natural disasters in all irrigation networks.

Source : JICA Study Team

c) Water Users' Federation (WUF) / Water Users' Association (WUA)

Roles of WUF and WUA are as listed below.

Table 3-117 Roles of WUF and WUA

Organizations	Responsible Activities
Water Users' Federation （WUF）	Main gate and facility operation Main canal maintenance Instruction to members and WUA
Water Users' Association （WUA）	Primary canal maintenance Secondary canal maintenance Water fee collection from members
DRAE	Technical advice and instruction to WUF/WUA

Source: The basic data collection survey on agriculture sector in Republic of Madagascar survey report, 2014

2） Overview of Related Plans and Development Status

a) Related plans

(i) Agriculture, livestock and fisheries sector programme - National agricultural investment plan / Programme sectoriel agriculture, élevage, pêche - Plan national d'investissement agricole (PSAEP/PNIAEP) 2016-2020

The vision of the plan is for "Madagascar in 2025 to integrate family farms and modernised processing units based on competitive and sustainable agricultural production, to ensure food security and to dominate export markets". i) Development of rational and sustainable production areas and use of resources; ii) Continued It will be based on five main operational programmes: i) promoting improved productivity and competitive production systems; ii) contributing to food and nutrition security and reducing risks for vulnerable groups; iii) improving access to domestic markets and repositioning exports; and v) improving institutional governance and strengthening the capacity of stakeholders. These programmes will contribute to increasing resilience, supporting nutritional enhancement and reducing risks in the face of disasters and crises affecting agriculture, nutrition and food security.

(ii) National Programme for Irrigated Perimeters and Watersheds / Programme national bassins versants périmètres irrigués （PN-BVPI）

Based on the MAP development strategy, the PN-BVPI was formulated in 2006, which integrates irrigation improvement projects targeting approx. 1 million ha of existing rice paddies nationwide and sustainable water source recharge projects through vegetation restoration and afforestation in the upstream areas of irrigation districts. In accordance with this program, Madagascar plans to irrigate 280,000 ha by 2012 with the support of international organizations, etc., to strengthen its rice production base. The request for assistance to the PC23 irrigation district in the southwestern part of Lake Alaotra was based on this policy.

(iii) Nationally Determined Expected Contribution of the Republic of Madagascar / Contribution Prévue Déterminée au niveau National (CPDN) de la République de Madagascar 2015

In order for Madagascar to meet its GHG emission reduction targets, measures proposed in the agricultural sector include the large-scale promotion of intensive/improved rice farming systems, conservation agriculture and climate change-responsive agriculture in general, and the promotion of arboriculture (5,000 ha per year from 2018).

It also includes the development of pilot initiatives in the framework of climate resilient agriculture models (watershed management, use of adapted varieties, fermentation with locally produced manure, irrigation infrastructure rehabilitation, facilitated access to inputs, conservation agriculture, agroforestry, etc.) or 'climate smart agriculture' applications, as well as the development of pilot initiatives in key agricultural areas, cash crops, cash crops, etc. The large-scale application of integrated resilient agriculture models in crop areas, extensive livestock areas, priority fisheries areas, mangroves and drought-sensitive areas.

(iv) National Rice Development Strategy / Stratégie Nationale de développement Rizicole (SNDR)

The National Rice Development Strategy (SNDR) was adopted as part of the operationalisation of the Rice Development Policy (Politique de Développement Rizicole, PDR). Its objective is to contribute to food security, improved incomes for rice sector stakeholders and economic growth. Specifically, it aims to strengthen the governance of the rice sector and deepen the expertise of stakeholders, double rice production by 2020, build domestic supply channels and gain a substantial share of regional and international markets. To achieve these goals, the strategy is based on five strategic axes: i) strengthening rice research; ii) intensifying agricultural production; iii) improving infrastructure; iv) organising markets and supply; and v) improving rice sector governance.

b) Development status

(i) Japan’s Assistance Policy

Assistance is provided to the agricultural sector, particularly rice production, to improve agricultural productivity and build value chains through the development of agricultural infrastructure such as irrigation facilities and technical cooperation. In addition, multi-sectoral nutrition improvement initiatives will be implemented in conjunction with rice productivity improvement in order to promote food security and improved nutrition.

The main assistance provided from Japan in the agricultural sector related to this project in recent years are summarised below. Other assistance includes technical cooperation in line with the policies outlined above, as well as individual training for SHEP and food security.

Table 3-118 Japan's Assistance

Project	Summary	Duration
Project for Development of Seed Production Field and Facilities (preparatory survey)	By improving facilities and equipment for seed production and strengthening the functions of institutions involved in certified seed production, the project aims to increase the production of certified seeds needed to increase rice production and contribute to the realisation of national strategies such as achieving self-sufficiency in rice. This project is subject to the use of grant aid.	2021 - 2022
Project for Rehabilitation of Irrigation System in South-West of Alaotra Lake (Grant Aid)	Rehabilitate irrigation facilities in the south-west and upstream areas of Lake Arocha, a major rice-growing region. Deforestation and slash-and-burn in the upstream areas has caused sediment to accumulate in rivers and irrigation canals, which has hampered the supply of irrigation water. This programme will ensure a stable supply of irrigation water to the target area and contribute to increasing rice production in the area.	2020-2021

Source : JICA Study Team

(ii) Assistance by related donors and private sectors

Assistance by related donors and private sectors in the agricultural sector related to this project in recent years are summarized below. According to WB's Country Partnership Framework (CPF) 2017-2021, WB will provide support in two priority areas: i) improvement of resilience and reduction of vulnerabilities, and ii) promotion of inclusive growth. In the agricultural sector, an integrated "landscape" program aims to promote climate-friendly agricultural production, support hydrological services (e.g., stabilization of river flows, sediment reduction), and reduce deforestation. All irrigation infrastructures built through this program met anti-cyclonic norms.

Table 3-1 Assistance by related donors and private sectors

Project/Donor	Summary	Duration/Cost
Agriculture Rural Growth and Land Management Project / WB	The objective of the Project is to improve rural land tenure security and access to markets of targeted farming households in selected agricultural value chains in the project areas, and to provide immediate and effective response to an eligible crisis or emergency. There are five components to the project: i) agribusiness value chain development; ii) the support to land policy and land rights registration; iii) the support to marketing infrastructure development and maintenance; iv) the project management and coordination; and v) the contingency emergency response.	2016 - 2022 US$ 53.27 million
AF Social Safety Net Drought Response / WB	The objective of the Project is to to support the Government in increasing the access of extremely poor households to safety net services and in laying the foundations for a social protection system. The AF will scale up the existing SSNP through cash transfers and community nutrition services to address some of the urgent needs of the poorest population suffering from the severe drought in the South of Madagascar, exacerbated by El Nino.	2016～ US$ 35.00 million
Sustainable Landscape Management Project / WB	The project will increase access to improved irrigation services and agricultural inputs and strengthen the integrated management of natural resources in the Selected Landscapes by the local actors and provide immediate and effective response to an Eligible Crisis or Emergency.	2017 - 2023 US$ 107.06 million *US$ 40.00 million was added in 2021

Source : JICA Study Team

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Damage to the agricultural sector caused by recent disasters are as listed below.

Table 3-2 Damage to the agricultural sector (cyclone)

Date	Area	Overview
Feb. 2012 Cyclone Giovanna	Districts with particularly huge damage Alaotra-Mangoro, Atsinanana	・ Total damaged area: 12,500 ha
Jan-Mar 2008 Cyclone Fame, Ivan and Jokwe	17 Districts (Analanjirofo, Atsinanana, Vatovavy Fitovinany, Atsimo Atsinanana, Sofia, Betsiboka, Analamanga, Amoron'i Mania Haute Matsiatra, Bongolava, Ihorombe, Alaotra Mangoro, Diana, Boeni, Melaky, Menabe, Atsimo Andrefana)	・ Total affected Crop: 80,000 ton by husk, 52,000 ton by rice ・ Total cost of damage: US$ 6.34 million (US$5.6 million for irrigation infrastructure) ・ Total cost of loss: US$ 88.4 million fo ・ Total recovery and reconstruction cost: US$ 6.3 million

Source : JICA Study Team

The Government of Japan provides assistance for seed production and irrigation facility rehabilitation and maintenance with the aim of increasing rice production through improved productivity. Meanwhile, in addition to the maintenance of irrigation facilities, WB is also involved in watershed management to prevent sediment inflow due to forest degradation from upstream areas and to conserve natural resources. Sediment inflow into rivers and watercourses also reduces the water conveyance surface area and causes flood damage.

4) Consideration of Disaster Risk Reduction Measures

As onsite surveys were not possible for this study, it is difficult to propose specific measures. For future measures for disaster risk reduction, the interviews with MAE, and WB who have implemented the project for irrigation development and watershed management around Lake Arocha, should be conducted to identify current issues on irrigation development, necessary measures and needs. Based on that, the measure such as capacity building on irrigation facility management and irrigation development including watershed management should be suggested.

(9) River management and Coastal Management

1) Overview of Relevant Organizations and Legal systems

As of September 2021, the following information is available on related institution and legal systems for river and coastal management.

Table 3-119 List of related institution in the field of flood management and coastal management

Institution	French name or English name
ANDEA	Autorité Nationale de l'Eau et de l'Assainissement
BNGRC	Bureau National de Gestion des Risques et des Catastrophes
BVPI	Bassins Versants et Périmètres Irrigués
CCGRC	Comité Communal de GRC
CLGRC	Comité Local de GRC
CNGRC	Conseil National de Gestion des Risques et Catastrophes
CPGU	Cellule de Prévention et de Gestion des Urgences
CRGRC	Comité Régional de GRC
CRIC	Comité de Réflexion des Intervenants en Catastrophes
DGM	Direction Générale de Météorologie
DGTP	Direction Générale des Travaux Publics
GTCC	Groupe Thématique Changement Climatique
MTPM	Ministère des Travaux Publics
PNGRC	Politique Nationale sur la Gestion des Risques et des Catastrophes
PNLCC	Politique Nationale de Lutte Contre le Changement Climatique
SABVRGF	Service de l'Aménagement des Bassins Versants, de la Reforestation et de la Gestion des Feux

Source: JICA Study Team

2) Overview of Related Plans and Development Status

As of September 2021, the status of support by other donors in the field of flood management and disaster risk reduction, according to the "Report on the Collection and Verification of Basic Information on Biodiversity Conservation, Climate Change Countermeasures and Disaster Risk Reduction in Madagascar, pp. 119-130, 2012." most of the projects related to disaster risk reduction are for post-disaster emergency supplies and food aid, and major donors and NGOs are providing such aid to areas affected by cyclones and floods.

As for activities related to urban drainage, AFD is implementing the PIAA project, and the WB is implementing the PRODUIR project for flood control in Antananarivo. The Antananarivo Plain Flood Protection Authority (APIPA), which is under the Ministry of Public Works and oversees flood control in the Antananarivo metropolitan area, and the City of Antananarivo are working together with AFD and WB to implement the project.

Institution in charge of flood control besides the Antananarivo metropolitan area were not able to confirm at the national level. According to the website of the Ministry of Public Works, APIPA implements flood countermeasures in collaboration with local public works departments, but the actual situation has not been confirmed.

3) Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

a) Overview of Madagascar's river management sector

The following is an overview of meteorological and geomorphological conditions related to the field of river management and coastal management.

In terms of climatic classification, the entire area belongs to the tropical zone, but influenced by the trade winds from the southeast, the coastal areas have a tropical climate, the plateau area called the Central Highlands (1,000 to 1,300 m above sea level) has a temperate climate, and the southern area has an arid climate. The annual climate is largely divided into dry (winter) and rainy (summer) seasons, with annual rainfall ranging from 300 to 3,500 mm, with significant regional differences. In the western area and central highlands, 90-95% of the annual rainfall is concentrated between October and April, and there is also a large seasonal difference[59].

The figure and the table below show the average monthly rainfall maps for the four stations (Tôlanaro, Antananarivo, Mahajanga, and Toamasina) available on the web. The figure below also shows the average monthly rainfall and average annual total rainfall for Tokyo for reference. From this, we observe the following.

- Looking at the average monthly rainfall, there is a large division between the dry season (May to September) and the rainy season (October to April), but Toamasina, located in the northeast, has more than 100 mm/month of rainfall in each month even in the dry season.
- The average annual total rainfall in Antananarivo and Mahajanga, located in the northwest,

[59] Report on the Collection and Verification of Basic Information on Biodiversity Conservation, Climate Change Countermeasures and Disaster Risk Reduction in Madagascar, JICA, 2012

is about 1,400 mm/year, about 150-200 mm/year less than in Tokyo. Tôlanaro, located in the southeast, has an average annual total rainfall similar to that of Tokyo. On the other hand, Toamasina receives about 3,000 mm/year of rainfall, which is about twice as much as in Tokyo.

- Since the country also receives a large amount of rainfall from cyclones, it is considered possible to estimate the planned scale flow rate for basins with average annual total rainfall similar to that of Japan by using the specific flow rate map of Japan.

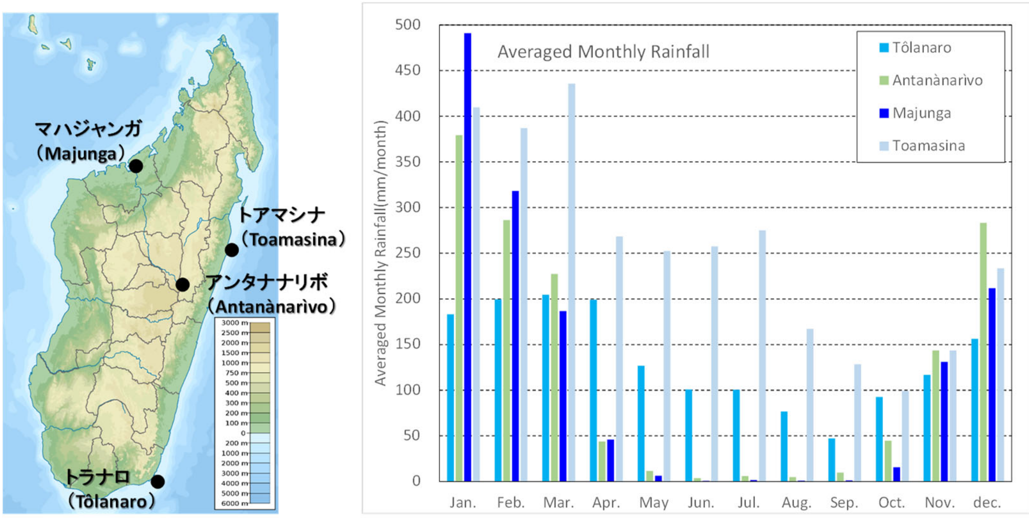


Figure 3-148 Average monthly rainfall in Madagascar

Source: Japan Meteorological Agency website (e.g., https://www.data.jma.go.jp/cpd/monitor/climatview/frame.php)

Table 3-120 Average monthly rainfall and average annual total rainfall in Madagascar

Month	Tôlanaro	Antananarivo	Mahajanga	Toamasina	Tokyo
1	183.2	379.4	491.0	409.9	59.7
2	199.4	286.3	318.2	386.9	56.5
3	204.5	227.5	186.5	435.9	116
4	199.1	43.9	45.9	268.5	133.7
5	126.9	11.6	6.3	252.5	139.7
6	100.9	3.8	0.6	257.6	167.8
7	100.4	5.9	1.6	275.0	156.2
8	76.5	4.9	0.9	167.1	154.7
9	47.2	9.8	1.0	128.3	224.9
10	92.6	44.7	15.5	99.0	234.8
11	116.8	143.4	131.0	143.3	96.3
12	156.3	283.2	211.7	233.6	57.9
Total	1,603.8	1,444.4	1,410.2	3,057.6	1,598.2

Source: Japan Meteorological Agency website

The table and the figure below show the major rivers and their locations in Madagascar, respectively. The major river here is defined as the length of the trunk river channel extension. Madagascar can be divided into three parts: the central plateau running north to south, and the eastern and western plains. The central plateau has mountains of 2,000 meters, with Chafajabona, the highest point on the plateau, at 2,643 meters above sea level. The highest peak in Madagascar is Mount Maromokotoro at 2,876 meters above sea level.

Table 3-121 List of major rivers in Madagascar

No.	River name	Trunk river channel length (km)	Remarks
1	Mangoky	564	
2	Onilahy	525	
3	Betsiboka	525	
4	Matsiatra	410	Subsidiary streams of the Mangoky River
5	Manambolo	370	
6	Mananantanana	350	Subsidiary streams of the Mangoky River
7	Ihosy	304	Subsidiary streams of the Mangoky River
8	Ikopa	300	Subsidiary streams of the Betsiboka River
9	Zomandao	283	Subsidiary streams of the Mangoky River
10	Mandrare	270	

Source: Major river confirmed from the US AID report, Madagascar Water Resources Profile Overview and trunk river channel length is being confirmed from GIS data by the JICA Study Team.

Figure 3-149 Topography and river location map of Madagascar

Source: JICA Study Team

b) Flood damage in the past

As a result of the web survey on the availability of recorded inundation maps and other data related to previous flood damage, the following was found.

- Rainfall distribution maps for recorded floods in Madagascar are available from the EU (Copernicus) and NASA, and inundation maps are available from the EU (Copernicus). The inundation map is the result of the analysis using satellite images.
- In the web survey, the flood inundation map is limited because it cannot collect information for all river basins. In addition, rainfall data is not available for timely or daily rainfall data, but only total rainfall contour maps for each flood event is available.
- Therefore, it is difficult to collect information that can provide a detailed picture of the characteristics of floods for each river, and field surveys are necessary.

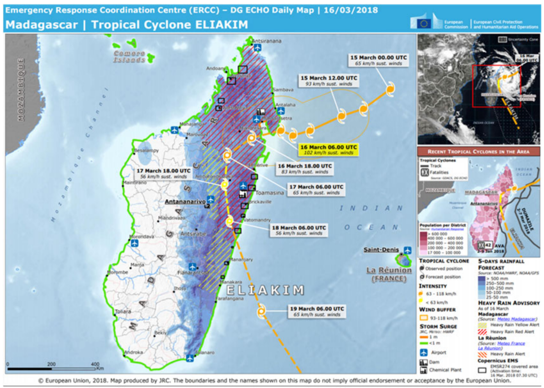
Rainfall distribution map (March/16/2018)	Inundation map (Maruch/10/2017)
	

Figure 3-150 Example of rainfall distribution map and inundation map for a flood event in the past

Source: Copernicus (https://emergency.copernicus.eu/mapping/)

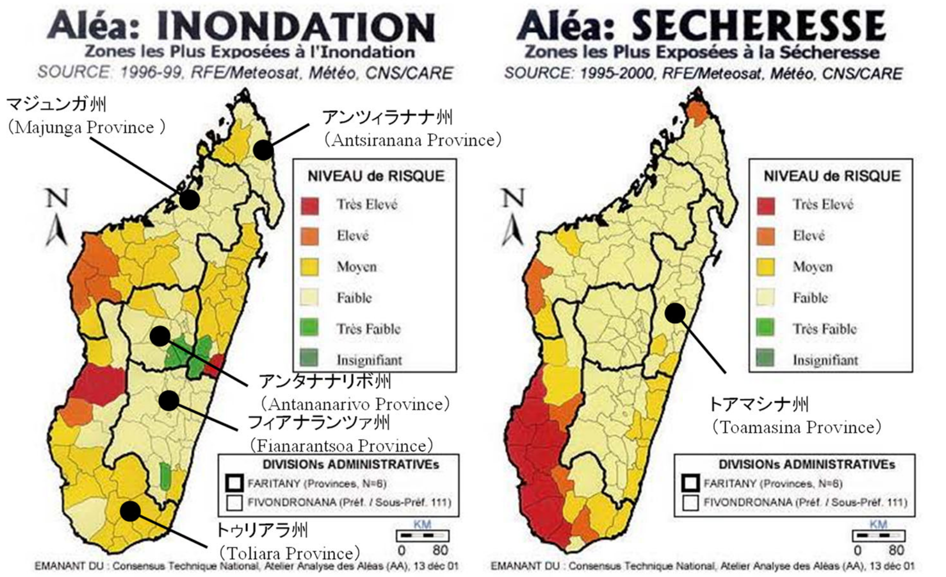
c) Available Hazard maps

Hazard maps for floods and droughts are shown in the figure below. From this, we can observe the following.

- The flood hazard map is usually developed by combining the following indicators of natural conditions: (1) rainfall intensity (rainfall per hour), (2) spatial distribution of rainfall, (3) permeability of soil and ground, (4) characteristics of soil and ground, (5) vegetation condition, (6) saturation of soil and ground, and (7) surface topography (e.g., catchment topography). On the other hand, the National Disaster Risk Management Office (Bureau National de Gestion des Risques et des Catastrophes (BNGRC)) plans to update its flood hazard analysis model to include satellite imagery and soil evapotranspiration indices. However, these data are difficult to obtain, and the revision is not in progress.
- The drought hazard map uses the same indicators as the flood hazard map, in addition the indicator of "the number and duration of below-normal annual precipitation." On the other hand, as same with the flood hazard map, the BNGRC wants to revise the drought hazard

analysis model, but the necessary data are not available.

- Looking at the figure below, in terms of flood risk by river basin, the Mamambole and Mangoky river basins in the west are at higher risk.



注）凡例は上から順に極高、高、中、低、極低、なし
出典：CNS (2001) Rapport de atelier technique sur l'analyse des aléas

Figure 3-151 Flood (left) and drought (right) hazard maps
Source: Collection and Verification of Basic Information on Biodiversity Conservation, Climate Change Countermeasures and Disaster Risk Reduction in Madagascar, p.97, 2012.

d) Identification of challenges in river management based on previous surveys

In the previous survey by JICA, "Report on the Collection and Verification of Basic Information on Biodiversity Conservation, Climate Change Countermeasures and Disaster Risk Reduction in Madagascar, pp.132-143, 2012," identified priority needs related to disaster risk reduction and the possibility of cooperation.

The table below shows the issues with identified priority needs and the possibility of cooperation in the field of river disaster risk reduction. From this, we can observe the following.

- Observation instruments and communication systems to be used for early warning and evacuation activities are listed as the top priority needs for the river management sector as of 2012.
- The next step is hazard analysis and hazard mapping, followed by risk analysis and risk mapping, and based on these, support is needed to develop strategies for river management.

Table 3-122 List of issues in the field of river management in previous JICA survey

Item	Issues	Solutions
Inadequate observation instruments and communication network for cyclone disaster forecasting	- Although there are 20 meteorological observation sites in Madagascar (as of 2012), the basic measuring instruments such as thermometers and rain gauges at the observation sites are all outdated, and there are many problems such as missing data and low accuracy. - Communication from the observation sites is limited to cell phone lines and radio networks. - The weather radar was installed more than 30 years ago, and although it is functioning, its accuracy is low. Therefore, new equipment is needed for accurate weather forecasting in the event of a cyclone. - The forecasting and analysis models used are those of the United States and the European Union, and the country's original forecasting model is needed for high-precision forecasting.	- Forecasting accuracy of cyclones, floods and droughts will be improved by installing new basic observation and communication equipment and transferring technology for the development of weather forecasting models. - This will result in the revision of the pre-warning and evacuation standards.
Unrenewed hazard risk analysis for flood and drought	- For floods and droughts that have brought a lot of damages in the past, the CPGU (Prevention and Emergency Response Unit) conducted a hazard risk analysis in 2003-2004, but satellite imagery and soil evapotranspiration index data were not available at the time. Since then, there have been no major updates to the data and analysis (although the risk analysis is updated every year for floods, the revisions are minor, reflecting the previous year's weather data). - Therefore, it is necessary to conduct hazard risk analysis of flood and drought using new data and to consider strategies to minimize the damage.	After collecting the necessary relevant data, hazard analysis and hazard mapping, risk analysis and risk mapping will be conducted, and based on these, strategies for disaster risk reduction will be formulated.
Damage to national highways due to landslide disaster	- Due to the increase in rainfall caused by climate change, deforestation and forest fires in recent years, landslides and slope failures on national highways have become more prominent. In addition, there is no system or institution to conduct surveys or implement countermeasures against landslides, and since there is no concept of implementing preventive measures in advance, there are damages such as collapses occurring at the same location every rainy season. - Therefore, it is necessary to conduct research, analysis, maintenance, and establishment of a system for landslide prevention. There have been no aid projects for landslide prevention in the past.	- Conduct research, analysis, and monitoring of landslides that occur and establish a road disaster risk reduction management system. - We will then consider strategies such as traffic control and structural measures.
Lack of equipment at the disaster risk management offices	- The BNGRC (National Disaster Risk Management Office) Operation Center has only two PCs and radios, and lacks the basic materials and equipment to respond to an emergency disaster. - Currently (as of 2012), there is no system in place for the timely dissemination of emergency information, such as the use of radio network for each region. These situations are even more pronounced in local disaster risk management offices.	Basic analysis equipment, communication equipment, field survey tools, and relief equipment will be provided, and technical assistance will be provided on how to use them.

Source: "Collection and Verification of Basic Information on Biodiversity Conservation, Climate Change Countermeasures and Disaster Risk Reduction in Madagascar, pp.132-143, 2012; organized by JICA Study Team

4) Consideration of Disaster Risk Reduction Measures

a) Consideration of project for installation of radar rain gauge and meteorological observation equipment (grant aid project), etc.

Considering the situation of the needs study in the river management, it was difficult to make an immediate project for flood countermeasures, etc. Therefore, in this study, we conducted a case study including implementation of radar rain gauge meteorological observation equipment as a survey of the possibility of launching a project in the future. For this reason, the results of the study are described in the next section separately relating to the meteorological observation field.

(10) Meteorological Observation

1) Background and objectives

Madagascar is located in the southwest Indian Ocean area, a cyclone-prone area, and has been severely affected by natural disasters such as cyclone storms, high water, floods, and landslides. In addition, as climate change due to global warming is expected to increase the number of disasters worldwide, the development of appropriate disaster countermeasures against natural disasters such as tropical cyclone storms, high water and floods is an urgent issue in the southwest Indian Ocean region and southeast Africa.

In order for Madagascar to contribute to mitigating the damage caused by tropical cyclones and other weather-related disasters due to climate change in the southwest Indian Ocean, including its own country, it is strongly required to strengthen its meteorological observation, communication, and forecasting and warning systems through the following two measures, and to promote cooperation among the southwest Indian Ocean region, including Madagascar and Mauritius, and the southeast African region, including Mozambique, Malawi, and Zimbabwe, which are also affected by cyclones.

① Effective meteorological observation (monitoring by radar rain gauge system)

② Timely and prompt exchange of meteorological observation data and information on tropical cyclones with countries in the southwest Indian Ocean and southern Africa

As described below, due to the lack of budget and capacity for the construction of facilities and the procurement and installation of equipment to deal with the aforementioned issues, it is difficult for the country to implement the project on its own. Therefore, it is important to support the introduction of radar rain gauge and meteorological observation equipment, as well as to improve the capabilities for meteorological observation and forecasting and early warning.

2） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

An online interview and other surveys were conductd with the Directorate General of Meteorology, Ministry of Public Works and Meteorology (DGM, Direction Générale de Météorologie) to understand the current status relating to the installation of radar rain gauge and meteorological observation instruments and the improvement of meteorological observation, forecasting and early warning capabilities.

The specific contents of the interviews and other surveys focused on the following three issues.

① Organizational structure and staff capacity

② Location and number of units to be installed

③ Trends in support from other donors

From the online interview, the following was found.

- The number of staff at the DGM was confirmed. Considering the country strength (population and nominal GDP) of Mauritius and other countries that JICA has supported so far, the number of staff is smaller in terms of land area as shown in the table below.

Table 3-123 Number of meteorological agency staff and national capacity of countries where JICA has implemented meteorology-related projects

Country name	**Name of organization**	**Number of staff**	**Population (‘0000 thousand people)**	**Nominal GDP (100 million dollars)**
Myanmar	DMH	62	5,141	About 772
Mauritius	MMS	115	127	About 141
Mozambique	INAM	360	3,036	About 149
Madagascar	DGM	89	2,769	About 137

Source: Population and nominal GDP data referred to basic data on the Ministry of Foreign Affairs website.
Source of the number of staff: Myanmar: Report on the Preparatory Survey for the Project for the Installation of Meteorological Instruments in the Republic of the Union of Myanmar, p. 2-1, March 2013.
Mauritius: Report on the Preparatory Study for the Meteorological Services Programme of the Republic of Mauritius, p. 2-1, November 2012.
Mozambique: Report on the detailed planning study for the project to improve the meteorological observation and forecasting/warning capabilities of the Republic of Mozambique, p. 13, November 2014.

- A breakdown of the staff shows that there are 42 technicians who have master’s in meteorology, which means that half of the DGM staff have master in meteorology.
- The annual budget for DGM is about 7.6 million yen, which is by far the smallest compared to other countries. This shows that the current budget does not allow for the purchase of not only radar rain gauge, but also other meteorological observation instruments and reference instruments for establishing traceability.
- With regard to observation instruments, currently, there is no radar rain gauge available for use, and other meteorological observation instruments are not fully operational. The surface weather observing equipment need to be replaced as soon as possible, as they include mercury barometers, which are prohibited for use.
- In addition, traceability has not been established due to the lack of reference instruments.
- There are also issues in securing power supply and communication networks, which are essential for the installation of radar rain gaugers and surface weather observing equipment.
- On the other hand, various project support by other donors is planned. In the future, it is necessary to check the contents of these projects by other donors and carefully examine the contents of cooperation.

Table 3-124 List of Q&As of online interviews and other surveys (1/3)

No.	Question from JICA Study Team	Response from DGM
Organization system and Ability		
1	JICA Study Team would like to confirm the current DGM organization system.	- The DGM consists of DEM (Direction of Operational Meteorology) and DRDH (Direction of Hydrometeorological Research and Development), where DEM is composed of SMO (Service of Operational Meteorology), SH (Service of Hydrology), and SMIT (Service of Maintenance and Technical Installation). - The DEM has the following operational responsibilities. (1) To prepare and publish meteorological and hydrological forecasts; (2) to prepare and publish meteorological and hydrological advisories and warnings for the safety of lives and human property in the event of a hydrological or meteorological disaster; and (3) to ensure the operation and maintenance of a nationwide hydrological and meteorological observation network.
2	How many DGM officers are there as of January 2022?	- There are 89 people.
3	How many of them are clerical staff and technicians/engineers, respectively?	- The number of administrative and technical staff is 26 and 53, respectively.
4	How many technicians/engineers have mastered the meteorology?	- There are 42 people.
5	Based on No. 4, are the appropriate number of staff members who have mastered the meteorology assigned to each of the observation department, the maintenance department of observation equipment, and the weather forecasting department?	- That's how I perceive it.
6	Based on No. 4, how many technicians/engineers are experts in communication and machinery (which can maintain and manage doppler radars)?	- None at this time.
7	JICA Study Team would like to know how much is the annual budget for the DGM?	- The amount is 263,900,000 MGA (Madagascar ariary). - In Japanese yen, this is about 7.6 million yen (at 1 MGA = 0.029 yen).
8	JICA Study Team would like to confirm the breakdown of labor costs, observation equipment purchase costs, observation equipment maintenance costs, etc. in annual budget for the DGM.	- The personnel cost is 35,000,000 MGA (about 1 million yen), the cost of purchasing observation instruments is 2,000,000 MGA (about 60,000 yen), and the cost of maintaining the observation instruments is 7,000,000 MGA (about 200,000 yen). - There is no consistency with No.7, so it needs to be checked properly in the future.

No.	Question from JICA Study Team	Response from DGM
9	Does the DGM have any plans to increase the DGM budget in the future?	- Yes. However, it depends on the government's decision.
10	Does the DGM have any plans to increase the number of DGM staff in the future?	- Yes. However, it depends on the budget from the government.

Source: JICA Study Team

Table 3-125 List of Q&As of online interviews and other surveys (2/3)

No.	Question from JICA Study Team	Response from DGM
Question from JICA Study Team		
11	How many doppler radars are there in Madagascar as of January 2022?	- There are three units.
12	JICA Study Team would like to confirm the current status of doppler radars that were answered in No.11 (for example, in use, out of order, etc.).	- All three units are broken since 1989.
13	JICA Study Team would like to confirm the current status of doppler radars that were answered in No.11 (for example, in use, out of order, etc.).	- We believe that radar rain gauges are needed at four locations: Morondava on the west coast, Antalaha on the northeast coast, Antananarivo, the capital city, and Farafangana on the southeast coast.
14	What kind of a doppler radar does the DGM think will be needed when installing a doppler radar in the future (for example, S band, X band, etc.)?	- We believe that X-band multifunctional radar is needed mainly because we recognize that they are the type of radar rain gauges that are more suitable for tropical regions.
15	When installing a doppler radar, it is essential to secure a stable power supply. JICA Study Team would like to confirm there is any problem for the stable power supply.	- We believe that the power supply is not stable and needs extensive maintenance. This problem will be solved in the Medair project.
Surface Meteorological Observation Equipment		
16	How many observation stations are there in Madagascar?	- As of January 2022, there are 69 observation stations.
17	JICA Study Team would like to know how many “manned” observatories (manual observatories) and automatic weather stations (AWS) are.	- Of these, 22 stations are manual stations 47 are Automatic Weather System (AWS), and the rest are used for meteorological observation.
18	JICA Study Team would like to confirm the number of synop stations (17 stations?).	- There are 34 Synop observation stations, but most of them are not functioning.
19	JICA Study Team would like to confirm how many “manned” observation stations (manual observation stations) use mercury barometers.	- Mercury barometers are used at all 22 manual stations.

No.	Question from JICA Study Team	Response from DGM
20	Please tell me how many stations are out of order with the observation equipment of the manned stations (manual stations).	- Observation instruments are malfunctioning at 15 stations.

Source: JICA Study Team

Table 3-126 List of Q&As of online interviews and other surveys (3/3)

No.	Question from JICA Study Team	Response from DGM
Surface Meteorological Observation Equipment		
21	When turning a manned observatory (manual observatory) into an unmanned observatory (AWS), it is essential to secure a stable power source. Please tell me if this is a problem.	- The lack of a stable power supply is always a problem.
22	When turning a manned observatory (manual observatory) into an unmanned observatory (AWS), it is essential to secure a stable power source. Please tell me if this is a problem.	- To address this issue, DGM is currently working with the PRADA and TAHMO projects for a data transmission and communication network using CLIMSOT.
23	Is the traceability of meteorological observation equipment established?	- No, we have not been able to establish any traceability at all. - DGM is currently considering the need for 97 observation stations in addition to the existing ones.
24	Does the DGM have standards such as traveling standards and national meteorological standard?	- No, there isn't. - DGM requires reference instruments that conform to WMO standards.
25	If you don't have enough standards such as traveling standards and national meteorological standard, please tell us how many standards you have as of January 2022.	- There is no reference instrument.
26	Does the DGM always maintain the meteorological observation equipment?	- There is no maintenance control.
Supports from Other Donors		
27	As of January 2022, please tell us about the status of support for DGM by donors other than JICA (whether there are projects in progress, new projects planned, etc.).	The following projects are planned - PACARC (UNDP, GEF) Project - PRADA and PRCCC (BMZ/GIZ) Project - HYDROMET Project - SADC/SARCIS Project - WMO CREWS Project - WFP/FBF Project - AD2M Project

No.	Question from JICA Study Team	Response from DGM
		- WHH and IOC (AFD/GCF) Project
28	Please tell us what kind of support DGM wants from JICA.	They want the following support - Weather radar network for radar rain gauge maintenance and training of related staff - Assistance with basic spare parts for radar rain gauges

Source: JICA Study Team

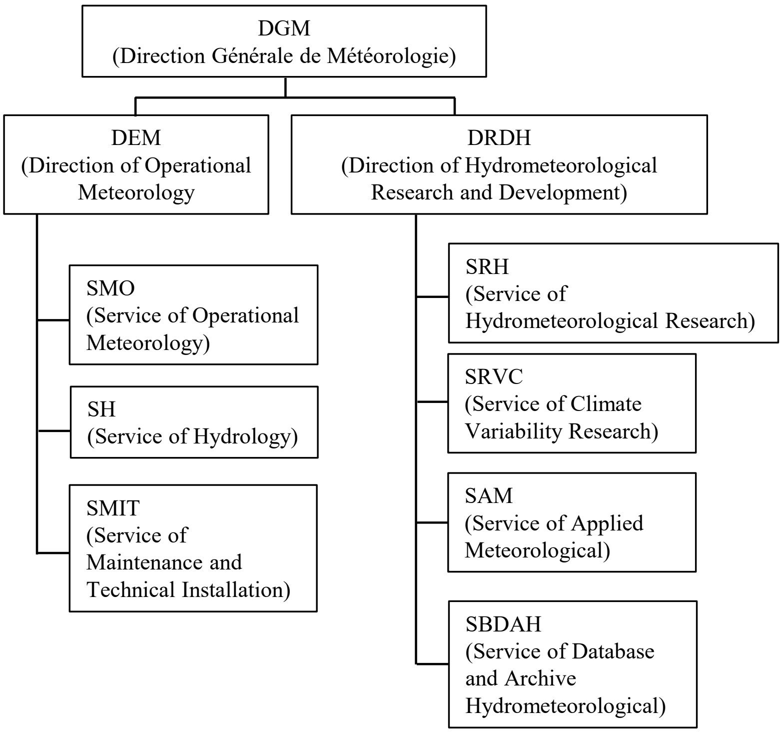


Figure 3-152 Organizational chart of Directorate General of Meteorology (DMO), Ministry of Public Works and Meteorology

Source: Materials provided by Directorate General of Meteorology (DGM), Ministry of Public Works and Meteorology (2021/10/29), with additions

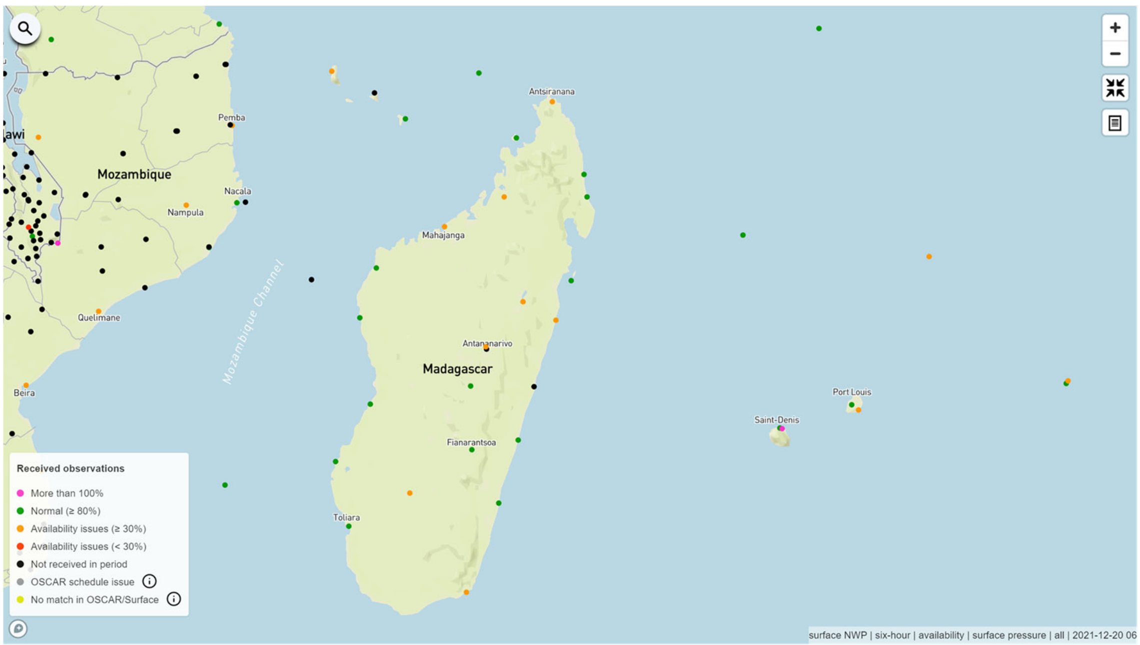


Figure 3-153 Location map of the DGM's 17 Synop stations in operation

Source: WMO

Trends in donor support are summarized in the table below. An description of the support provided to the DGM is included in the "Summary of Implementation" column. In addition to support for the installation of meteorological observation equipment (general rainfall and wind speed automatic surveying equipment) and meteorological observation centers, the support from donors is mainly focused on capacity building for the development of early warning systems using meteorological forecasts and predictions, and support plans for the installation of radar rain gauges are not present.

Table 3-127 Contents of Support to DGM from Donors

Project Name	Donor	Tern	Budget	Description
PACARC (Improving Adaptation and Resilience Capacities in the face of Climate Change in Rural Communities) project	UNDP/ GEF	2016 -2019	39.5 Thousand USD	Installation of meteorological observation equipment in 11 facilities including the capacity building in the community
PRCCC (Program for Strengthening the Conditions and Capacities for Sustainable Adaptation to Climate Change) project	GIZ/ BMZ	2016-2020	8,000 Thousand euro	Support on formulation of climate change adaptation plan and repair in meteorological observation center in 4 region
PRADA (Adaptation of agricultural value chains to climate change) project	GIZ/ BMZ	2017-2022	-	Support in data collection capacity for consideration of adaptation in agriculture sector
HYDROMET project	GCF	2020-2024	71,386 Thousand USD	Installation of meteorological observation equipment and early-warning system based on the standard of WMO
SARCIS (Southern African Climate Information Services for Disaster Resilience Development) project	SADC/ AfDB	2017-2019	3,436 Thousand euro	Installation of early-warning equipment and meteorological observation equipment
CREWS (Climate Risk & Early Warning System) project	WMO/ WB/UN DRR	2020-	None	Regional cooperation leaded by the Indian Ocean Committee (Madagascar is the supporting country)
FBF(Forecast-based Financing) project	WFP	Unknown	Unknown	Capacity building on seasonal forecast and early warning regarding food security
AD2M(Support Development in the Menabe and Melaky Regions) project	IFAD	2015-2023	40,400 Thousand USD	Adaptation plan in small scale farmer (DGM is involved in weather forecast but the details are unknown)

Source: From the websites of the projects and summarized by the JICA Study Team

3） Consideration of Disaster Risk Reduction Measures

Based on the above “Background and objectives" and " Result of Online interviews", JICA Study Team will propose the following two disaster risk reduction cooperation measures related to radar rain gauges and surface weather observing equipment (grant aid projects). The installation of the radar rain gauge itself will cost over 3 billion yen, so it is necessary to divide the project into two parts.

Table 3-128 Summary list of disaster risk reduction cooperation measures

Project name	Project form	Assumed cooperation period	Estimated amount (100 million yen)
Radar rain gauges and surface weather observing equipment installation project	Grant aid	2 years	Installation of radar rain gauges: 40.3 Surface weather observing equipment: under consideration
Meteorological observation and forecasting/warning capability improvement project	Technical cooperation	Four years	Under consideration (This includes the cost of installing reference instruments.)

Source: JICA Study Team

4） Radar rain gauges installation project (grant aid project)

JICA has been supporting the introduction of radar rain gauges in Mauritius, a neighboring country of Madagascar, and other countries. With these as a reference, the introduction of radar rain gauges was discussed.

Table 3-129 List of existing projects related to the installation of meteorological observation instruments used as a reference

No.	Project name	Cooperation period	Remarks
1	The Project for Improvement of the Meteorological Radar System	April 2013 - January 2015	Reference for radar rain gauges
2	Mauritius Climate Change Response Capacity Building Project	July 2014 - April 2016	Reference for capacity building projects
3	Meteorological Observation and Forecasting/Warning Capacity Improvement Project in Mozambique	April 2015 - March 2018	Reference for capacity building projects
4	Meteorological Observation Instruments Installation Project in Republic of the Union of Myanmar	March 2013 - 2017	Reference for radar rain gauges and ground-based observation instruments

Source: JICA Study Team

a) New radar rain gauge (weather radar) to be installed

S-band radar is a bandwidth that maximizes the basic features of weather radar, such as "long range" and "real time.” Compared to other bandwidth, it can easily transmit and receive high-powered radio waves, and subject to atmospheric and rainfall attenuation, and can provide quantitative rainfall information over a wide area, making it suitable for monitoring large-scale weather disasters such as cyclones. Therefore, as in Mauritius, the weather radar in Madagascar will be S-band, and the radar rain gauge system will be used to enable switch between rainfall monitoring and disturbance monitoring in order to accurately detect sudden changes in the weather (disturbances, cyclonic storms, storms, tornadoes) in real time.

On the other hand, although the detection range of radar rain gauges is 450 km according to the specifications as shown in the table below, the actual detection range is about 300 km even with S-band if we exclude sea areas.

Table 3-130 List of main specifications of radar rain gauge

Main specifications	**Newly installed radar rain gauge**
Main purpose	Monitoring of cyclones and heavy rainfall
Band	S band
Transmission frequency	2,800MHz
Rainfall resolution	256 shades
Detection distance of rainfall with rainfall intensity of 1 mm/h or more	450km
Monitoring (doppler) function of strong wind, storm wind and storm	Yes
Rainfall accumulation function	Yes

Source: Excerpt from the Report on the Preparatory Survey for the Meteorological Services Plan for the Republic of Mauritius, p.3-7, November 2012

Weather radar system installed; exterior view of the building

Weather radar system installed; exterior view of the building

Radar operation control equipment, data and protocol conversion equipment, receiving signal processing equipment, and transmitters installed

Aerial equipment installed

Figure 3-154 Radar rain gauge case study (Mauritius)

Source: JICA (https://www.jica.go.jp/oda/project/1261260/index.html)

b) Location of radar rain gauges

The main purpose of installing radar rain gauges is to monitor cyclones and heavy rainfall.

Therefore, the number and locations of radar rain gauges to be installed were studied by overlaying the detection distance of radar rain gauges with areas of high flood and storm risk due to previous cyclones.

- Based on the actual path of cyclone passage (left of the below figure), radar rain gauges need to be installed to cover the entire country as cyclones are making landfall all over Madagascar.
- Based on the annual cumulative maximum wind speeds of previous cyclones (center of the below figure), the potential for damage from cyclone-related storms in northeastern Madagascar is high, and radar rain gauges should be installed to cover the Indian Ocean waters northeast of Madagascar.
- The population distribution of Madagascar (right of the below figure) shows that although

there is a concentration of population in the capital city, Antananarivo, the population is distributed around the major cities in the country. In order to provide uniform information to all citizens, radar rain gauges need to be installed to cover the entire country.

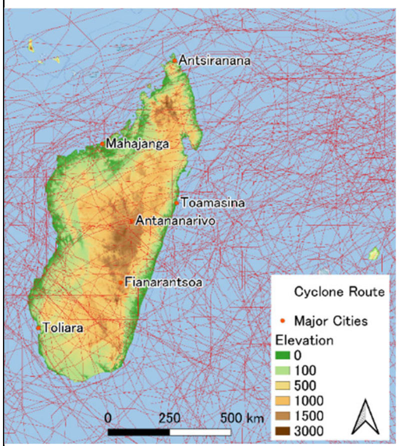
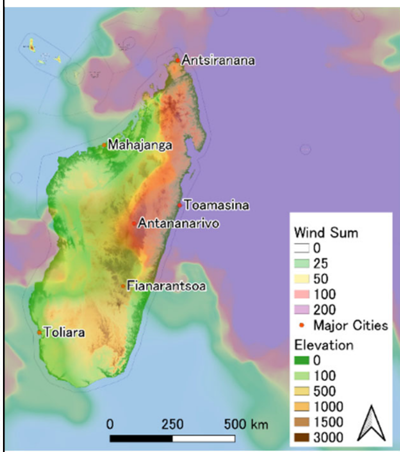
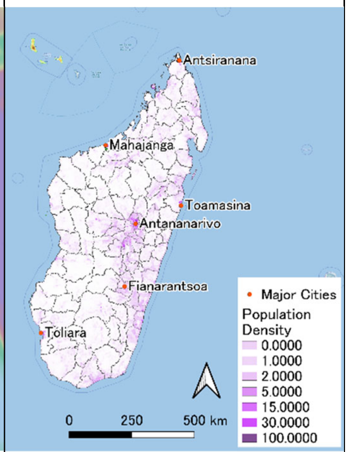
Passage results of past cyclones	Annual cumulative maximum wind speeds of past cyclones (km/h)	Population distribution in Madagascar (persons/100m2)
		

Figure 3-155 Disaster risk of past cyclones and population distribution in Madagascar

Source: JICA Study Team

The installation locations of radar rain gauges were studied based on the previous cyclone landfall and population distribution in the area.

- Based on the results of the interviews, DGM wants to install radar rain gauges in the following four cities: Morondava, located on the west coast; Antalaha, located on the northeast coast; Antananarivo, the capital city; and Farafangana, located on the southeast coast. Based on this, the location map of the radar rain gauges is shown in the upper left corner of the figure below.
- If the number of locations where a radar rain gauge will be installed in two location as shown on top right of the figure below, the locations are Mahajanga in the northwest and Fianarantsoa in the southeast), a detection distance of 450 km can cover the whole country, but if the detection distance is 300 km, the whole country cannot be covered. In addition, the Indian Ocean waters northeast of Madagascar cannot be covered by the radar rain gauges.
- If the number of locations where a rader rain gauge will be installed in three location as shown in the bottom left of the figure below, the locations are Antananarivo, the capital city, Antsiranana in the north, and Toliara in the south), a detection range of 450 km would cover the entire country and the Indian Ocean waters northeast of Madagascar. However, with a

detection range of 300 km, they cannot cover eastern Madagascar in particular.

- As a result, it is necessary to conduct a detailed study on the locations of future installations, but at this point it is considered desirable to install radar rain gauges in the following four cities considered by DGM (Morondava on the west coast, Antalaha on the northeast coast, Antananarivo, the capital city, Farafangana on the southeast coast).

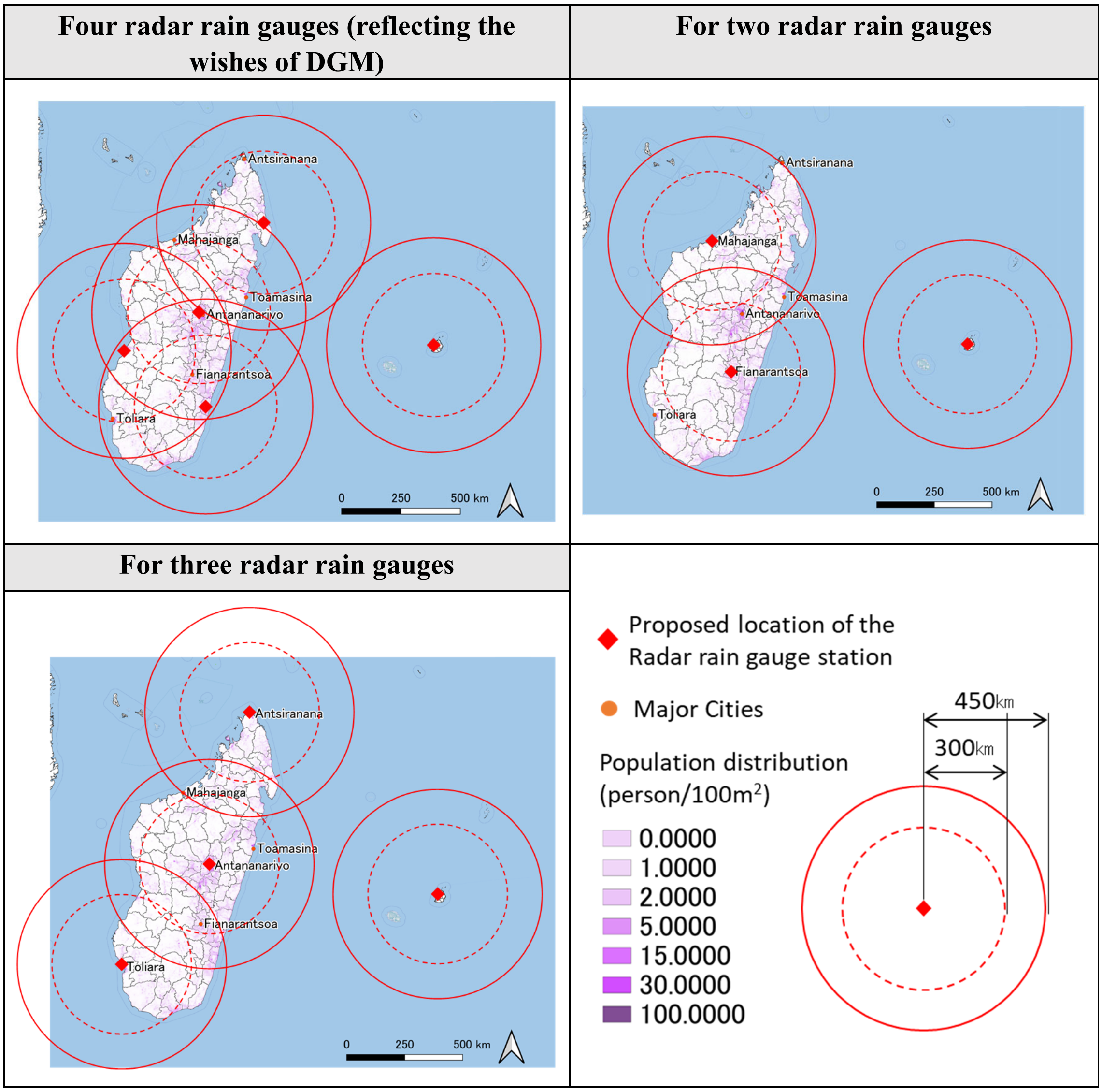


Figure 3-156 Relationship between detection distance and installation locations of radar rain gauges

Source: JICA Study Team

c) Consideration of power supply for radar rain gauges

As for the scale of power supply required for this facility, based on a similar project[60], it is assumed that the capacity of the power receiving equipment from the commercial power supply will be 100 kVA and that two diesel engines with a capacity of 75 kVA will be installed. In this case, the cost is estimated to be about 15,000 US dollars for the power receiving equipment and 130,000 US dollars for the engines.

In addition, considering that this equipment will be covered by renewable energy sources and storage batteries, it is generally expected that solar power and wind power will be adopted. In the case of photovoltaic power generation, assuming an annual operating rate of 15% and a facility load of 855 kWh per day (assuming diesel engine capacity, a power factor of 95%, and a load factor of 50%), a capacity of approximately 240 kW would be required. Based on international equipment prices (NREL 2021), a solar PV installation is estimated to cost US$370,500.

If a similar assumption is made for wind power generation, and the operating rate of the power generation facility is assumed to be 25% per year, the installed capacity would be about 140 kW, and the installed cost would be US$612,750. Furthermore, assuming that the storage capacity is for one day, and referring to the international price (NREL 2016), the equipment cost is estimated at 247,950 US dollars.

d) Consideration on the communication system for radar rain gauges

The rainfall data collected by the radar rain gauges should be aggregated at the DGM central station in the capital city of Antananarvo via the nearest Synop observation station, and the data from radar rain gauges across the country should be complemented and combined with each other. The transmission bandwidth required is about 2 Mbps per radar rain gauge. The following communication channels are required.

i) Radar rain gauge station - Synop observation station (manned station)

Since it is usually difficult to construct and maintain an optical cable communication channel to the radar rain gauge station installed on the mountain, a microwave (5 GHz band) wireless communication channel will be secured. Because of the high directivity of the microwave band, the radar rain gauge station will be installed at a location where visibility can be ensured within a radius of about 50 km from the Synop observation station. If the visibility from the Synop observation station cannot be ensured, a 50-meter-high steel tower will be set up near the Synop

[6060] Report on the Preparatory Survey for the Meteorological Services Plan of the Republic of Mauritius observation station, and microwave antennas will be laid on the tower.

ii) Synop observation station (manned station) - DGM central station

The bandwidth of the communication channel will be investigated, and if a bandwidth of 4 Mbps or more including margin can be secured, that communication channel will be used. If there is a shortage, new or additional optical fiber cables should be considered.

e) Approximate project cost of radar rain gauges

The estimated cost of installing a radar rain gauge is shown at the table below as an approximate project cost of radar rain gauges. This is the same amount as the estimated cost of introducing the system in Mauritius.

Based on the table, the cost is about 1.08 billion yen per location, and at least 4.32 billion yen is needed as a schematic project cost since radar rain gauges will be installed in four locations according to the figures above Installation location of radar rain gauge.

Table 3-131 List of estimated costs for radar rain gauge (1 location)

Expenditure item		**Estimated project cost (million yen)**
(1) Construction of facilities	Weather radar tower facility	385
(2) Equipment cost	Weather radar system	578
	Weather radar data display system	
	Weather data communication system	
(3) Soft component		9
(4) Design and supervision fees		105
Total		1,077

Source: Report on the Preparatory Survey for the Meteorological Services Plan for the Republic of Mauritius, p. 3-70, November 2012

5) Surface weather observing equipment installation project (grant aid)

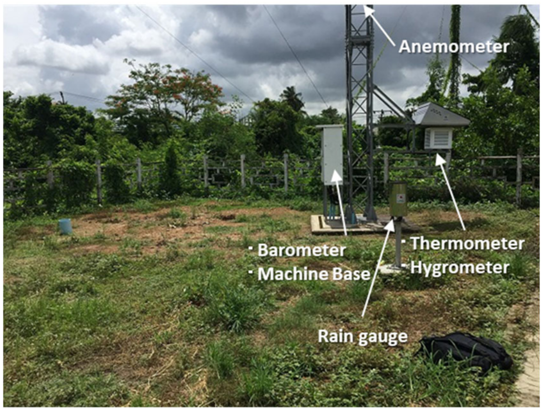
a) Surface weather observing equipment

As part of Surface weather observation, it is necessary to observe atmospheric pressure, temperature, humidity, wind direction and speed, precipitation, sunshine duration, solar radiation, clouds, visibility, and atmospheric phenomena. In the projects in other countries that JICA has supported so far as shown in the table below, automatic observation stations for atmospheric pressure, temperature, humidity, wind direction and speed, and precipitation have been installed as surface weather observing equipment as shown in the table below. The same surface weather observing equipment shall be installed here as well.

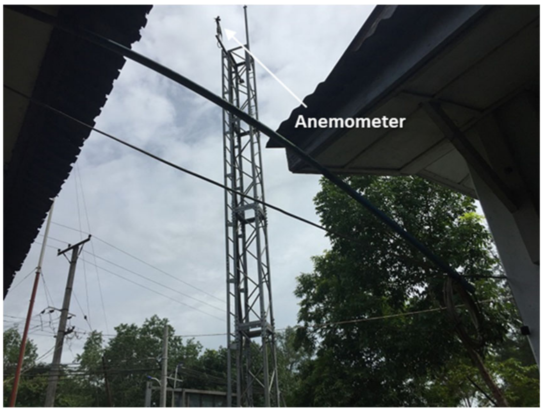
Table 3-132 List of previous projects related to the introduction of meteorological observation instruments used as a reference (mention again)

No.	Project name	Cooperation period	Remarks
1	The Project for Improvement of the Meteorological Radar System	April 2013 - January 2015	Reference for radar rain gauges
2	Mauritius Climate Change Response Capacity Building Project	July 2014 - April 2016	Reference for capacity building projects
3	Meteorological Observation and Forecasting/Warning Capacity Improvement Project in Mozambique	April 2015 - March 2018	Reference for capacity building projects
4	Meteorological Observation Instruments Installation Project in Republic of the Union of Myanmar	March 2013 - 2017	Reference for radar rain gauges and ground-based observation instruments

Source: JICA Study Team



Automatic observatory in Myanmar (Yangon)



Automatic observatory in Myanmar (Pantheon)

Figure 3-157 Examples of surface weather observing equipment installed in past JICA projects

Source: JICA Study Team

b) Installation location of surface weather observing equipment

There are currently 34 Synop observation stations in Madagascar, but most of them are not functioning, and only 17 stations are operational as shown in the figure below.

Therefore, it is considered desirable that the surface weather observing equipment to be installed as part of the support at the existing Synop observation stations (34 stations).

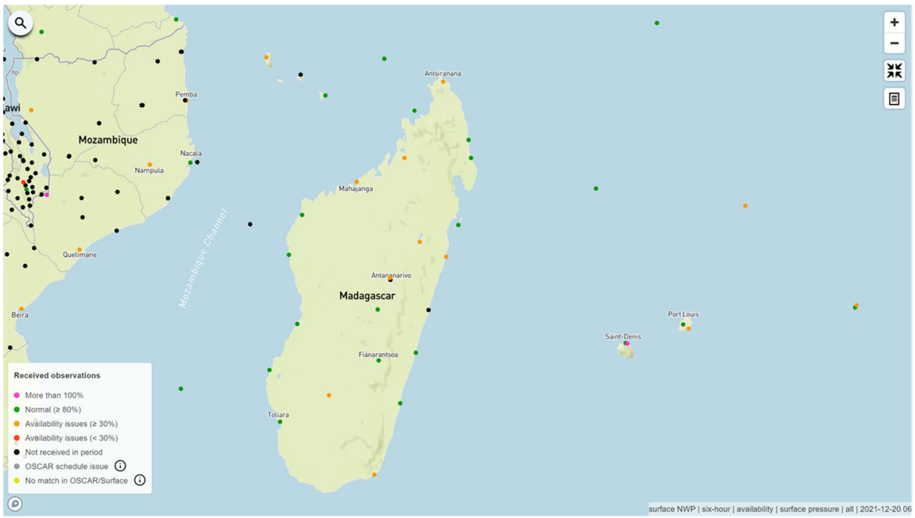


Figure 3-158 Location map of the DGM's 17 Synop stations in operation

Source: WMO

c) Approximate project cost of surface weather observing equipment

Based on the previous JICA project[61], the estimated project cost for the introduction of surface weather observing equipment was calculated (Table below). The project targets 30 surface weather observation stations, and as shown in Table below, the estimated project cost for only surface weather observation stations (automatic weather observation system in the same table) is not known. For this reason, the estimated project cost for the establishment of ground meteorological stations was assumed to be 15 million yen per station.

As mentioned above, there are 34 Synop stations in Madagascar, so the estimated project cost for the establishment of ground meteorological observatories is 510 million yen (15 million yen x 34 stations).

Table 3-133 Approximate project cost of surface weather observing equipmen

Items		**Approximate project cost（30 stations）**
Equipment fee	Weather radar system Weather radar data observation system Weather data satellite communication system Weather data communication system Automated weather observation system	340 million yen

Source: JICA Study Team

6) Meteorological observation, forecasting and early warning capability improvement project (technical cooperation)

a) Goals and specific activities of the existing capability building projects

A summary of the capability building projects that JICA has carried out in other countries is shown at the tables below.

With reference to the results of interviews with DGM, the specific activities of the project for improving meteorological observation and forecasting and warning capabilities in Madagascar were discussed.

- In Madagascar, rather than improving the capacity for climate change adaptation as in Mauritius, it is thought that the country first needs to improve its capability for meteorological observation and forecasting and warning. In particular, it is first and foremost

[61] Republic of the Union of Myanmar Meteorological Observation Equipment Development Project Preparatory Survey Report, 2013

important to carry out proper meteorological observations.

- It is considered important to provide on-the-job training to improve the capacity for maintenance and management of radar rain gauges and surface weather observing equipment, including traceability. In addition, it is important to implement on-the-job training to improve the ability related to forecasting and warning.
- As in the case of Mozambique and Myanmar, it is important to investigate the needs of each user (government agencies, media, private companies, etc.) regarding the forecasting/warning system to be provided and to understand the issues, as well as to provide support on how to provide the information to end users, including how to present it.

Table 3-122 Summary of existing projects (1/3)

Project name	The Project for Capacity Development on Climate Change Measures in Mauritius
Overall goal	The implementation of climate change adaptation measures is enhanced
Project Purpose	The capacity of GoM to deal with climate issues is strengthened
Activity	a. [Output 1] Sectoral guidelines/policies on climate change adaptation are established a.1 Identify line Ministries or other organizations for climate change adaptation measures in the fields of coastal protection and management. (Activity 1-1) a.2 Analyze impacts of climate change on these sectors, especially with focus on negative impacts. (Activity 1-2) a.3 Collect the baseline data (from the line ministries, international sources and ongoing JICA projects). (Activity 1-3) a.4 Analyze (GIS, Vulnerability Assesement, etc) the collected data and identify adaptation measures. (Activity 1-4) a.5 Establish guidelines (policies and standards) in relation to climate change. (Activity 1-5) b.. [Output 2] Climate change education and public awareness activities are enhanced b.1 Plan climate change education and public awareness activities with the Climate Change Division (CCD) and the Information and Education Division (I&ED) of MOESDDBM (target, curriculum and media, etc.). (Activity 2-1) b.2 Obtain information/materials for climate change campaigns. (Activity 2-2) b.3 Develop resource materials with the CCD and the I&ED for sensitisation for various targeted groups. (Activity 2-3) b.4 Train the trainers – teachers, community, women and youth leaders – to conduct public awareness activities. (Activity 2-4) b.5 Sensitisation materials such as a video clip, a 3D digital model of Mauritius, a card game and panels are developed for training and campaigns. (Output 2-5) b.6 Capacity of CCD staff for sensitisation activities is enhanced. (Output 2-5)

Source: Project Completion Report of the Mauritius Climate Change Capacity Building Project, pp. 7-37, 2016.

Table 3-122 Summary of existing projects (2/3)

Project name	Technical Cooperation Project for the Capacity Enhancement of Meteorological Observation, weather forecasting and warning in Mozambique
Overall goal	Capacities to respond the natural disasters are enhanced in Mozambique.
Project Purpose	INAM is capable to issue improved weather forecasting and warnings by using quality-controlled meteorological data
Activity	OUTPUT 1: Capacities in meteorological observation at INAM are enhanced 1-1. Conduct baseline survey and identify issues about surface and upper weather observation, radar, satellite and others. 1-2. Procured traveling standard instruments are calibrated by WMO/RIC (Japan) and INAM is responsible for second calibration. 1-3. Develop guidelines for the monitoring heavy rain with satellite and ARG data and checkup list for ARG. 1-4. Develop guidelines and manuals for the traceability and inspection of meteorological instruments. 1-5. Conduct trainings for the monitoring and analysis for heavy rain with satellite and ARG data. 1-6. Conducting training for the traceability and inspection of meteorological instruments according to guidelines and manuals based on the activity (1-4) 1-7. Conduct follow-up activities to monitor and analyze heavy rain on daily operation. 1-8. Conduct follow-up activities to establish the traceability and inspection of meteorological instruments OUTPUT 2: Capacities in weather forecasting and warnings at INAM are enhanced 2-1. Conduct baseline survey and identify issues about forecasting and warning 2-2. Conduct training of weather forecasting method. 2-3. Conduct trainings of methodology on weather forecasting and warning by using ground weather observation, ARG, satellite and GPV data. 2-4. Conduct follow-up activities to establish comprehensive weather forecast and warning by using the output of activity 2-2 and 2-3. 2-5. Conduct baseline survey to identify needs of users such as INGC, DNA, Media and private company and identify issues on weather forecast and warning product provided by INAM. 2-6. Improve weather forecast and warning base on the finding of activity (2-5).

Source: Project Completion Report of the Technical Cooperation Project for the Capacity Enhancement of Meteorological Observation, weather forecasting and warning in Mozambique, p. 2, 2018

Table 3-122 Summary of existing projects (3/3)

Project name	Project to enhancing capacity of weather observation and forecasting
Overall goal	Improved weather information is utilized effectively by the people in Myanmar and disaster risk reduction organization
Project Purpose	Reliable weather information is delivered to the public and disaster risk reduction organization
Activity	Output1: Reliable observation data are collected from equipment such as weather radars and surface observation systems 1-1. To identify issues in operation of newly installed three meteorological radars. 1-2. To develop operation and maintenance guidelines of three meteorological radars for obtaining reliable data. 1-3. To conduct On the Job Training (OJT) based on the guidelines developed by (1-2) 1-4. To identify issues in operation and maintenance of automatic weather observation and surface observation systems at the pilot stations. 1-5. To develop guidelines of quality control for equipment of automatic weather observation and surface observation. 1-6. To develop manuals of regular inspection, calibration and maintenance of weather observation equipment. 1-7. To establish traceability method of observation equipment and to develop manuals. 1-8. To conduct On the Job Training (OJT) based on the manuals developed by (1-6) (1-7) Output 2: Capacity on weather observation radar data analysis is improved. 2-1. To conduct training on radar data analysis. 2-2. To conduct training on method to obtain reliable meteorological radar data using automatic weather observation data and other weather data. 2-3. To improve QPE information continuously. Output 3: Quantitative weather forecast is developed. 3-1. Provide training on operation and utilization of Himawari-Cast for weather forecasting 3-2. Develop weather guidance system (MOS and Kalman filter) by using NWP GPV data for issuing quantitative forecasts 3-3. Specify issues for acquisition status of domestic and international meteorological data necessary for comprehensive weather forecasting 3-4. Provide training on comprehensive weather forecast ing with a variety of meteorological data obtained from weather guidance system, HimawariCAST, weather radar and AWSs 3-5. Forecast support materials are developed and quantitative forecasts are issued Output 4: Quantitative weather forecast is developed. 4-1. Identify issues on the contents of weather informationon the web site of DMH. 4-2. Improve contents of weather information to be utilized by users easily. 4-3. Improve contents of weather information for smart phones.

Source: Planning Competition Description, pp. 13-14, January 2019

Based on the existing JICA projects in several countries shown above, the proposed project for improving meteorological observation and forecasting/warning capacity in Madagascar is shown in the table below. However, we have not been able to fully discuss the specific details of the project formation with our counterparts because we were not able to travel to Madagascar. When forming a full-scale project, it is necessary to confirm and discuss with the relevant counterparts from the high-level objectives.

Table 3-134 Madagascar: Project to Improve Meteorological Observation and Forecasting Capacity

Project name	Madagascar Meteorological Observation and Forecasting Capacity Improvement Project
Overall goal	Improve the capacity to respond to natural disasters in Madagascar.
Project Purpose	DGM will use the quality-controlled meteorological data to improve and issue pre-warning, which will be provided to public and disaster management agencies.
Activity	Outcome 1: Highly reliable meteorological observation data are collected from meteorological radars and ground-based instruments. 1-1 Identify issues related to the operation of the three newly installed weather radars. 1-2 Establish guidelines for the operation and maintenance of the three weather radars to obtain reliable data from them. 1-3 Provide OJT according to the guidelines prepared in 1-2. 1-4 Identify issues related to the maintenance of automated meteorological observations and ground meteorological observations at representative sites. 1-5 Establish guidelines for quality control of automated and ground-based meteorological observations. 1-6 Establish a manual for periodic check, calibration, and maintenance of meteorological instruments. 1-7 Establish a traceability method for observation instruments and prepare a manual. 1-8 Provide OJT based on the manual prepared in 1-6 and 1-7. Outcome 2: The ability to analyze weather radar data will be improved. 2-1 Conduct training on analysis of radar data. 2-2 Provide training on methods to obtain reliable weather radar data using automated meteorological observations data and GPV (Grid Point Value) data. 2-3 Continuously improve QPE information. Outcome 3: Quantitative weather forecasts will be developed. 3-1 Provide training on the use of HimawariCast (forecast analysis using meteorological satellite data) for weather forecasting. 3-2 Introduce a weather guidance system (Model Output Statistics (MOS) and Kalman filter) using GPV data for quantitative weather forecasting. 3-3 Identify and analyze issues related to the status of acquisition of domestic and international meteorological data necessary for comprehensive weather forecasting. 3-4 Provide training on comprehensive weather forecasting techniques using data obtained from weather guidance systems, HimawariCast, weather radar, and automated meteorological observations. 3-5 Forecast support materials will be prepared, and quantitative forecasts will be provided. Outcome 4: Easy-to-understand weather information is provided. 4-1 Identify issues with weather information content on the DMH website.

	4-2 Improve meteorological information content to make it easier for users to use. 4-3 Improve weather information contents for mobile phones.

Source: JICA Study Team

7） Introduction of reference instruments necessary for establishing traceability

In order to be able to compare observations with temporal and spatial differences with each other, it is necessary to unify the scales of measurement, define standards, and make each observation according to those standards. This fixed relationship of mutual scales is called "traceability" (left of the below figure). In order to ensure the traceability of observations, it is necessary to calibrate the scales used in each observation. Calibration here means to compare the observation with a certain standard specified in advance and adjust the scale of observation to the result. This calibration process is essential for the accurate detection of environmental changes through global observations (right of the below figure).

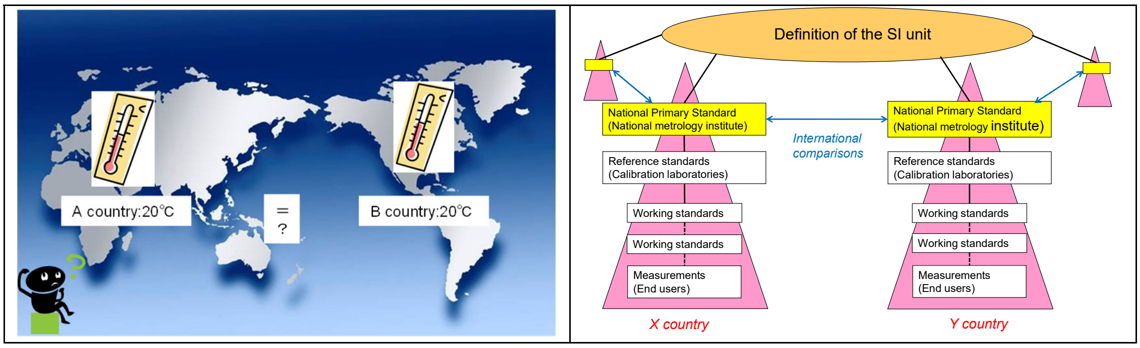


Figure 3-159   Image related to traceability

Source: Japan Meteorological Agency, with some additions

Assuming the introduction of surface weather observing equipment for atmospheric pressure, temperature, humidity, wind direction and speed, and precipitation, the following equipment required to ensure traceability of barometers, thermometers, humidity, and precipitation will be provided.

- Air temperature (thermometer) standard
- Air temperature (thermometer) moving standard
- Atmospheric pressure standard
- Thermostatic bath
- Atmospheric moving standard
- Digital Assman ventilation psychrometer
- Atmospheric pressure test unit

In order to provide continuous support, consistency and compatibility with the equipment for certification used by the Japan Meteorological Agency will be considered.

3.3 Malawi

3.3.1 Disaster Risk Profile

(1) Qualitative Evaluation of Hazard Distribution

1) Situation of Hazard Distribution in Malawi

The hazard data described in "2.1.2 How to identify overview of disaster risk" was visualized in GIS to identify the profile of hazard as shown in the figure below.

- Flood has occurred due to rainfall from cyclones, etc., but based on the history below, the risk of disaster due to strong wind, etc. is limited.
- Flood risk is high in the lowlands of the Shire River basin, a subsidiary stream of the Zambezi River that flows through the south of the country.
- Mountainous areas in the north are at high potential of Landslides.

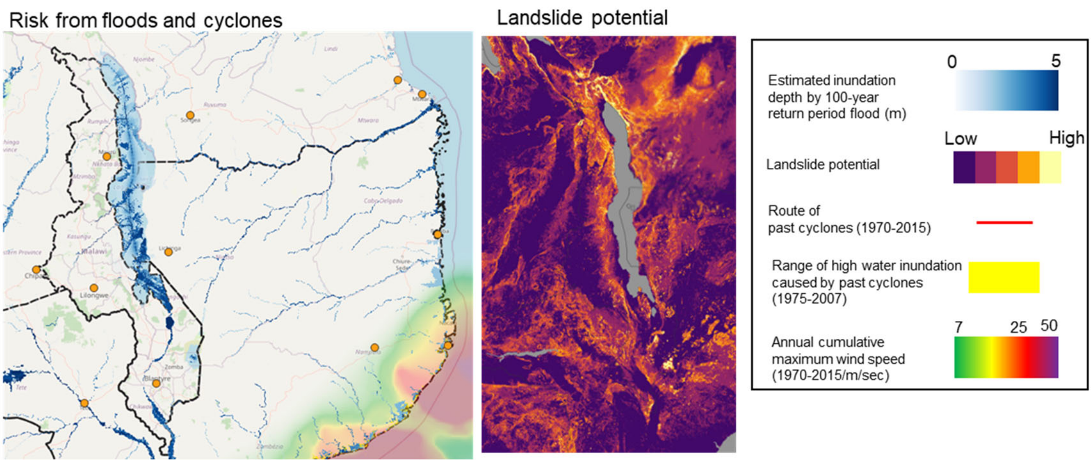


Figure 3-160 Hazard distribution in Malawi
Source: Each data source is listed in Chapter 2, Open Street Map (background map)

2） Situation of Hazard Distribution in Major Cities of Malawi

Situation of hazard distribution in each major city was identified according to the criteria shown in "2.1.2 Basic Idea and Methodology to Identify Disaster Risk Profile ". The population of major cities was confirmed based on UN-Habitat and World Population Review, and the major cities with large population sizes were sorted out.

Table 3-135 Hazard status in major cities in Malawi

City name	Population size (thousand person)	Hazard status			
		Flood	Cyclone	Storm Surge	Landslide
Lilongwe	1,121	✓	✓	—	✓
Blantyre	932	✓✓	✓	—	✓✓
Mzuzu	175	✓	✓	—	✓✓
Chikwawa (District)	50	✓✓	✓	—	✓✓
Nsanje (District)	33	✓✓	✓	—	✓✓

Source: JICA Study Team

a) Lilongwe

Lilongwe is a capital city located in central Malawi and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "✓" since inundation area exists along the Lilongwe river (Figure bellow (1)). Storm surge hazard was evaluated as "-" since it is an inland city. Hazard of the strong wind was evaluated as "✓" since there is no distribution of Annual accumulative wind speed but the area is affected by the Cyclone making landfall from the northern to central region of Mozambique. Landslide hazard was evaluated as "✓" since area with high landslide potential score over the medium level exists in the eastern area (Figure bellow (2)).

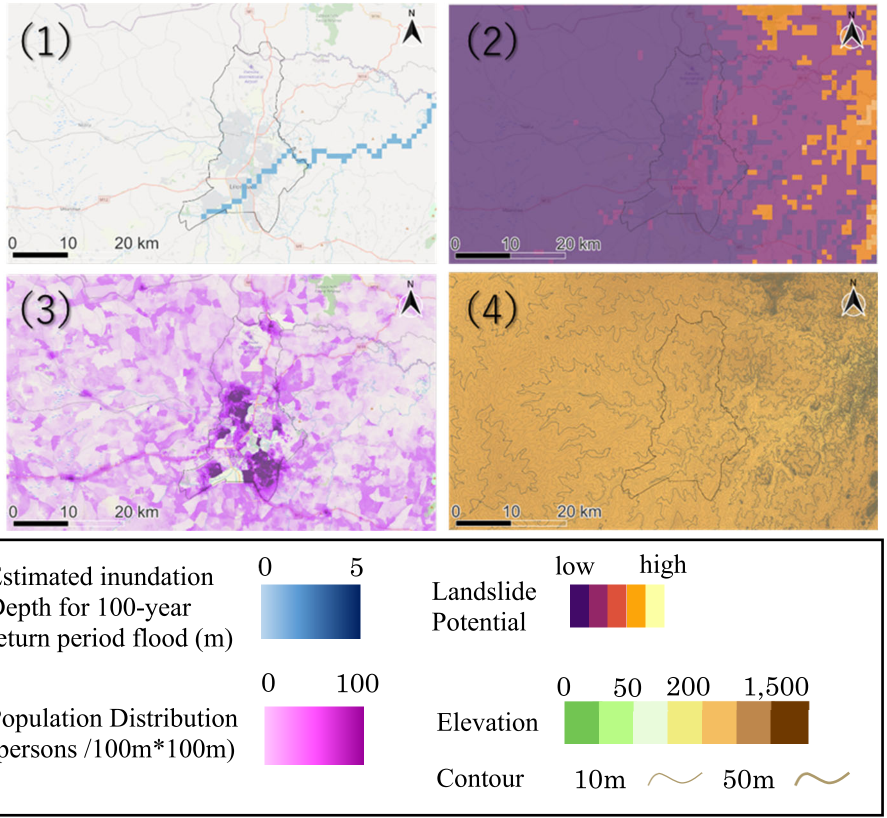


Figure 3-161 Situation of Hazard Distribution in Lilongwe

Source: JICA Study Team

b) Blantyre

Blantyre is a city located in southern Malawi and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "✓" since inundation area do not exists in the city but it was affected and damage by flood occurred in the time of Cyclone Ana in 2022 (Figure bellow (1)). Storm surge hazard was evaluated as "-" since it is an inland city. Hazard of the strong wind was evaluated as "✓" since there is no distribution of Annual accumulative wind speed but the area is affected by the Cyclone making landfall from the northern to central region of Mozambique. Landslide hazard was evaluated as "✓✓" since area with high landslide potential score over the medium level is distributed in the central hill side area and the eastern and western area of the city (Figure bellow (2)).

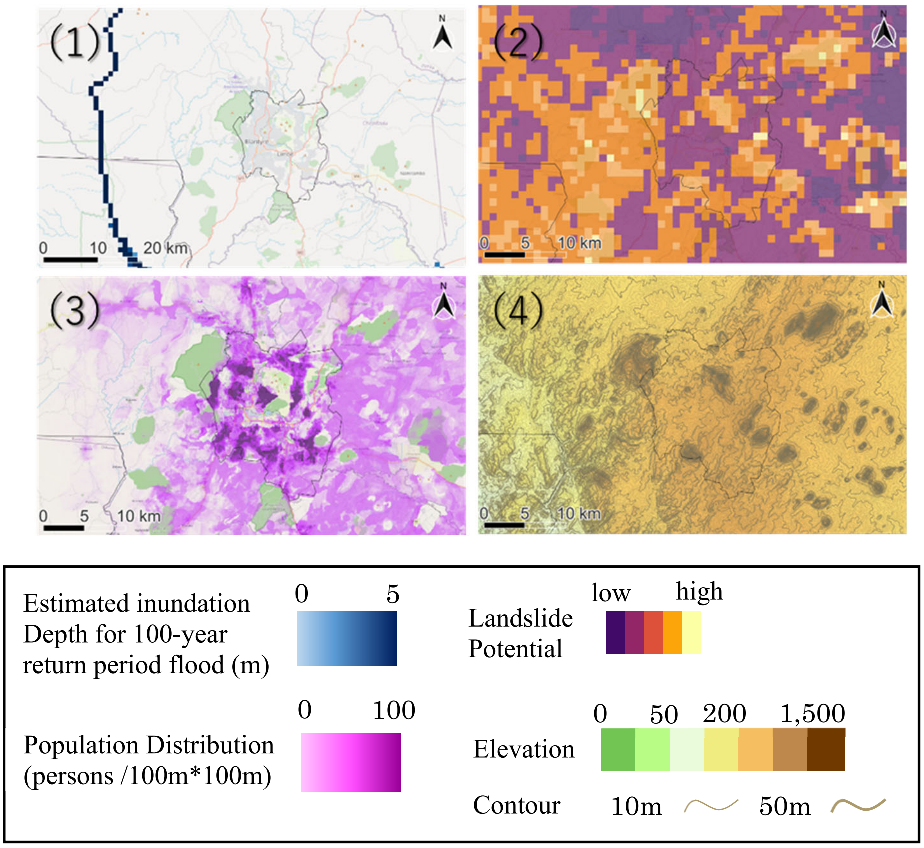


Figure 3-162 Situation of Hazard Distribution in Blantyre

Source: JICA Study Team

c) Muzuzu

Mizuzu is a city located in northern Malawi and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "–" since inundation area do not exists in the city (Figure bellow (1)). Storm surge hazard was evaluated as "-" since it is an inland city. Hazard of the strong wind was evaluated as "–" since there is no distribution of Annual accumulative wind speed in the city. Landslide hazard was evaluated as "✓✓" since area with high landslide potential score over the medium level is distributed in the southern area (Figure bellow (2)).

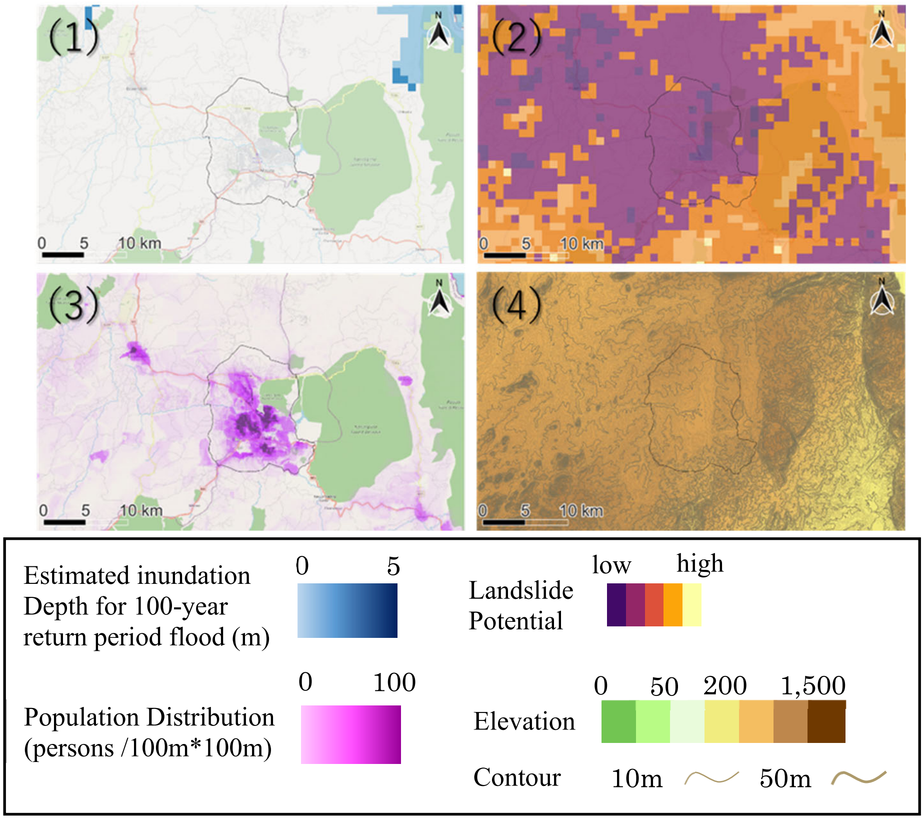


Figure 3-163 Situation of Hazard Distribution in Muzuzu

Source: JICA Study Team

d) Chikwawa district

Chikwawa district is located in southern Malawi of the lower basin of Shire river and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "✓✓" since inundation area is distributed along the Shire river (Figure bellow (1)). Storm surge hazard was evaluated as "-" since it is an inland city. Hazard of the strong wind was evaluated as "✓" since there is no distribution of Annual accumulative wind speed but the area is affected by the Cyclone making landfall from the northern to central region of Mozambique. Landslide hazard was evaluated as "✓✓" since area with high landslide potential score over the medium level is distributed in the northern area of the city (Figure bellow (2)).

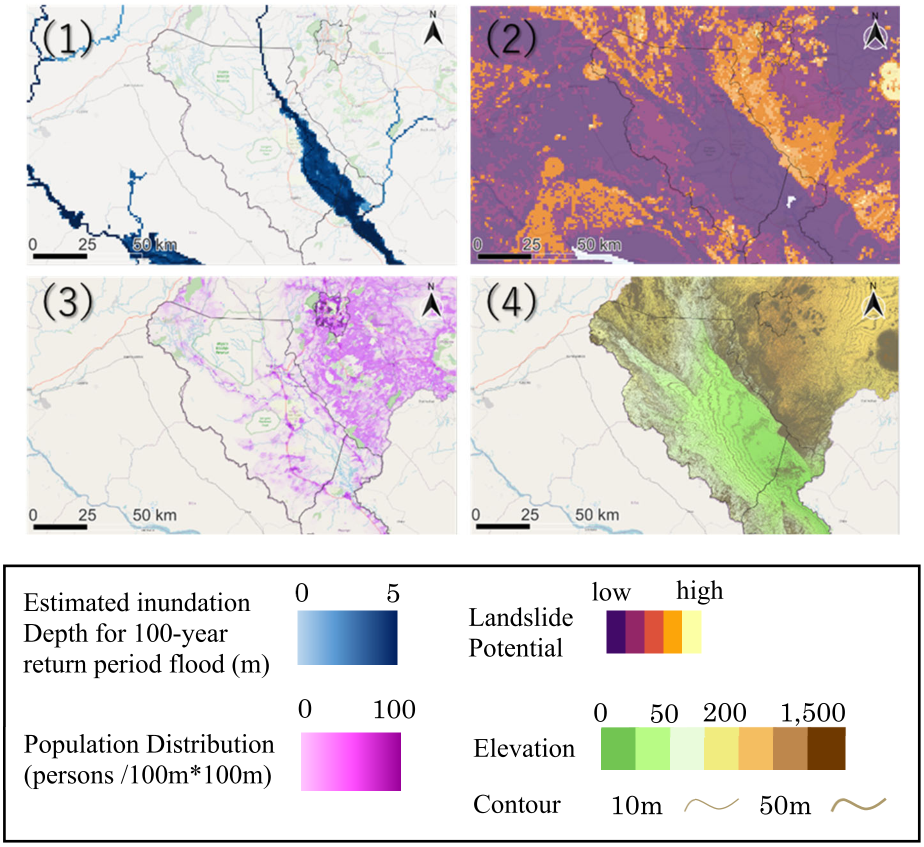


Figure 3-164 Situation of Hazard Distribution in Chikwawa District

Source: JICA Study Team

e) Nsanje district

Nsanje district is located in southern Malawi of the lower basin of Shire river and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "✓✓" since inundation area is distributed along the Shire river (Figure bellow (1)). Storm surge hazard was evaluated as "-" since it is an inland city. Hazard of the strong wind was evaluated as "✓" since there is no distribution of Annual accumulative wind speed but the area is affected by the Cyclone making landfall from the northern to central region of Mozambique. Landslide hazard was evaluated as "✓✓" since area with high landslide potential score over the medium level is distributed in the western area of the city (Figure bellow (2)).

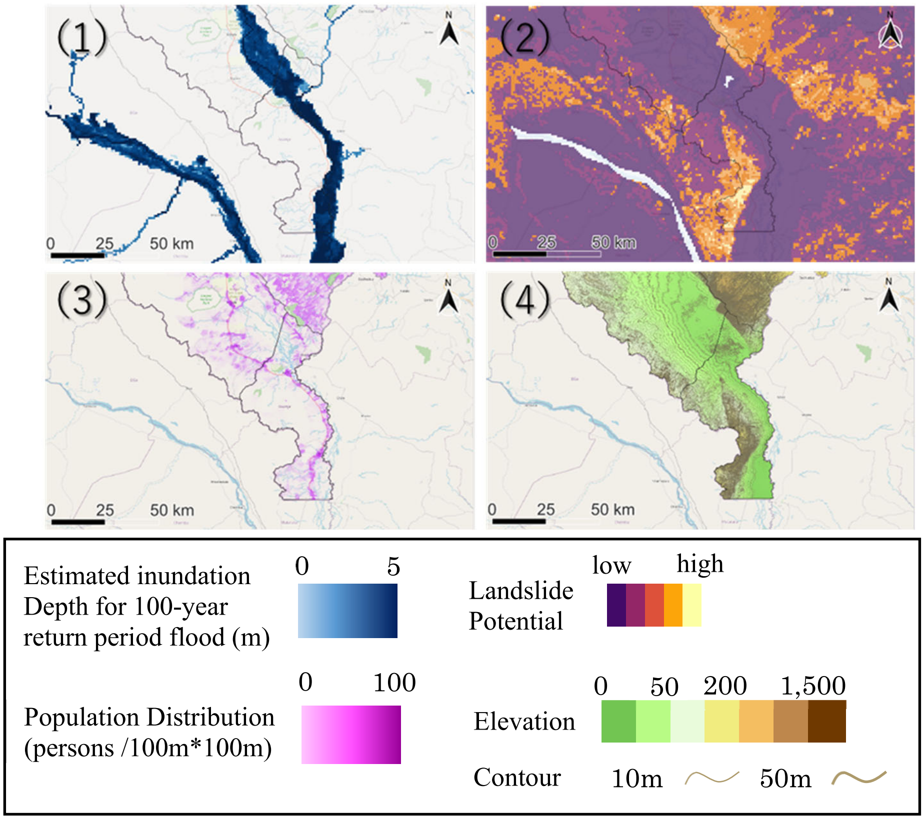


Figure 3-165　Situation of Hazard Distribution in Nsanje District

Source: JICA Study Team

(2) Estimation of Potential Economic Losses due to Disasters

Based on the results of the qualitative assessment of the hazard distribution, a more detailed assessment of the disaster risk was conducted for Lilongwe and Blantyre in terms of population size and hazard magnitude. For GDP per capita, the data from World Bank was used for the year 2020. The relationship among each hazard area and population distribution is shown in the table below.

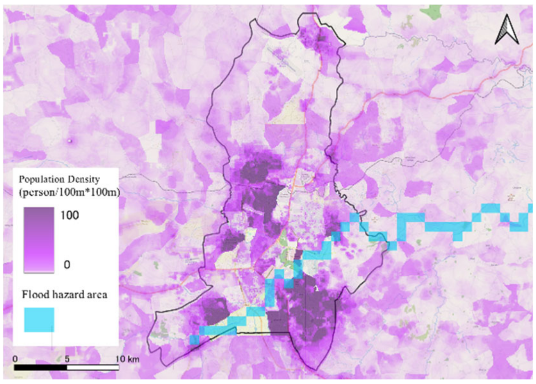
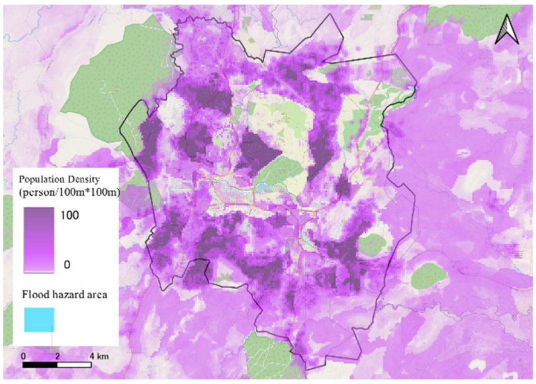
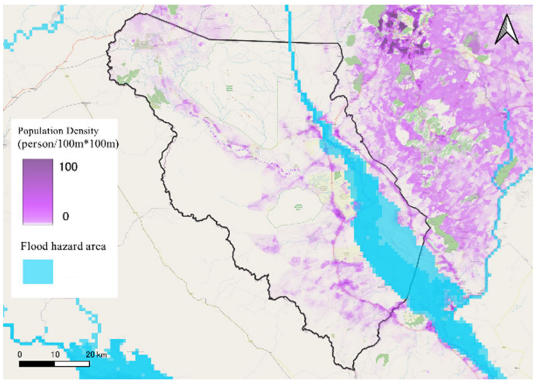
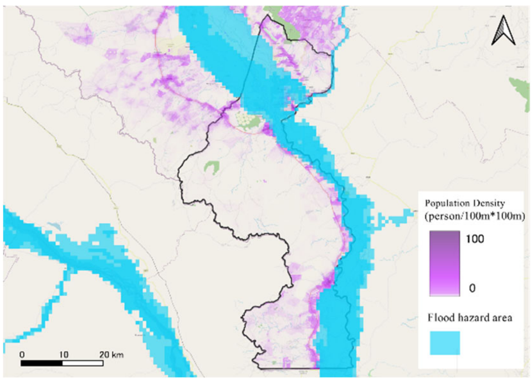
<table>
<tr><th colspan="2">Flood hazard and population distribution</th></tr>
<tr><th>Lilongwe</th><th>Blantyre</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><th>Chikwawa district</th><th>Nsanje district</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Figure 3-166 Distribution of Hazard and Population in in major cities in Malawi (1/2)

Source: JICA Study Team

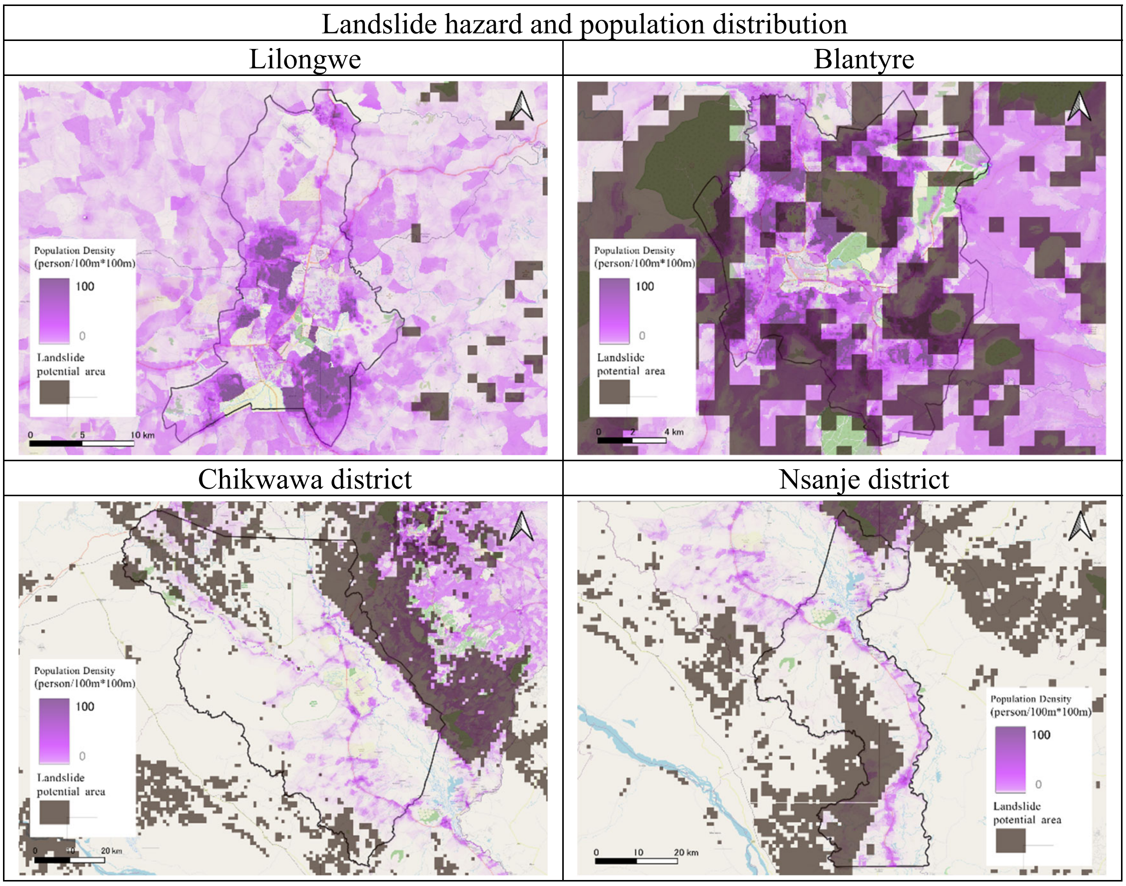


Figure 3-167　Distribution of Hazard and Population in in major cities in Malawi (2/2)

Source: JICA Study Team

Table 3-136　Potential Economic Loss of Major Cities in Malawi

Hazard	Target city	Lilongwe	Blantyre	Chikwawa district	Nsanje district
Flood	Damaged area (km²)	20	0	547	422
	Damage area ratio (%)	5%	0%	11%	22%
	Population affected ('0000 persons)	6.8	0.0	6.5	7.5
	Estimated damage (million USD)	**32**	**0**	**31**	**35**
Landslide	Damaged area (km²)	0	108	804	494
	Damage area ratio (%)	0%	46%	16%	25%
	Population affected ('0000 persons)	0.0	42.5	8.3	5.4
	Estimated damage (million USD)	**0**	**201**	**39**	**25**

* GDP per Capita (Current USD / person) used the data from WB
the value in the year 2020 which is (636.8USD / person) was used

Source: JICA Study Team

In addition to the two major cities of Lilongwe and Blantyre, the potential economic loss of Chikwawa district and Nsanje district was also estimated since broad area of the Shire river lower basin area is large, and the effect of the flood hazard could be large.

Although the population distribution is limited compared to the two major cities, the estimated potential economic loss was as same as Lilongwe in Chikwawa district and Nsanje district. Therefore, it is considered that it is efficient to implement flood management counter measures in possible inundation area in the lower Shire river basin.

For Blantyre, a more detailed analysis is needed because the global model analysis does not show the distribution of the expected flood inundation area, since localized floods are not fully understood.

With regard to landslide disaster, the number was large in Blantyre. Detailed study is needed for specific countermeasures, but the priority for countermeasures is considered to be lower than another hazard.

(3) Damage and Loss Disaggregated by Sector

1) GFDRR Disaster Risk Profiles

In Malawi, damage assumptions from floods and landslides are being studied separately for buildings, educational and healthcare facilities, transportation infrastructure, and agricultural infrastructure. The damage assumptions are estimated for each sector on a 10-year probability scale and a 50-year probability scale. Furthermore, based on these probability scale damage assumptions, the Average Annual Loss (AAL) is estimated.

Table 3-137 Sectoral damage estimate in Malawi in GFDRR Disaster Risk Profiles

Disaster type		Flood		Landslide
Conditions for analysis		50-year probability scale	Estimated annual damage	Estimated annual damage
Affected population	Affected population (persons)	450,000	100,000	100
Building	Amount of damage (Thousand USD)	150,000	30,000	150
Education and Hygiene	Number of affected facilities (number of buildings)	150	45	-
	Facility damage (Thousand USD)	-	-	10.5
Traffic Infrastructure	Damage extension (km)	250	70	-
	Amount of damage (Thousand USD)	-	-	60
Agriculture	Amount of damage (Thousand USD)	15	4	-

Source: Summarized by the JICA Study Team from GFDRR Disaster Risk Profile (Malawi)

In the GFDRR disaster risk profile the distribution of disaster risks by province is visualized by disaster type and by sector as follows:

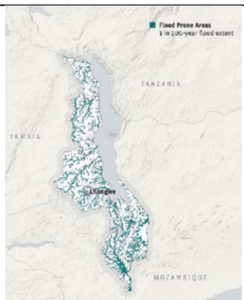
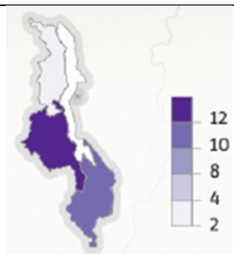
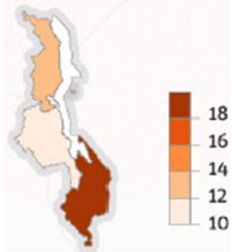
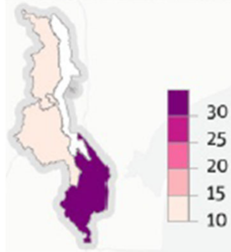
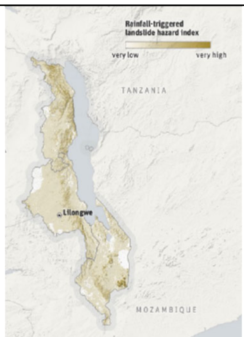
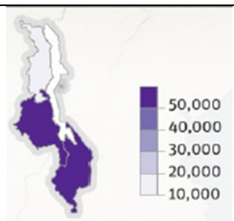
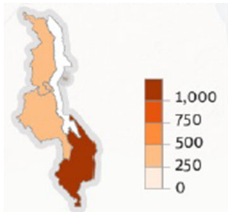
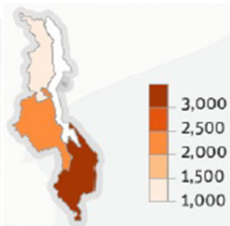
	Hazard distribution	Building damage	Educational and health facilities	Transportation Infrastructure
Flood	 *Flood inundation extent at 100-year probability scale	 *Estimated annual damage (million USD)	 *Estimated annual damage (number of buildings)	 *Estimated annual damage extension (km)
Sediment disaster	 *Landslide potential index due to rainfall	 *Estimated annual damage (USD)	Healthcare facilities Educational facilities  *Estimated annual damage (number of buildings)	

Figure 3-168 Distribution of disaster risks by type and sector

Source: Summarized by the JICA Study Team from GFDRR Disaster Risk Profile (Malawi)

The above results show that the damage to buildings is the largest in sectoral damage.

Looking at the distribution of hazard by type of disaster, flood risk is concentrated in the southern part of the country, and flood control in the southern region could be considered to be important for educational and health facilities and transportation infrastructure.

In particular, the southern region is the nexus of the Sena Corridor extending from the port of Beira in Mozambique and the Nacala Corridor extending from the port of Nacala in Mozambique is located. This corridor is a key transportation infrastructure, so it is considered important to implement countermeasures in the region.

In terms of landslide, disaster risk is also concentrated in the southern region. On the other hand, the hazard is high also high in the mountainous areas in the north, and this needs to be taken into account when developing the road infrastructure planned to connect the cities of Malawi with the Dar es Salaam corridor into Tanzania in the future.

2) Sectoral damage summarized in PDNAs

In Malawi, PDNAs have been prepared for three disasters: the 2012 floods, the 2015 floods, and the 2019 cyclone, and the damage amounts are summarized in the table below. The amount of damage to agriculture, houses, and transportation infrastructure is significant and shown in light blue colour on the table. Among the industries, the amount of damage to agriculture is outstandingly high, and disaster risk reduction measures in the agricultural sector are considered to be of high priority.

Table 3-138 Damage to each sector summarized in PDNA in Malawi (million USD)

Sector		2019 (Cyclones)	2015 (Flood)	2012 (Flood)	Total
Industry	Agriculture	33.1	68.0	0.7	**101.8**
	Fishery	3.2	0.0	0.0	3.2
	Industrial, commercial, and other damage	2.0	11.0	0.0	13.0
	Sightseeing	0.0	0.0	0.0	0.0
Social assets	Houses	106.6	139.0	0.8	**246.4**
	Education	21.1	12.0	0.0	33.1
	Hygiene	2.6	12.0	0.3	14.9
	Other	0.0	0.0	0.0	0.0
Infrastructure	Traffic	37.0	50.0	0.2	**87.2**
	Electricity and communications	3.1	1.0	0.0	4.1
	Water and sewage	6.4	26.0	0.8	33.2
	Other	5.1	6.0	0.0	11.1

Source: Excerpt of damage amounts by sector from past PDNAs

3) Disaster Damage and Loss Statistics

Malawi's disaster damage statistics for the targeted disasters (floods, cyclones, Storm Surge, and Landslides) aggregate the number of deaths, damage to houses, and actual damage to roads caused by 1,471 events between 1899 and 2018, which are summarized in the table below.

In the Sendai Framework for Disaster Risk Reduction, it is the duty of each country to consolidate not only damage to houses, but also economic losses, damage to education and healthcare facilities, agricultural land, and road infrastructure. In Malawi, UNDP (United Nations Development Programme) support for disaster damage statistics is being implemented. According to interviews with UNDP (as of December 2021), the database based on the support is not available to the public. In the future, more detailed damage statistics will be required.

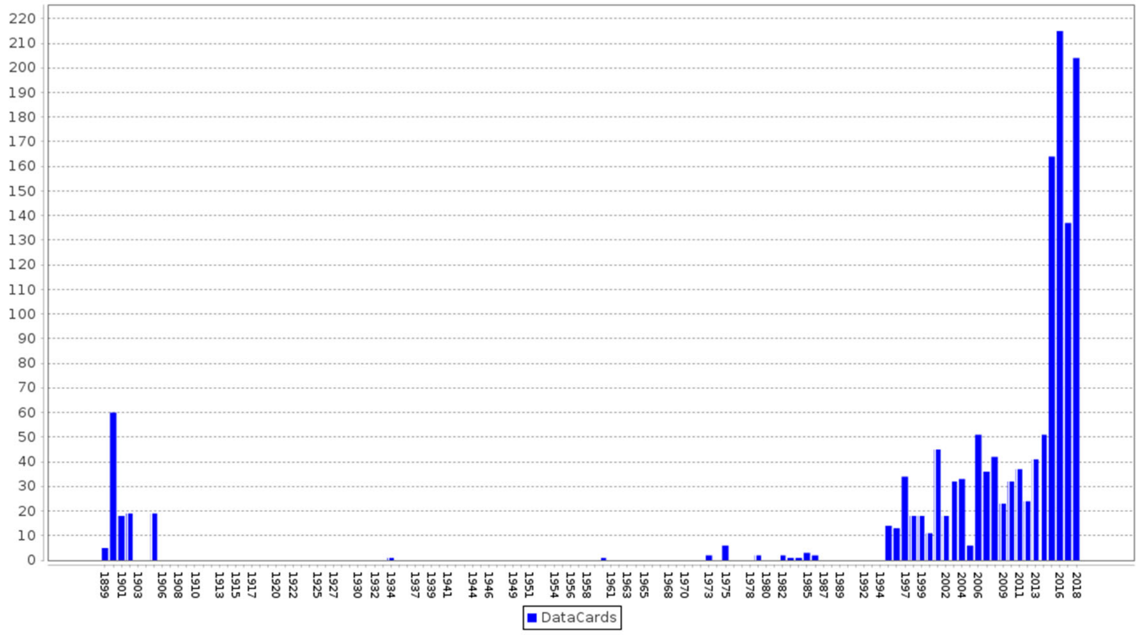
Table 3-139 Disaster damage statistics for Malawi by Sector

Targeted disaster types	Flood, Cyclone
Target year	1899-2018
Number of disaster events	1,471
Number of deaths	582
Partial damage to houses (buildings)	789,024

Source: Data collected from DesInventar and summarized by JICA Study Team

In addition, the annual trends of the number of disaster events and the number of damaged houses (destroyed + partial damaged) were confirmed to analyse the trend of damage. The number of disaster events shows an increasing trend. In terms of the number of houses damaged increasing trend cannot be found but the highest value was recorded in 1997 and high value are continuously recorded in the resent years.

Recently (after around 2000), due to the improvement of capacity to collect disaster damage and loss data including small-scale disasters, it is difficult to compare the previous and past statistics on the same basis. On the other hand, DesInventar has summarized information on large-scale disasters from the past, so it is possible to identify the rough trends. In DesInventar, information collected after 2005 will be used to evaluate the achievement of the indicators for the global target of the Sendai Framework for Disaster Risk Reduction, so it is expected that the information will be summarized on a uniform basis. Therefore, it is important to check the trend of the statistics continuously in order to understand the damage trend.



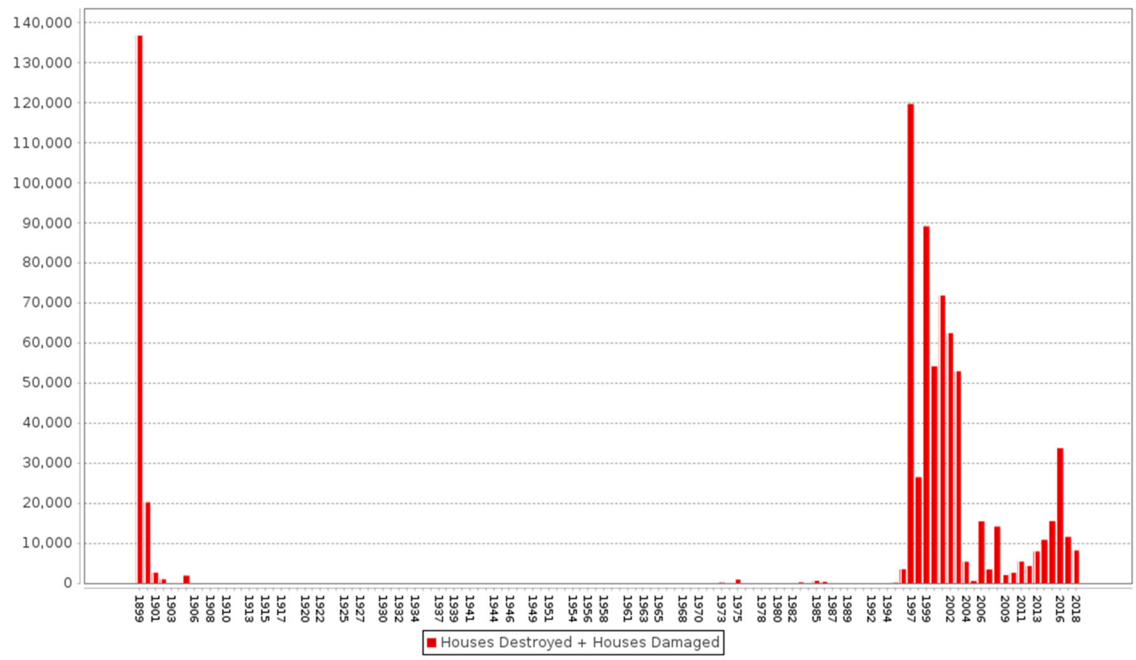


Figure 3-169 Trend of Disaster damage and loss in Malawi from 1898 to 2018

(Above: Annual Disaster Event, Bellow: Annual damaged houses (destroyed+partial damaged))

Source: DesInventar

3.3.2 Climate Change

(1) Observed and Projected Climate Change

Climate of Malawi is known as savannah, which is greatly influenced by its elevation and the huge Lake Malawi. In general, it is characterized by two seasons: the wet season, which lasts from October to April, and the dry season, which lasts from May to September. The dry season is cool and dry, while the wet season is warm and humid. The average annual temperature ranges from 12 to 32°C, with the highest temperatures occurring in late October or early November and the lowest temperatures in June or July. Average annual rainfall in Malawi ranges from 500 mm in the lowlands to over 3,000 mm in the highland plateaus such as the Nyika Plateau.

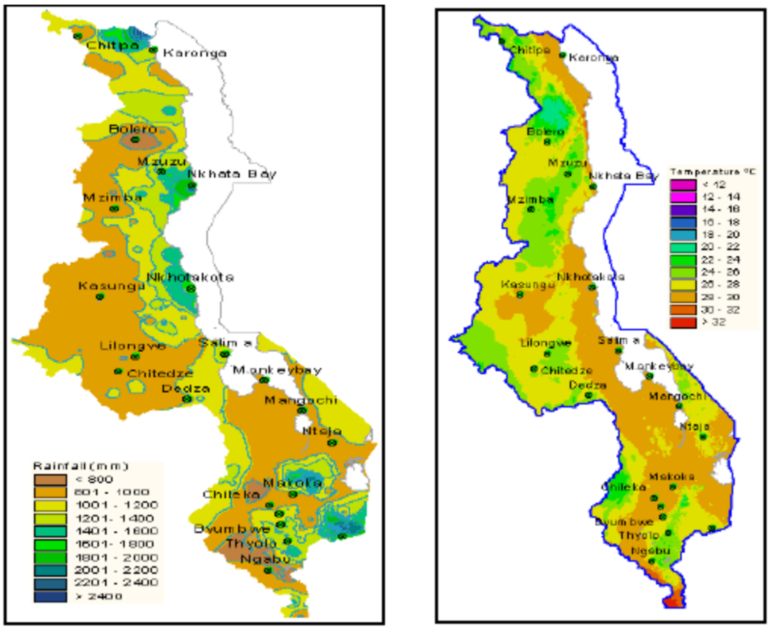
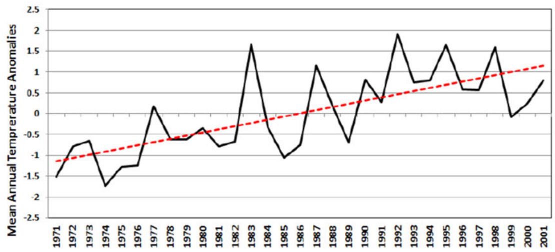


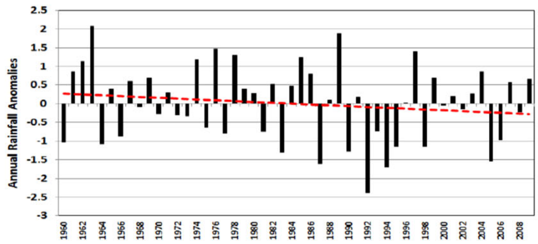
Figure 3-170 Circumstances of temperature and precipitation

Source: The Third National Communication, 2021

In Malawi, it has been observed that the average annual temperature increased by 0.9°C between 1960 and 2006, with an average increase of 0.21°C per decade. In particular, it is known that the rate of increase is high during the rainy season (December to February) and low during the summer season (September to November). With regard to precipitation, it has not been possible to identify long-term trends due to the large annual variation in precipitation. With regard to temperature, it has been shown that the average annual temperature has been fluctuating significantly by the data of the 28 monitoring stations from 1971 to 2001, the trend is for the average temperature to increase continuously. As for precipitation, although the occurrence of heavy rainfall and the variability of rainfall are large, the annual rainfall is clearly on a downward trend nationwide.



Source: based on Ngongondo et al. (2015)



Source: Based on Ngongondo et al. (2015)

Figure 3-171 Trend of annual average temperature（1971-2001）and annual precipitation change (1960-2009）

Source: The Third National Communication, 2021

The future projections of temperature and precipitation are shown in Table 3-132. In all regions, the temperature is projected to increase, with a maximum increase of 4.2°C by the end of the 21st century and an overall increase of 1.3°C to 2.6°C. Other trends predicted include a) minimum temperatures rising faster than maximum temperatures, b) slightly lower rainfall from October to December, with an increase from January to March, and c) El Niño may cause of increasing extremes, resulting in increased magnitude, intensity, and frequency of floods, droughts, and strong winds.

Table 3-140 Future projection of temperature and precipitation

Location	**Near Century Period: 2011-2040.**	**Mid Century Period: 2041-2070.**	**End Century Period: 2071-2100.**
Lower Shire Valley	0.03°C-0.04°C: temperature increase.	1.4°C-2.8°C: temperature increase.	2.5°C-4.2°C: temperature increase.
Shire Highlands	0.034°C: temperature increase (Jun-Dec).	1.0°C: temperature increase.	1.5°C-2.4°C: temperature increase.
Central Areas	0.7°C-0.9°C: temperature increase.	1.3°C: temperature increase.	Temperature increase.
Lakeshore Areas	0.8°C-0.9°C: temperature increase.	1.5°C-2.0°C: temperature increase.	2.5°C-3.0°C: temperature increase.
Northern Areas	0.2C-0.9°C: temperature increase.	1.4°C-1.9°C: temperature increase.	1.7°C-2.3°C: temperature increase.
Location	**Near Century Period: 2011-2040.**	**Mid Century Period: 2041-2070.**	**End Century Period: 2071-2100.**
Lower Shire Valley	800 mm – 1000 mm: mean rainfall.	January rainfall to increase by 8% while summer will be drier by 3% to 5%.	Rainfall to decrease by about 15%.
Shire Highlands	1000 mm – 1200 mm: mean rainfall.	Winter rainfall to increase by 15% while summer rainfall will decrease by 10%	Summer rainfall to decrease by 25%.
Central Areas	800 mm -1100 mm: mean rainfall.	October to December rainfall to decrease by 10% to 22%.	October to December rainfall to decrease by 20% to 56%.
Lakeshore Areas	March to April rainfall will increase by 5% to 25%.	Winter rainfall will decrease by 65%.	There will be a general decrease in rainfall by 60%.
Northern Areas	Increase in rainfall by 3% to 8% during the period January to April.	October to December rainfall to decrease by 10% to 36%.	Rainfall to decrease by 56%.

Source: The Third National Communication, 2021

The expected impacts by the above climate change are projected as shown in the below table.

Table 3-141 Expected impacts of climate change

Sector	Impacts
Agriculture	Current: The main crop is maize, which is grown on 80% of the cultivated land. Productivity is low mainly due to land degradation, dependence on rainfed water, pests and diseases, limited irrigation, and unstable weather conditions. The majority of small-scale farmers have low agricultural technology, lack of cooperation among stakeholders (lack of knowledge and technology sharing), lack of agricultural R&D, post-harvest losses, lack of processing technology and capacity, lack of market linkages, limited financing, slow mechanization, inadequate logistics, and many other challenges. Livestock production is another important sub-sector that has been growing in scale in recent years. The impact of climate change is a concern for the livestock sector as well as the food production sector. Vulnerability: - Limited agro-processing facilities - Over-dependency on rain-fed agriculture and biomass energy - Poverty exacerbated by drought, floods, hailstorms and population pressure. - Lack of insurance schemes to compensate farmers in the event that a climate induced shock strikes compounds the situation further as assets and livelihoods are destroyed by these events living them with nothing to rely on. - Inadequate hazard maps. Inadequate crop diversification.
Water	Surface water and groundwater are abundant, rivers (such as the Sile, Luo, Linsipe, Bua, Dwanga, Lukulu, Songwe, Luhu, and Kiwira) and lakes (such as Lake Malawi, Lake Chilwa, and Lake Chiuta) are the main water sources. River water is mainly derived from rainfall and is abundant during the rainy season. On the other hand, floods are frequent. In addition, many river basins are under severe pressure from deforestation, unsustainable agriculture, housing, mining, industry, commerce, tourism, and climate change. Previous studies have also shown that the country is vulnerable to floods, droughts, and strong winds (especially those associated with tropical cyclones) In 2015, more than 15 districts experienced severe flooding. These floods were caused by record-breaking heavy rainfall (record-breaking rainfall in the first two weeks of rainfall), with flooding occurring in areas such as Songwe, Rufilia, Lingfasa/Lweya, Likangala/Tondwe, and Sile/Luo. The country has established a flood warning system that includes MAIWD and DCCMS, DCPCs and ACPCs in rural areas, and even NGOs. In some areas, automatic flood warning systems are in place, but manual flood warning systems are common and inadequate.
Forestry	It has been pointed out that the distribution of vegetation and animal habitats may change and become extinct. While 90% of the original forest vegetation has already been lost, the impact of climate change and other anthropogenic factors on biodiversity is expected to be greater than before. In particular, deforestation for the procurement of firewood as a fuel source is a major problem. The impact of climate change on natural ecosystems, especially in the highlands, coupled with this anthropogenic deforestation, is causing soil erosion and loss. There are concerns that changes in rainfall and temperature will alter the optimal growing season for crops, resulting in increased crop failures and insufficient water supply for agriculture.。
Health	Diarrhea, malaria, and malnutrition are considered as possible indicators of health hazards due to climate change. Studies are conducted by Ministry of Health and Department of Climate change and Metrological service on the relationship between these events and seasonal variations, and there is concern that the occurrence of these health hazards will increase with climate change.

Sector	Impacts
Energy	While the poor quality of electricity supply is an issue, there are concerns about environmental degradation due to climate change (adverse effects on power generation facilities due to high levels of water weeds and sludge in lake and river water) and reduced hydropower generation capacity due to insufficient water supply (hindrance to stable electricity supply from the Shire River). Decreased rainfall will cause a reduction in the power generation capacity of run-of-river small hydroelectric power plants. If there is a disruption in the supply of fuel (oil, etc.) from outside the country due to climate change, there is a possibility of a serious energy supply shortage.
Transport infrastructure	There are concerns about the risk of damage to port facilities due to increasing of severe storms and water level of the lake, and the impact on infrastructure such as roads, bridges, railroads, and air networks. There are also concerns about the impact of increased transportation costs due to drought and changes in water availability, as well as disruptions to service operations and supply chains.
Fishery	There are concerns that increased evapotranspiration, low water levels, and reduced inflows due to higher temperatures and shorter rainy seasons will lower the water levels of water bodies and adversely affect the use of water bodies and the productivity of fisheries and aquaculture in various ways. Outbreaks of water-borne diseases, severe droughts affecting fisheries and aquaculture, and floods, flash floods, and landslides caused by heavy rains are also feared to have adverse effects on fisheries by destroying aquaculture ponds, houses, and infrastructure necessary for sustainable fisheries and agricultural production.
Tourism	There are concerns about negative impacts on tourism such as changes in the best season for tourism due to changes in temperature and precipitation patterns (prolonged drought in the middle of the rainy season), procurement of food for tourists, disruption or damage to roads and other infrastructure, and increased operating costs (introduction of in-house power generators, etc.).

Source: The Third National Communication, 2021

(2) Policies and Strategies for Climate Change

1) National level

In Malawi, the Malawi Growth Development Strategy III (MDGS III) for a period of five years from 2017 to 2022 has been carried as as base of national development under a medium-term framework for national development called The Malawi Growth Development Strategy (MDGS). Climate change issues are being addressed under agriculture, water development, and climate change management among the five major priority areas of MDGS III. It aims to improve meteorological and climate monitoring systems for early warning and timely response, develop policy and operational environment for strengthening climate change and meteorological services, make communities resilient to the impacts of climate change, and strengthen climate change research and technology development.

The National Climate Change Management Policy (NCCMP) was formulated in 2016 and is supposed to integrate climate change into national development planning and implementation. The NCCMP includes climate change adaptation; climate change mitigation; capacity building, education, training and awareness raising; research and technology development and transfer; and systematic observation, climate change financing, and addressing cross-cutting issues such as AIDS and gender. In addition, National Adaptation Plan Framework (NAP) was developed in 2020. This NAP Framework presents the principles, approaches, priority areas, priority sectors and themes, and components of NAP implementation for the NAP process in Malawi. The activities prioritized in the NAP framework are: a) addressing capacity gaps and weaknesses in the implementation phase of the NAP process; b) analyzing current climate and future climate change scenarios; c) assessing vulnerability to climate change and identifying sectoral, regional and national adaptation measures; d) integrating climate change adaptation into national and local and sectoral development plans, e) developing a long-term national adaptation implementation strategy, and f) managing progress and evaluating effectiveness through periodic reviews of the NAP process. The status of the formulation of national climate change related policies and measures is as follows.

Table 3-142 Policies and strategies of climate change

Name of policies, strategy (published year)	Outline
Vison 2020 (2003)	The vision Provides a framework for national development goals, policies, and strategies. It emphasizes sustainable development, GHG monitoring, promotion of anti-ozone measures, and public awareness on climate change issues. The Vision 2063 in line with the 2030 Agenda and the African Union (AU) Agenda 2063 is under developing.
First National Communication (NC1) (2003)	Submissions to the UNFCCC. Periodic reports on national climate change status, GHG emissions, mitigation and adaptation policies and implementation plans and status.
National Strategy for Sustainable Development (2004)	Strategy for implementation of activities and programs related to the UNFCCC. Utilization of satellite data, awareness and dissemination of climate change issues, various studies on climate change including NC3, etc. are included.
Second National Communication (NC2) (2012)	Submissions to the UNFCCC. Periodic reports on national climate change status, GHG emissions, mitigation and adaptation policies and implementation plans and status.
National Resilience Strategy 2018-2030 (2018)	National Resilience Strategy developed in 2018. It presents the initiation of a transition to protective and productive investments targeting food insecure and poor households, strengthening institutional enforcement and multi-sectoral planning and implementation. It has four pillars: agricultural resilience; catchment protection and management; risk reduction, flood management, early warning and response; and protection of human and social assets.
Intended Nationally Determined Contributions (2015)	Submission to the UNFCCC on pledges for actions on adaptation and mitigation to be undertaken between 2015 and 2040. It advocates adaptation measures related to afforestation and reforestation, as well as the development of drought-tolerant crop varieties, irrigated agriculture, and aquaculture.
Third National Communication (NC3) (2021)	Submissions to the UNFCCC. Periodic reports on national climate change status, GHG emissions, mitigation and adaptation policies and implementation plans and status.
Updated Nationally Determined Contribution (2021)	Submissions to the UNFCCC as updated of the INDC. Concrete strategies for Malawi's climate change priorities for the period

Name of policies, strategy (published year)	Outline
	2020-2040, with an annex to facilitate implementation, mainstreaming, monitoring and reporting in order to accurately track progress in NDC implementation and financing. A government vision aimed at establishing a solid foundation for a sustainable and prosperous Malawi in line with Malawi Vision 2063.

Source: The Third National Communication, 2021

Planned climate change adaptation were indicated in the updated of the NDC. Prioritization of adaptation measures, sector-level performance indicators and targets have been developed, and ten strategic adaptation measures related to (i) institutional framework, (ii) knowledge, technology and finance, and (iii) improving resilience to the most vulnerable have been identified.

Table 3-143 Strategic climate change adaptation

Objective	Pillar	Strategic Adaptation Actions	Adaptation actions
Promote enabling environment to facilitate CCA mainstreaming	Institutional framework	Establishment of the institutional arrangements for the multi-sector coordination of climate change actions, including the definition of its composition and mandate.	NAP's mandate
		Testing and institutionalization of mechanisms to integrate CCA into the next "National Development Plan" or equivalent and sectoral planning instruments, including the annual sectoral budgets and guidelines	NAP's implementation Definition of guidelines to integrate CCA into sectoral planning and budgeting
Improve the capacity for data and information management and sharing, and access to technology and financing for adaptation	Knowledge, technology and financing	Development and implementation of a research programme on climate change impacts and CCA actions	Research programme on climate resilient technologies, including industry and drought tolerant and fast-growing vegetal species
		Implementation of a capacity building plan and integration of CCA into curricula	CB at national and district levels to use the guidelines CB on EWS and data downscaling CB on Wash interventions CB on wildlife and tourism management CB on aquaculture and cage farming CB on diagnose, prevention and control of climate-sensitive diseases and malnutrition Integration of forestry, livelihoods and environmental management in curricula
		Implementation of the communication plan	Public campaigns on water conservation measures Campaigns on hygiene and sanitation

Objective	Pillar	Strategic Adaptation Actions	Adaptation actions
		Operationalization of an overarching M&E framework covering the NDC and potentially the NAP, SDGs and Sendai Framework	Elaboration of recommendations for climate M&E in the scope of the NDC
		Elaboration and implementation of a resource mobilization plan	Preliminary estimates of costing of the actions and measures included in the NDC
Plan and implement adaptation actions toward an increased resilience of the most vulnerable Malawians	Resilience of the most vulnerable	Elaboration of NAPs for priority sectors	Elaboration of NAPs for agriculture, biodiversity and ecosystems, fisheries, health, infrastructures and housing, tourism and water resources
		Development of CCA planning tools tested in particularly vulnerable communities, demonstrating an integrating CCA approach in various sector	Development of simplified methodologies as a basis to assess risks and identify community-based adaptation options and measures to include in local CCA plans and budgets Design of local EWS
		Elaboration of a portfolio of CCA priority actions for the key sectors aligned with sectoral planning and budgeting, using nature-based solutions and ecosystems-based adaptation	Effective and efficient EWS Accessible and harmless water Blooming biodiversity and ecosystems and eco-tourism Smart agriculture, livestock and fisheries Climate-proofed infrastructures, buildings, and energy systems Healthy and protected people

Source: 2021 Updated NDC

2） Regional level

As a response to climate change adaptation at the local level, there is one case where a climate change adaptation strategy was implemented in Elephant Marsh, located on the floodplain of the lower Silé River between Chikwawa and Kailomo in southern Malawi, as shown below. The area depends for its water resources on Lake Malawi, the adjacent sub-basin, the Luo River, and the water resources of the upper Silé River basin[62].

[62] Report of climate resilient livelihoods and sustainable natural resources management in the Elephant Marshes, Malawi, prepared by MRAG Ltd in Association with Southern Water, Anchor Environmental and Streamflow Solutions

Table 3-144 Climate adaptation strategies of Elephant March

Examples of climate adaptation strategies identified as important across the whole Elephant Marsh and additional sub-area specific strategies.

Elephant Marsh Sub-area	Strategies identified as sub-area priorities
Whole Marsh	Agricultural support and technology experimentation including access to improved seeds, introducing some diversity to crops and intercropping long season pigeonpea. Studies should explore drivers of agricultural production (e.g. subsidies that incentivise monocropping). Reducing wildlife interactions, in particular crocodile attacks and hippos destroying crops.
Northern	Drought resistant crops, Improving sanitation and access to water
Western	Managing livestock. Improving access to water. Improving sanitation and access to water
Eastern	Managing water and erosion
Central	Priority for the area is to enhance protection and reduce access. On the basis of the scenario assessment this is likely to have the greatest benefit for the Elephant Marsh biodiversity in the face of identified climate and development change.
Southern	Improving communication links Supporting BVC management of local fisheries. Studies should assess changes in fish species abundance.

Source: https://rsis.ramsar.org/RISapp/files/35551875/documents/MW2308_mgt170608.pdf

(3) Supports from Other Donors

In Malawi, several international organizations and national donors have been providing various types of support for climate change-related policy making and project formulation. In particular, the UN-led NAP-GSP (Environment National Adaptation Plan Global Support Programme) has provided support in a wide range of areas.

Table 3-145 Support from donors (As of 2021)

Programme/project	Period	Funding source	Geographic coverage
Agriculture Sector Wide Approach (ASWAPsp II)	2017-2020	Multi Donor Trust Fund	12 districts
Agriculture Sector Wide Approach (ASWAPsp I)	2010-2014	Multi Donor Trust Fund	12 districts
Sustainable Agriculture Productivity Programme (SAPP)	2012-2021	IFAD	6 districts
Malawi Drought Recovery and Resilience Project	2017-2021	World Bank	28 districts
Malawi Floods Emergency Recovery	2015-2018	World Bank	15 districts
Programme for Rural Irrigation Development –PRIDE	2017-2023	IFAD	8 districts
Shire Valley Irrigation Project (SVIP)	2013-2018	under the Green Belt Initiative	7 districts
Shire Valley Transformation Programme (SVTP) -in 3 phases	2018-2031	World Bank, AfDB & GEF	2 districts
Shire River Basin Management Programme	2012-2027	IDA (World Bank), GEF & Least Developed Countries Fund (LDCF)	Along Shire River Basin
Fertiliser Input Subsidy Programme (FISP)	annually from 2005 to-date	Malawi Government & Donors	28 districts
Small Stock Development Programme	2012-2020	Malawi Government	28 districts
Agriculture Infrastructure and Youth in Agribusiness Project	2016-2021	AfDB	2 districts

Source: The Third National Communication, 2021

3.3.3 National and Urban Development

(1) National Axis and Strategic Cities

The largest city in Malawi is Lilongwe, the capital city in the central part, with a population of about 647,000 (2022, World Population Review). Prior to independence, Lilongwe was nothing more than a provincial city, but after being relocated from Zomba in the south in 1975, its population grew rapidly, surpassing Blantyre in the mid-2000s to become the largest city in the country. It has a strong character as a political center while the industrial activity is scarce. This was followed by Blantyre in the south, with a population of 585,000 (2022, ditto). It is the center of Malawi's economy, and is thriving in commerce and is also home to industries such as food and brewing.

The above two cities are prominent in the urban population, while other cities are much smaller. The third largest city, Mzuzu, is in the center of the north, but with a population of 175,000 (2022, ditto). Zomba is the fourth largest city, located on the southern plateau which is known with good landscapes and climate. Because of this, it was made the capital during the British colonial era and continued until 1975. The population of Zomba in 2008 was 90,000, with the headquarters of the University of Malawi, which makes the city characterized as a cultural city.

The urban population is only 15.3%, but the national population is expected to increase from 2.2 million in 2015 to 6.3 million in 2040. Accordingly, urban population of the above mentioned four cities, i.e.) Blantyre, Lilongwe, Mzuzu and Zomba, will accommodate increased urban population accompanying from the national population growth.

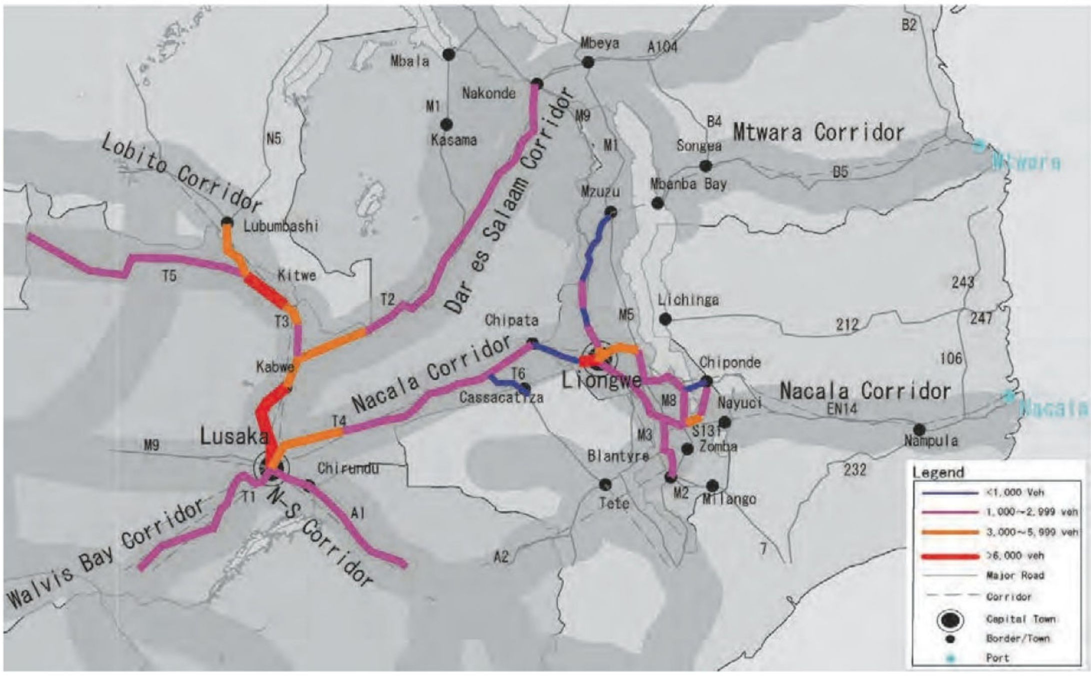


Figure 3-172 Distribution of Major Facilities and Human Settlements

Source: Seychelles Strategic and Land Use Plan 2040

(2) Cross-border Infrastructure

Malawi is a landlocked country bordering Tanzania on the north side, Zambia on the west side, Mozambique on the south and east sides, and part of the west side. For this reason, access to the seaports required for international trade is only possible by land transportation. Major ports that provide access to shipping include Nacala and Beira in Mozambique, Durban in South Africa and Dar es Salaam in Tanzania.

Currently, Malawi mainly uses the Senna Corridor, which is easily accessible by car and has a shorter distance to the port than other corridors. The road conditions in the Nacala Corridor are poor in Mozambique, and the railway operations between Mchinji and Nkaya has poor infrastructure related to freight facilities such as warehouses. However, thanks to the railroad refurbishment from Nkaya to the port of Nacala, Malawi transportation companies have recently begun to use the Nacala Corridor. If the railway renovation between Mchinji and Nkaya is completed, it is expected that more carriers will use the Nacala Corridor.

(3) Location of Important Industries

Malawi's main industry is agriculture, with 80% of the population (2019) engaged in the primary industry. Most of the arable land is used by smallholders for agricultural production in rainwater. According to the Food and Agriculture Organization of the United Nations (FAO) (2014), the land use ratio is 60% (about 5.9 million ha) for agricultural land, 34% (1.7 million ha) for forestry, and 6% (400,000 ha) for other uses. Regeneration of natural resources (land, soil, water, natural fish, forests, wildlife) has been hampered by continued population growth of over 3%. Most of the cultivable land has already been used as agricultural land, and since it is subdivided during inheritance, the land area that can be used by small-scale farmers' households is decreasing.

Corn is widely cultivated throughout the country as the main crop, but can be categorized as as a self-sufficient crop. The most promising commercial crops are leaf tobacco (55.6% of total exports, 2019), sugar (7.17%), tea (7.95%), and peanuts (3.1%). To avoid excessive reliance on tobacco exports, commercial crops are being diversified and several small export crops such as macadamia nuts are being developed.

As another primary industry, the fishery industry is more important as a country for both the purpose of self-consumption and income improvement.

Malawi is not blessed with mining resources, only limestone and a small amount of coal are mined. The uranium discovered in the north in 2009 was developed and grew to account for 11.3% of total exports in 2013, but was closed in 2014 due to sluggish prices.

(4) Key Cities in Terms of Urban Development

According to Malawi's Vision MALAWI 2063 (2020), Malawi is to become an industrialized upper-middle-income country that is "comprehensively wealthy and self-reliant" by 2063.

The year 2063 marks the 100th anniversary of Malawi's independence, and the country aims to shift from “dependence” to “wealth creation” and “self-reliance”. The goal is to promote a pathway that enables the poor to create wealth to end poverty.

In this direction, three pillars have been raised.

Table 3-146 The three pillars in Malawi's Vision

Pillar	Content
i.) Highly productive agriculture and commercialization	Produce and supply raw materials for industrial processing and healthy, nutritious food. The growth of agro-based industries associated with job creation will help ensure that urban centers are economically productive. Urban centers, including cities in tourism hubs, serve as consumers of agricultural products. Such a structure will create a competitive agricultural value chain and ensure an increase in the number of young people engaged in agriculture.
ii.) Industrialization	This will be achieved by increasing investment in establishing traditional and non-traditional manufacturing, innovation, mining and other services. Manufacturing is essential to building a resilient, integrated, independent, and self-sufficient economy. Thus, industrial growth generates a lot of employment, income, and opportunities. Above all, the growth of the industry implies the availability of ready markets for agricultural products and thus the commercialization of agriculture is enhanced. At this point, the wage rate in the city will begin to rise.
iii.) Urbanization	Provide competent opportunities to accelerate socioeconomic transformation. The country needs smart, well-planned and serviced secondary cities rooted in sustainable economic activities in agriculture, tourism, mining and industry. Urbanization follows an integrated approach that includes spatial, economic, social, and environmental considerations.

Source: Prepared by JICA Study Team based on Malawi's Vision MALAWI2063 (2020).

As for the third pillar, urbanization, it emphasizes the collaboration between agriculture and cities, and says that tourism destinations that take advantage of Malawi's nature and culture will be developed as hub cities, supporting the commercialization of agriculture through tourists' consumption in cities, leading to the creation of comprehensive wealth and the promotion of self-reliance. In addition, it cites the development of strategies to promote urban development using the transformation of the agricultural sector that contributes to the creation of wealth.

Current problems in Malawi's cities include increasing rural-urban migration, characterized by the fact that many of the migrants are young, unskilled and economically poor. Further, urban planning is inadequate, and infrastructure and social services such as water supply, electricity supply, waste management, education, health, and transportation are not keeping pace with urban population growth.

The Malawi Growth and Development Strategy (MGDS) III was developed as a follow-up strategy to MGDS II (2011-2016) for a period of five years. The five priority areas under this strategy are as follows

i. Agriculture, water development and climate change management

ii. Education and capacity building

iii. Transportation and ICT infrastructure

iv. Electric power, industrial and tourism development

v. Health and residents

In addition, disaster is positioned as one of the other development areas, as disaster risk management and social support. The strategy states that in Malawi, disasters have increased in intensity and frequency in recent years due to climate change, population growth, urbanization and environmental degradation, and that disasters impede socio-economic growth and development, undermine the capacity for state investment in key sectors, and exacerbate poverty among rural and urban populations. It states that, for this reason, it is important to recognize and address different risks and different levels of damage and loss to the socio-economic development of a country. It is further mentioned that the National Disaster Risk Management Policy (DRM Policy) and a DRM Law are currently being finalized (as of 2017). However, DRR measures for specific areas are difficult to implement because hazard and vulnerability is not yet well defined, and DRR has not been mainstreamed in each sector because its relevance to disaster risk is not understood in most sectors. Therefore, the need to conduct comprehensive disaster risk assessments at all levels and disseminate the results to reflect them in development planning is emphasized. This indicates that Malawi's efforts in disaster risk reduction are just beginning.

As key cities in the above vision and strategy, the Lake Malawi area and national parks are mentioned as candidates, although no specific place names are given. In addition, as mentioned earlier, Malawi is a landlocked country, so cities that serve as nodal points for corridors connecting to other countries are highly important. In addition, considering the balance of the country's location and the distance to Lake Malawi, Mzuzu is also a region with potential.

(5) Urban Development System

1) Land system

Land tenure in Malawi can be divided into three categories: public land managed by the government, private land guaranteed to be owned by a British monarch during the colonial era, and customary land managed by local village heads and traditional chiefs. Traditional Land Act does not guarantee individual land ownership. Most of the land used by smallholders is customary land, and farmers traditionally occupy or have the right to use it do not own it. As this discouraged small-scale farmers from investing, the land law was revised in 2016. Traditional customary land was abolished, and individual small-scale farmers, Malawi people including corporations can own the land as a private estate took land as Customary estate by registration.

2） Urban planning

The Town and Country Planning Act of Malawi was enacted in 1948 and then significantly revised in 1988. It stipulates the planning authorities, type of plans (the National Physical Development Plan, District Physical Development Plans, Local Physical Development Plans), development management and execution, special areas (the Land Development Control Area Order, the Improvement Area Order, the Vacant Land Development Order, the Building Preservation Order, the Accelerated Development Area Order, Subdivision Control Area Orders), development by the government sector, land acquisition and compensation, etc. Compared to the old law, the physical plan is a country, region, district by introducing the three layers of the plans, the urban planning system became more comprehensive compared with the old law. At the same time, the minister can be authorized to develop and control non-statutory planning areas by issuing an order.

At the occasion of the revision of the Land Law, the Town and Country Planning Act was revised together with the following acts to secure conformity and renamed to the Physical Planning Act 2016.

- Land Survey Act 2016
- Customary Land Act 2016
- The Registered Land (Amendment) Act 2016
- Public Roads (Amendment) Act 2016
- Forestry (Amendment) Act 2016
- Land Acquisition (Amendment) Act 2016

Around 68% of Malawi's urban space is occupied by urban poor, and informal settlements continue to expand. Informal settlements are vulnerable to floods, road accidents, fires, plagues, etc., which are prominent urban disasters in Malawi. The urban planning system has been criticized for " city and focuses on creating an orderly space, while ignoring the poor."

3.3.4 Disaster Management Plan and Implementation Structure

(1) Legal Framework and Planning for Disaster Management

Malawi's Disaster Preparedness and Relief Act (1991), enacted in response to the floods of that time, provides for the establishment of a government agency in charge of disaster management, a framework for disaster management policy, a process for the President to issue emergency disaster management measures and respond to them, the establishment of a disaster management fund, and the establishment of disaster management response systems at the local and community levels. Based on the Disaster Preparedness and Relief Act, the National Disaster Risk Management Policy (NDRMP, 2015) has been formulated under the leadership of the Department of Disaster Management Affairs (DoDMA). The National Disaster Risk Management Policy aims at mainstreaming disaster prevention and mitigation into various levels and sectoral plans and strengthening disaster response capacity and includes coordination of relevant agencies to achieve strategic and comprehensive national resilience. In the short term, a National Contingency Plan has been developed and is updated annually. The National Resilience Strategy 2018-2030 also provides measures to realize the goals of the National Disaster Risk Management Policy. For example, with regard to flood countermeasures, the report includes policies to analyze flood risks and promote the development of disaster prevention infrastructure in areas where the need for countermeasures is high. These frameworks have been considered in the light of the Kyoto Protocol (1997), African Strategies for Disaster Risk Reduction (2004), Hyogo Framework for Action (2005) and Sendai Framework for Disaster Risk Reduction (2015).

However, in order to promote these policies and strategies, there are many issues that have not yet been realized based on the status of implementation of various measures by the relevant organizations, and it seems that there are issues such as financial constraints. In addition, the DoDMA is supposed to play the role of coordination for the promotion of disaster management policies. The budgets required for the implementation of disaster management policies should be comprehensively coordinated and allocated by relevant government agencies, cities and municipalities, etc. However, in reality, due to budgetary constraints, appropriate coordination is not in place and support from international donors, etc. is often required to promote specific disaster management efforts in Malawi.

In addition, a Disaster Risk Financing Strategy and Implementation Plan (DRFS), 2019-2024, has been developed in light of Malawi's recent experience with serious disasters and the financial challenges it has faced. This is a strategy to strengthen public finances in preparation for disasters. It aims to ensure that disaster management budgets are allocated appropriately and efficiently to the implementation of necessary disaster management measures and beneficiaries based on disaster risks.

In Malawi, it was noted from the interviews with DoDMA (that there is a wide variation in response capacity among local governments at the local government level, but disaster management planning at the district level is underway in some areas. In some districts of the Southern Region of the country, where the risk of flooding is relatively high, disaster reduction plans are being formulated in cooperation with NGOs and donor support projects. In order to promote disaster prevention and mitigation measures in major cities undergoing urban development, disaster risk reduction plans have been formulated in Lilongwe, Blantyre and Mzuzu. According to DoDMA, hazard maps have not been prepared at this time, but will be prepared by the end of 2022 with the cooperation of the World Bank.

(2) Implementation Structure of Disaster Risk Reduction and Management

Malawi's national disaster management system is stipulated in the National Disaster Risk Management Policy, with DoDMA assuming the coordinating function and coordinating the activities of the National Disaster Preparedness and Relief Committee, the National Disaster Risk Management Technical Committee, cross-sectoral Technical Sub-Committees, NGOs, and international donors. At the district level, there is the District Civil Protection Committee, under which is the Area Civil Protection Committee, and under which is the Village Civil Protection Committee. DoDMA oversees and coordinates the entire disaster management system from the national level to the local level. Regarding the staffing structure of DoDMA, there are 20 staff members

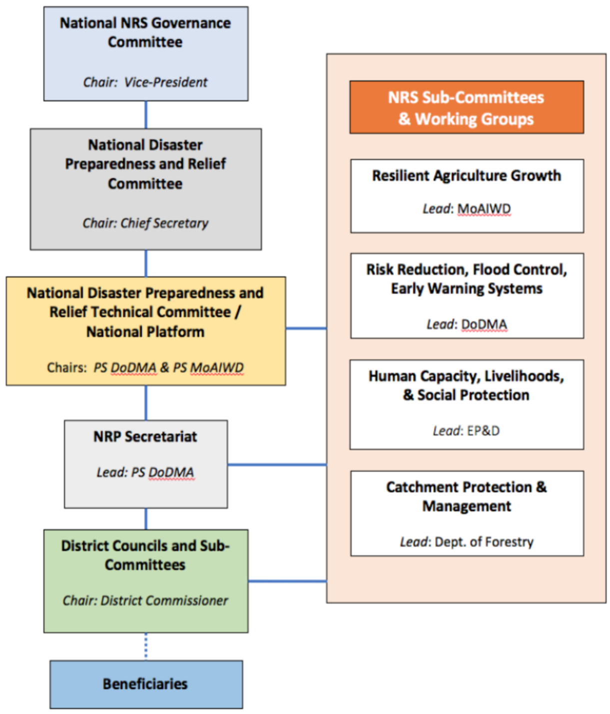


Figure 3-173 Promotion structure of the National Resilience Strategy
Source: Malawi National Resilience Strategy 2018-2030

at the national level, with one staff member in charge in each of the 28 districts.

It also coordinates and responds to the activities of the District Disaster Management Committee and other committees at the district level.

For disaster risk reduction mainstreaming and more resilience, the National Resilience Strategy (2018-2023) describes the framework and approach for coordination, and as shown in the figure, four sectoral working groups have been established, and the policy is to promote efforts for resilience and disaster mitigation in cooperation with DoDMA and related ministries and agencies. However, there is little clarity on how to specifically mainstream disaster risk analysis and related agencies into their efforts, and how to promote disaster risk reduction measures at the city and municipal levels. Understanding and implementing disaster risk assessment, as well as human resource development and organizational strengthening on the part of the government to manage consultants and others, are considered to be important issues at the national and local levels. The results of interviews with DoDMA also indicate that strengthening the capacity of human resources and organizations is an issue. In addition, there are no special budgetary measures for the development of disaster prevention infrastructure.

3.3.5 Trends in Donor Support

(1) Overview of Donor Support

According to the Ministry of Foreign Affairs of Japan's International Cooperation Bureau's Official Development Assistance (ODA) Country Data Collection, totals for 2000-2017, donor aid to Malawi is dominated by the World Bank Group's International Development Association (IDA) and European Union (EU) institutions such as the European Commission and the European Investment Bank. By major donors, the U.S. and the U.K. provide the largest parts of the aid.

Table 3-147 Top five donor economic cooperation achievements (in millions of dollars)

Achievements in economic cooperation with international organizations		**Economic cooperation performance of major donors**	
IDA	2,119.4	U.S.	2,604.6
EU Institutions	1,635.2	The United Kingdom	2,245.1
GFATM	984.05	Norway	926.7
AfDF	672.8	Germany	592.1
IMF-CTF	336.4	Japan	573.8

Source: Compiled by the research team from Official Development Assistance Country Data Collection (2000-2017), International Cooperation Bureau, Ministry of Foreign Affairs of Japan

Malawi's National Strategy MGDS III, developed by the government, runs through 2022 and focuses on education, energy, agriculture, health, and tourism. In addition, “Malawi's Vision MALAWI 2063” has been announced to transform Malawi into an independent upper-middle income country by 2021. However, despite significant economic and structural reforms to sustain economic growth, the country remains one of the poorest in the world.

Globally, Malawi ranks among the countries most vulnerable to climate change, with low coping capacity and high risk. The changes experienced through climate change, including increased frequency and intensity of phenomena such as floods, droughts, and dry spells, and outbreaks of pests and diseases, present Malawi with a wide range of challenges. Particularly floods and droughts, which are the main causes of chronic food insecurity, impacts the sustainability of water security, water quality, energy resources, and rural livelihoods. Especially the agricultural sector remains highly vulnerable to weather-related disasters because more than 90% of agricultural production is dependent on rainwater, even though it is the main industry supporting the country's economy, employs more than 80% of the labor force, and accounts for 90% of export earnings.

According to the table of focused sectors of development partners shown in the COUNTRY STRATEGY PAPER (CSP) 2018-2022 of the African Development Bank, it can be seen that the majority of support by sector goes to health, agriculture, water, sanitation, and irrigation. It can be seen that chairs and co-chairs are also assigned by sector. In the working group on disaster management, WB is the chair and DFID and Ireland are co-chairs, with USAID, Norway, Germany, UN agencies, and Flanders as cooperating donors.

Table 3-148 Policy consultation and aid coordination by development cooperation partners

Development partners	Agriculture	Integrated Rural Development	Environment, Land and Natural Resources	Tourism, Wildlife	Water, Sanitation & Irrigation	Trade, Industry, & Private Sector Development	Disaster and Risk Management	Health	Education	Gender, Youth and Sports	Roads, Public Works & Transport	ICT & Research and Development	Energy & Mining	Economic Governance	Democratic Governance	Public Administration	Total
WB	A	A	A	A	A	L	L	A	A		A	A	L	A			13
AFDB	A		A		A	A			L		L	A	A	A			9
EU	A	AC			A	A			FA		AC		A	A	A		9
OPEC Fund	A	A			A	A		A	A		A		A				8
DFID	A	A	A		A	A	AC	AC	A	A	A		A	A	A	A	14
USAID	L	A	A		A	A	A	L	AC					A	A	A	11
JICA	A	A	A		A	A		AC	AC		A		A	FA			10
Ireland	A	A	A		A		AC	AC						A	A	A	9
Norway	A		A	A			A	A		A				A	A		8
China	A									A	FA	FA	FA				5
Germany							A	A	A					A			4
UN Agencies	A	A	A		A	A	A	A	A	A		A	A	A	A	A	14
AusAID					A												1
CDC								A									1
Global Fund								A									1
Netherlands								A									1
Abu Dhabi											A						1
Kuwait Fund											A						1
Flanders	A						A										2
Saudi Fund								A			A						2
ICEIDA					A			AC	AC								3
India					A	A							A				3
BADEA	A				A						A						3
Total	13	8	8	2	13	9	8	14	10	4	11	4	9	10	6	4	

Note: A = active, L = lead, AC = assigned co-chair, and FA = future active engagement.

Source: AfDB COUNTRY STRATEGY PAPER (CSP) 2018-2022

(2) Trends in Aid from World Bank (WB)

The COUNTRY PARTNERSHIP FRAMEWORK (CPF) 2021-2025, which sets out the WB's aid policy, identifies three themes: "Promoting Sustainable, Diversified and Inclusive Growth", "Strengthening Human Capital and Reducing Vulnerability", and "Digital development" and "women's empowerment" are positioned as crosscutting themes. Most recently, the program has provided assistance for the health and economic impact of the domestic economic downturn caused by the COVID-19 pandemic.

WB has provided support to the disaster management sector in the past through post-disaster recovery response, but after Cyclone Idai in 2019, WB plans to shift its focus from post-disaster response to proactive disaster management. So far, capacity-building assistance has been provided to the Government of Malawi, including "strengthening institutional and financial capacity for disaster and climate risk management" and "strengthening the capacity to prepare a national investment plan for climate change action. In particular, the Malawi Disaster Risk Management (DRM) Development Policy Finance (DPF) project is working to strengthen the institutional and financial capacity of the Government of Malawi for multi-sectoral disaster and climate risk management. The program consists of three pillars: (i) strengthening the institutional framework and coordination mechanisms for implementing national disaster and climate change adaptation measures; (ii) improving climate change and disaster resilience in physical development and infrastructure; and (iii) strengthening government financial capacity for adaptive social protection mechanisms and disaster response. It is financed by GFDRR and the European Union within the framework of the "Africa, Caribbean, Pacific and European Union Natural Disaster Risk Reduction Program" managed by GFDRR. Specific projects have invested in multi-hazard risk information for national and local decision-making, hydromet services, and early warning.

The policy for future aid in the disaster sector is to "improve resilience in urban and rural hotspots" as one of the goals of private sector-led employment promotion. Specifically, the proposal is to expand efforts to enhance natural resource management, urban resilience, and disaster preparedness. It will consider larger investments in resilient urbanization by continuing the ongoing Malawi Watershed Services Improvement Project, the Malawi Resilience and Disaster Risk Management Project, and the Lilongwe Water and Sanitation Project, as well as continued investment in Malawi's early warning and disaster preparedness systems. The company will do so.

Table 3-149 List of relevant projects in the field of disaster response / disaster risk reduction

Project Name	Project Objective	Financier	Starting Year
MALAWI-Disaster Risk Management Development Policy Financing with Cat DDO	To strengthen the institutional and financial capacity of the Government of Malawi for multi-sectoral disaster and climate risk management.	IDA IDA Grant	2019
Malawi Resilience and Disaster Risk Management Project	To support the recovery of livelihoods and infrastructure in flood and drought affected areas and strengthen capacity for flood and drought risk management	IDA Grant	2016
Malawi Floods Emergency Recovery	To "sustainably restore agricultural livelihoods, reconstruct critical public infrastructure to improved standards in the flood-affected districts, and improve the Government of Malawi's disaster response and recovery capacities".	Ida Credit from Crw	2015
Malawi Emergency Recovery Loan	The Malawi Emergency Recovery Project is aimed at supporting the restoration of assets and production following the drought-induced emergency in early 2005, and thereby supporting the growth path central to the macroeconomic program adopted by the new administration since May 2004.	IDA Grant	2005
EMERGENCY DROUGHT RECOVERY PROJECT	To allow the Government to maintain key commitments to economic priorities, and investments consistent with the Poverty Reduction Strategy Paper (PRSP) process and fulfill immediate obligations to avert famine.	IDA Ida Grant for Natural Disasters	2002

Source: WB Website Projects & Operations

(3) Trends in Aid from the African Development Bank (AfDB)

The main objective of the CSP 2018-2022, which sets out the AfDB's aid policy, is to support the foundations of private sector-led growth by investing in public infrastructure to stimulate private investment, promote diversification, build economic resilience and reduce poverty and inequality. The two pillars of the plan are "Investing in Energy and Transport Infrastructure Development" and "Investing in Economic Transformation by Enhancing Agricultural Value Addition and Water Infrastructure". In the area of electric power, it positions the Songwe basin as being more resilient to climate change.

To date, AfDB's specific support has been mostly in the areas of agricultural irrigation, road maintenance, and water management, while disaster assistance has only been seen in emergency assistance for droughts and floods. However, the need to address climate change is mentioned in the CSP, and future support is expected since the AfDB has positioned mainstreaming climate change measures in the infrastructure sector as one of its challenges.

Table 3-150 List of relevant projects in the field of disaster response / disaster risk reduction

Project Name	Project Objective	Financier	Starting Year
2002 Flood Emergency Relief Aid	To prevent loss of human life and maintain the nutritional status of the population affected by the flood in the seven most-hit districts.	Special Relief Funds	2002

Source: AfDB Website Projects & Operations

3.3.6 Selection of Key Cities

Based on the overall situation of disaster risk, climate change, land development, urban development, and donor support in Malawi, this study will focus on Lilongwe and Blantyre as the key cities for disaster risk reduction and the potential of support projects at the city level.

As for the inter-city infrastructure, etc., it was decided to focus on the Sena Corridor, agriculture and irrigation related facilities, etc. The study will focus particularly on these key cities and inter-city infrastructure, but the study of potential support projects will not be limited to these, but will be conducted flexibly as appropriate based on sectoral conditions, local needs, and issues related to regional disaster risk reduction.

3.3.7 Information Collection and Analysis for Cooperation in the Field of Disaster Risk Reduction in Each Sector

(1) Urban Development and Disaster Risk Reduction

1） Lilongwe City

The disaster situation confirmed based on the field survey in Lilongwe City is shown as follows.

[Topographical features and major disasters**]**

Overall, the main rivers (Lingazi and Lilongwe) flow from west to east, with the Lingazi joining the Lilongwe near the east side of Lilongwe city center. Due to Lilongwe's rugged topography, during the rainy season, heavy rains flow down to the lowlands and eventually flow into the Lilongwe River. As a result, the water levels of the Lingazi and Lilongwe rivers have risen dramatically, and in low-lying areas, the rainwater that once flowed toward the rivers is now flowing back into the waterways, flooding the entire region. In addition, the ground has been scoured by rainwater flowing down unpaved roads, ditches, and dry valleys, causing damage to structures that have collapsed.

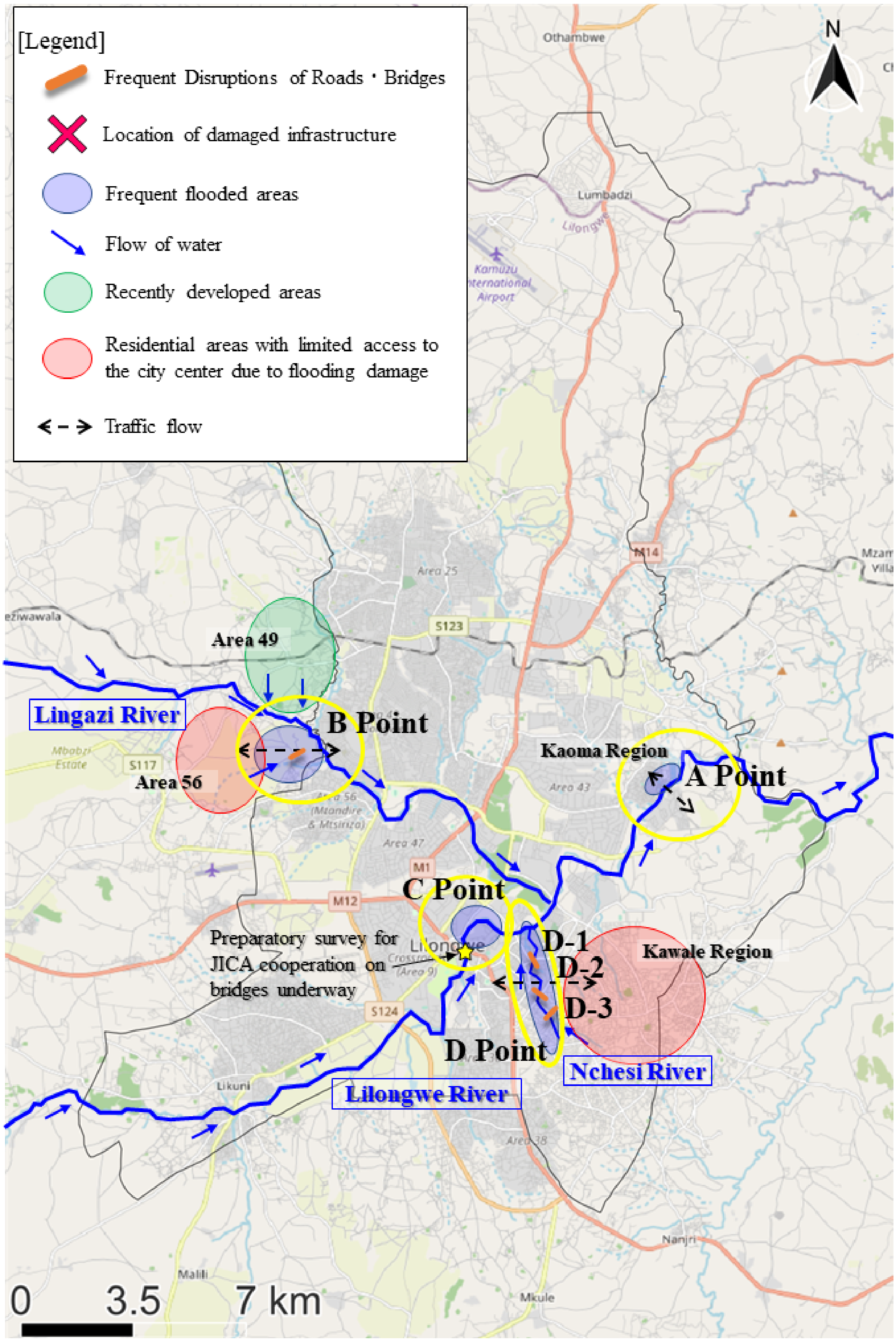


Figure 3-174 Topographical Features and Disaster Occurrence in Lilongwe

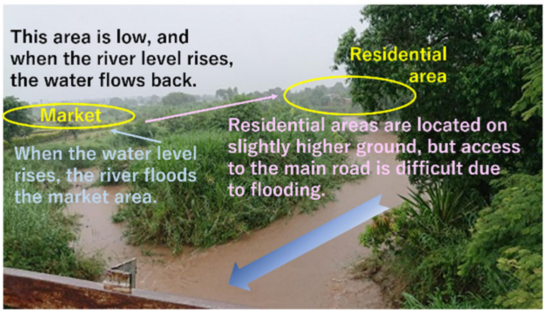
Source: Prepared by JICA Study Team

[View of Disaster Points: Points A, B, and C]

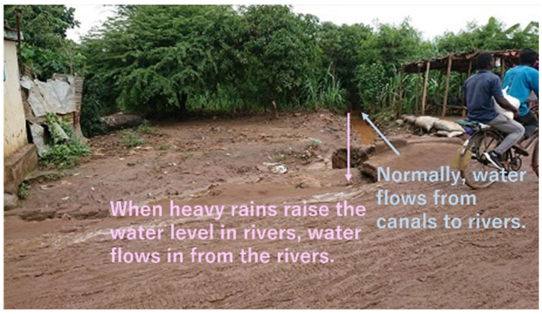
For three out of the four disaster points pointed out by Lilongwe City (points A, B, and C) in the meeting on12th February 2022, as mentioned in the preceding, rainwater flowing in over a short period of time raises the water level of the Lingazi and Lilongwe rivers, thereby causing flooding of low-lying areas around the rivers.

A: Kaoma District: Rainfall flows into the river at a rapid pace.

Rainwater flows into rivers from roadside ditches.



B: Area 56: Access from the main road will be difficult.



Market Street: flooded by about 1m every year

C: Lizulou Market: buffer zone is 10m from the river, but flooding can occur further away.

The market is located on a slope, so the upper part of the market is not flooded, but the water flows through the streets in the market like a drainage channel.

Figure 3-175 A view of the disaster points in the city listed by Lilongwe City (Part 1)

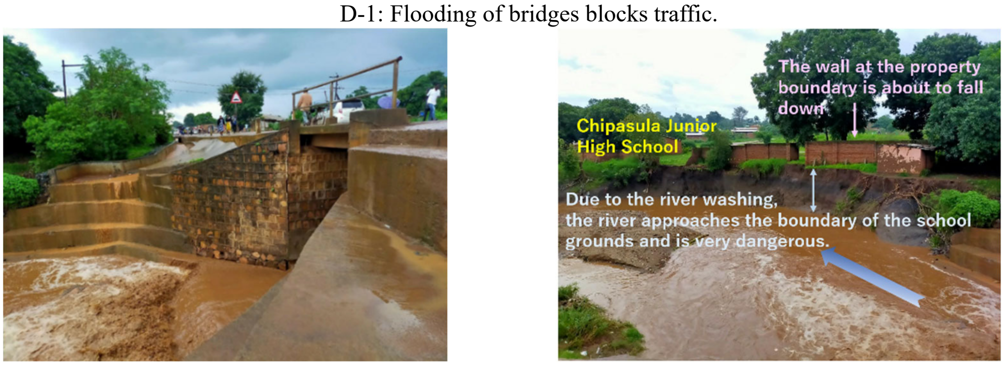
Source: JICA Study Team photos

[View of Disaster Points: Point D]

The one remaining disaster point (point D) is the three bridges over the Nchesi River; although the need for countermeasures has been recognized, these have not yet been implemented due to its small size.

- D-1: Flooding of the bridge will block traffic, and access to the Kaweah area will be limited.
- D-2: The riverbank is washed away by the river, and the river approaches the site of the junior high school.
- D-3: There is an elementary school at the bend of the river, and the flow from upstream could hit the elementary school.

D-1: Flooding of bridges blocks traffic.



D-2: Near the river at Chipasula Middle School: the schoolyard has been eroded by the river water movements

D-3: There is an elementary school at the point where the river line bends, making a dangerous situation

Figure 3-176 A view of disaster points in the city listed by Lilongwe City (Part 2)

Source: JICA Study Team photos

[Possibility of countermeasures]

Based on the field survey, the following are possible countermeasures.

< 3D hazard map creation using GIS >

Malawi is a large metropolitan area of located in a hilly region, so in order to accurately grasp the flow of water, it is effective to visualize the topography in three dimensions. In particular, it is not a sufficient countermeasure to build bridges and embankments without understanding the overall picture of where and at what speed the flow of water caused by heavy rain will pass; it is necessary to create a 3D hazard map that gives an overall picture of hazards in the city.

< Development of River Management Master Plan for Nchesi River and Bridges Replacement Project >

In the mountainous areas along the Nchesi River, housing has been developed on the surrounding slopes, and when it rains, rainwater from these areas flows into the river at once. In addition, because the riverbed slope is as steep as 1/100th, the river flow easily becomes faster due to a sudden rise in water, and riverbank erosion occurs in the meandering sections. As this situation has increased the risk of damage to critical infrastructure such as elementary and junior high schools along the river, so it is necessary to consider measures such as improvement of embankments. Also, because of flooding of bridges due to swollen rivers, there is the problem that it could cause the separation of the central Lilongwe and Kawale districts, therefore the replacement of the three bridges connecting the districts should also be considered.

< Lingazi River Management Master Plan >

The Lingazi River has a problem of rising riverbed due to sediment accumulation and flooding in the lower reaches due to rapid rise of water. Therefore, it is necessary to consider countermeasures to mitigate damage such as installing a debris control dam (sabo dam) upstream to prevent sediment from flowing downstream and to prevent a sudden rise in water levels downstream.

< Review of land use planning and guided technical cooperation project>

After clarifying the hazards using the 3D hazard map and other methods mentioned earlier, disaster prevention plans will be formulated and land use plans will be reviewed, and structural measures will be reflected in land use plans. In addition, in order to make the plan effective, it is important to not only formulate the plan, but also to consider measures to guide land use, prepare a roadmap, and it is necessary to implement a capacity building project that includes the development of an implementation plan, including a budgetary plan, and a study on the establishment of a mechanism for implementation.

2） Blantyre City

The disaster situation confirmed based on the field survey in Blantyre City is shown as follows.

[Topographical Features and Major Disasters]

Blantyre is a city located on a rugged hilly terrain. The urban areas of Blantyre and Eastern Limbe are located in the gentler part of the country, but with many hills. The Mudi and Limbe rivers that cross the city are steep rivers that flow through valleys. The gradient is about the same as that of mountain rivers in Japan, and there has been no outflow flooding where these rivers overflow and flow into urban areas. However, in recent years, due to the loss of vegetation on slopes and the development of residential areas, rainfall has been flowing down the surface of the earth and into rivers all at once, and waste dumping into rivers has reduced the flow capacity of rivers. Also, due to a variety of factors the bridges are low and the culverts have a small cross section, so the bridge itself may be a bottleneck.

As a result, when it rains heavily, the river's downstream capacity is not able to cope with the rainfall flowing in all at once, causing a sudden rise in water levels in some parts of the river, which can be extremely dangerous, resulting in the flooding (or partial collapse) of houses that are built close to the riverbank. Also, In the central part of the city, flooded roads due to poor drainage and other disasters were observed; in terms of housing damage, in the case of houses made of bricks set in mud, the mud that held the bricks together flowed out during the long rains, causing the walls to collapse.

[On-site confirmation of disaster occurrence]

On January 24-25, 2022, when Cyclone Ana made landfall, the most affected districts were the informal high-density residential areas in northern Muddy Dam, where a flash flood occurred on a small river (the Nasolo River) and swept away houses in the vicinity. The area has houses built close to the banks of a small river in the district, and the river channel is narrow, so it can be said that the area is prone to dangerous conditions when the water level rises rapidly. However, since the area is informally settled, river management in this area is not a priority for Blantyre City. Therefore, it is necessary to take measures to induce people of such areas to live in areas with low disaster risk.

In addition, flood damage occurs every year at intersections in central urban areas such as Blantyre city area on the west side and Limbe city area on the east side even during heavy rains other than during cyclones. Rainwater flowing into intersections in relatively low elevation areas of the central city will cause flooding damage of about 50 cm, making it impossible for vehicles to pass through.

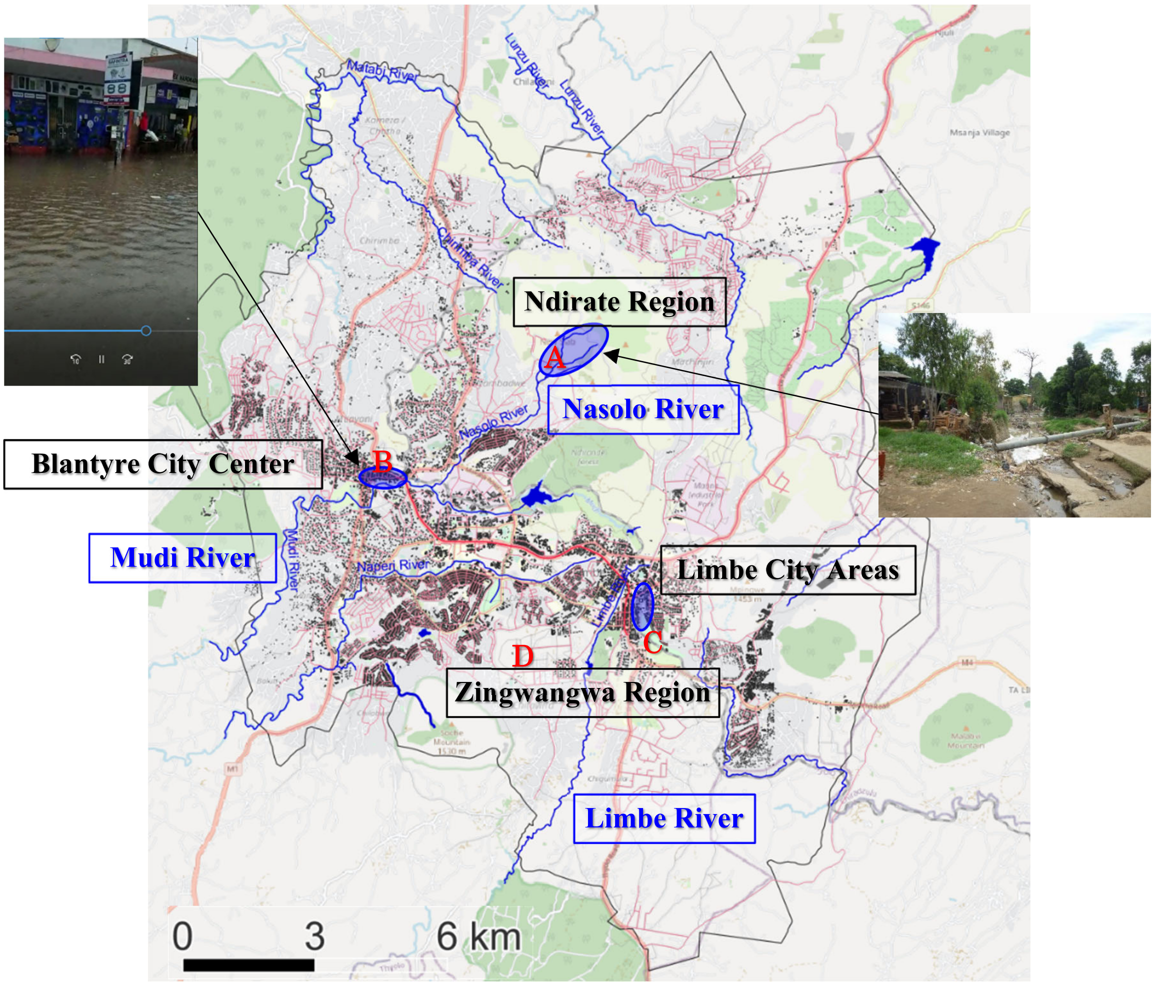
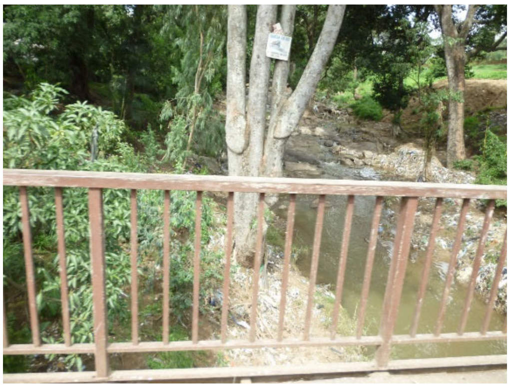


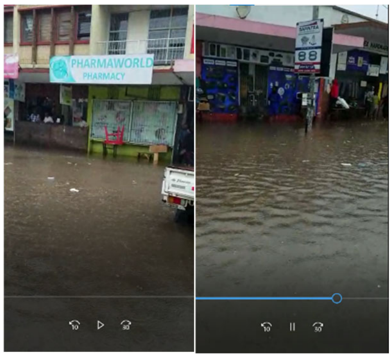
Figure 3-177 Damage Occurrence Situation in Blantyre City

Source: Prepared by JICA Study Team

Point A: The Nasolo River flowing through the Dirand district (as of February 4)



Waste dumping in the Mudi River.



Point B: Flooding in central Blantyre

View of a sloping residential area (Jingwangwa district)

Figure 3-178 Development at disaster occurred sites and high risk areas in Blantyre

Source: JICA Study Team photos

[Possibility of countermeasures]

< Drainage channels to reduce flood damage in urban areas >

At the points where flooding damage occurred (points B and C), both Blantyre and Limbe city centers have the Mudi River and Limbe River flowing nearby, respectively, so drainage to both rivers is considered possible.

The following Figure shows the relationship between the flooded areas in downtown Blantyre and the Mudi River. The Mudi River flows near the flooded area; since there is a height difference of about 5 meters between the riverbed of the Mudi River and the height of the road, it is thought that the flooding damage can be solved by constructing a drainage system that can properly drain rainwater from the city to the river.

The situation in the central city of Limbe (Point C) is similar, and therefore, it can be resolved by applying measures to drain the Limbe River.

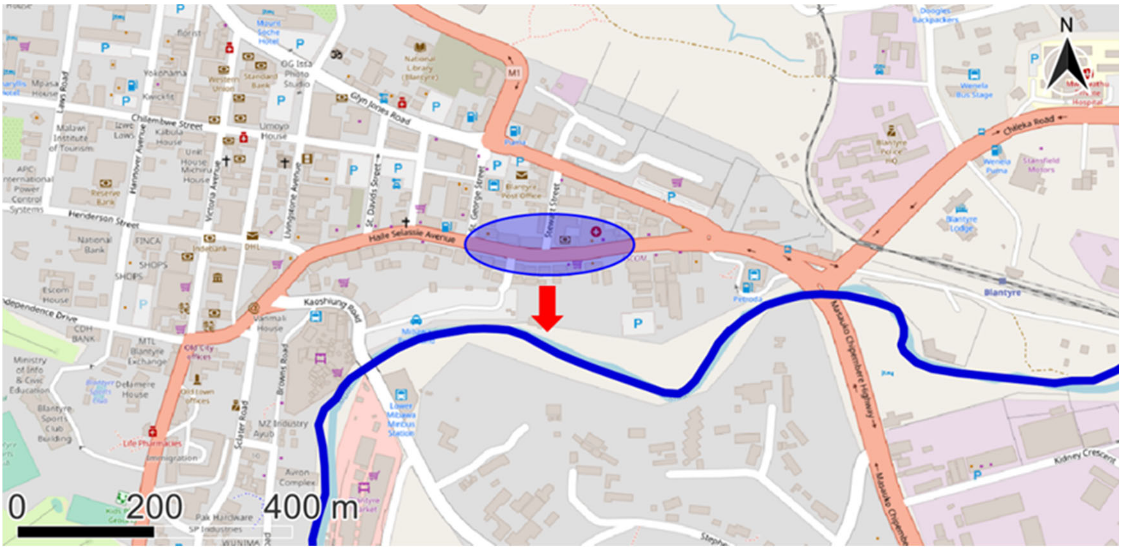


Figure 3-179 Location of Blantyre flooded intersection and river

Source: Prepared by JICA Study Team

< Support to revise Urban Structure Plan>

In Blantyre, urban areas have developed in areas that are relatively flat and less susceptible to river flooding among the hills; however, with the expansion of the city, residential areas are expanding into slopes and lower elevation areas with high hazards such as floods and landslides. In particular, in such high hazard areas, such as the uncontrolled construction of houses as informal settlements, there is a lack of management through land use regulations.

In Blantyre, with the support of World Bank, the acquisition of elevation data (DTM) and preparation of hazard maps for the city are underway.[63] In addition, the City of Blantyre's Urban

[63] Subcomponents in "MALAWI RESILIENCE AND DISASTER RISK MANAGEMENT PROJECT" included in 2.3 Strengthening Comprehensive DRM in Districts and Cities.
https://documents1.worldbank.org/curated/en/289231583511716943/pdf/Malawi-Resilience-and-Disaster-Risk-

Structure Plan 2000-2015 needs to be revised, and it is being considered to update this plan using World Bank's hazard maps.

Therefore, when reviewing the plan based on the hazard map of the World Bank, it is considered that support for planning should be provided to reflect structural and non-structural measures in the plan, and at the same time, support should be included for practical consideration of measures to guide residents in informal areas to appropriate areas.

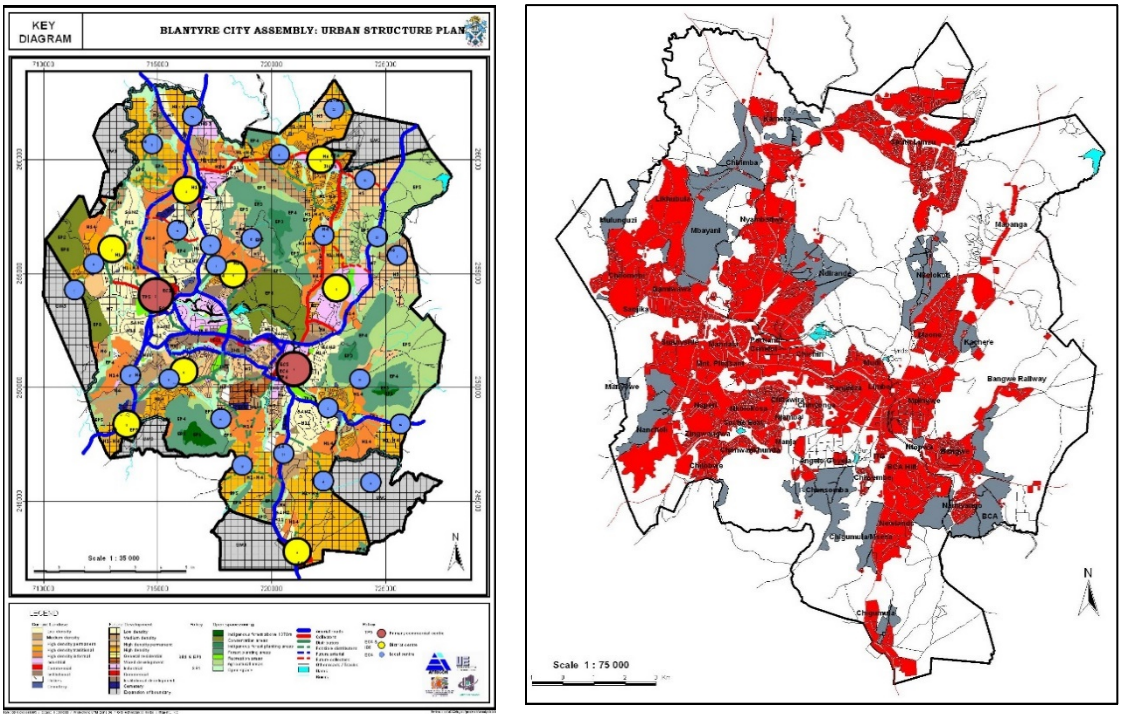


Figure 3-180 Urban Structure Plan 2000-2015 for Blantyre City (left) and the Distribution of informal areas (gray/right)

Source: Blantyre City Assembly, Urban Structure Plan

According to the Director of the City Planning Department of Blantyre City, the city has asked each donor to support the revision of the plan, so it is necessary to confirm the specific details of the request to each donor.

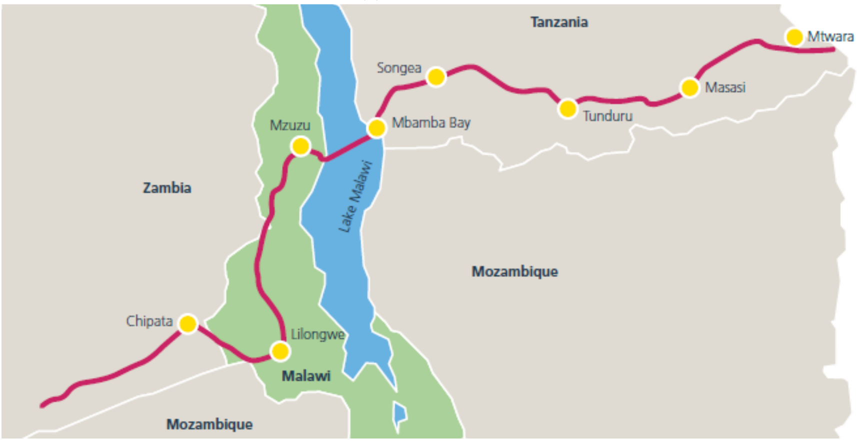
Management-Project-Additional-Financing.pdf

(2) Transportation

Malawi's national transportation network consists of road, railroad, inland water transportation, and aviation. One of the most important features of Malawi's transportation system is that, due to its landlocked geography, imports and exports use international ports in neighboring countries such as Mozambique and South Africa, and land transportation has been planned and developed mainly to connect Malawi to these international ports. As a result, Malawi's transportation costs are assessed to be among the highest in the SADC region, ranging from US$7 to US$10 per tonne-km, which is a major obstacle to social and economic development in the country. The roads and railroads that serve as transportation routes to international ports in neighboring countries are international development corridors in the Southern African region supported by foreign donors such as WB and AfDB.

The International Economic Corridor in Malawi is shown in Figure 3-181. The "Durban Corridor" refers to Malawi's the North-South Corridor to the Port of Durban, South Africa, while the "Dar es Salaam Corridor" refers to the North-South Corridor to the Port of Dar es Salaam, Tanzania.

(a) Mtwara Corridor



(b) Nacala Corridor

(c) North South Corridor

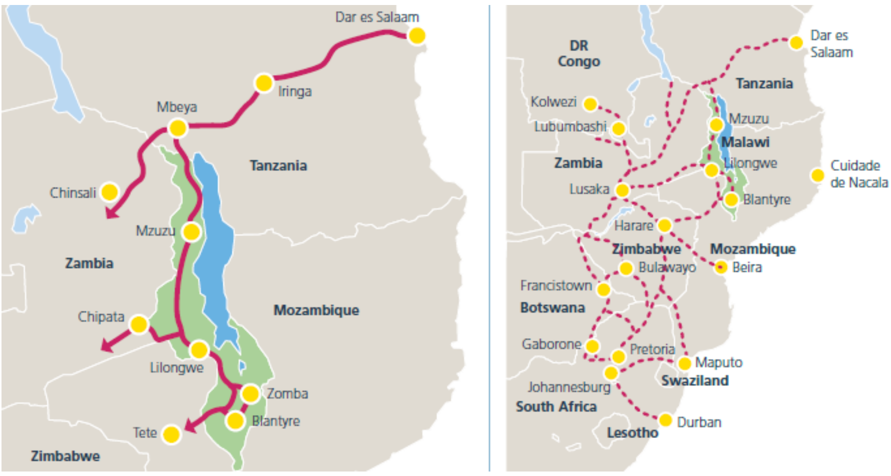


Figure 3-181 International corridors in Malawi
Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

According to the Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017 (NTMP), roads are responsible for more than 70% of domestic freight transportation and 90% of international freight. In the past, railroads were the main means of transporting international cargo, but recently the use of railroads has been declining due to suspension of railroad service for a long period and other factors. As a result, cargo, including bulk cargo, is still being transported by road over long distances to international ports in neighboring countries.

The nearest international port from Malawi is Port of Beira (825 km). However, many traders use the Durban corridor, which has high transportation costs because it is 1,150 km further away and includes two border crossings (see Table 3-151). The reason for using the port of Durban, which has higher transportation costs, is that transportation is more reliable than in the Beira corridor. This suggests that if the convenience and reliability of using the Beira or Nacala Corridor is improved, it could contribute significantly to reducing transportation costs in the country. It is also important to increase the share of railroads because the transportation cost of railroads is smaller than that of roads, as shown in Table 3-152.

According to the National Transport Policy, Government of Malawi (Apr. 2015), 60 percent of international cargo uses the Durban corridor (one-third of these are in adjacent countries), 19 percent the Beira corridor, 17 percent the Nacala corridor %, and 4% the Dar es Salaam corridor.

Table 3-151 Transportation costs (US$/ton) for exports and imports in Malawi

Exports	Mode	Tobacco		Sugar		Tea		Cotton		Food crops		Food residues	
		2004	2016	2004	2016	2004	2016	2004	2016	2004	2016	2004	2016
Beira	Road	62	138	82	71	44	103	-	83	-	90	-	87
Durban/ Johannesburg	Road	123	233	127	164	67	-	-	245	45	184	-	-
Nacala	Rail	58	61	36	49	22	88	-	68	37	73	-	-
Other Africa	Road	-	-	-	-	65	-	-	-	50	-	101	120

Imports	Mode	Fuel		Fertiliser		Cement		Wheat	
		2004	2016	2004	2016	2004	2016	2004	2016
Dar es Salaam	Road	141	154	-	-	75	137	-	-
Beira	Road	121	118	-	108	60	164	-	135
Durban	Road	-	-	179	173	-	-	-	144
Nacala	Rail	95	116	61	115	40	134	-	128

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

Table 3-152 Percentage of transportation costs in the prices of exports in Malawi

Exports	Mode	Tobacco		Sugar		Tea	
		2004	2016	2004	2016	2004	2016
Beira	Road	3%	3%	17%	16%	4%	5%
Durban/ Johannesburg	Road	5%	6%	26%	36%	6%	
Nacala	Rail	2%	2%	8%	11%	2%	4%

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

1) Overview of Relevant Organizations and Legal systems

The Ministry of Transport and Public Works (MoTPW) is the ministry responsible for transportation and public works in Malawi. It formulates policies and plans for transportation and infrastructure development, and coordinates between ministries and between subsectors of transportation. The practical work is handled by departments and public corporations within the organization, and in some subsectors, the operation of facilities is handled by private companies under concession. The organizations responsible for the major subsectors of the transportation sector are listed in Table 3-153.

Table 3-153 Key Institutions in the Transportation Sector in Malawi

Subsector	Key Institutions
—	Ministry of Transport and Public Works (MoTPW)
Road	Roads Authority (RA), Malawi Road Fund Administration Department of Road Traffic and Safety Services (DRTSS) National Road Safety Committee
Railroad	Department of Rail Services (DRS) Central East African Railways, CEAR *Concessionaire
Inland water transportation	Department of Maritime Services (DMS) Malawi Port Company *Concessionaire
Aviation	Department of Civil Aviation (DCA)

Source: JICA Study Team

In addition to the agencies and organizations listed in the table, there are other structures such as the Corridor Management Institution (CMI), the Joint Transport Sector Review (JTSR), and the Public Private Partnership (PPP) Commission. Public Private Partnership (PPP) Commission. The CMI was established for the purpose of coordinating with relevant countries on international development corridors (see Table 3-154). The JTSR was introduced for coordination and consultation among subsectors and stakeholders in the transportation sector. In 2009, the MoTPW introduced the “Transport Sector Performance Monitoring Indicator Framework (TSPMIF)” as a framework for managing and supervising the entire transportation sector and evaluates the performance of each sector annually. The JTSR was introduced for the purpose of gathering and discussing with relevant organizations in each subsector. JTSR meetings were held every year for attendance, and relevant organizations in each subsector, related organizations and private companies, and experts (universities) attended to formulate action plans and conduct quarterly monitoring. However, according to an online interview with MoTPW held in November 2021, the JTSR was terminated after the 2018 meeting and replaced by a new form of meeting called "National Planning Commission", which has not yet been held as of November 2021 due to the COVID-19 pandemic.

Further reforms are needed for efficient management, supervision and operation of the transportation sector, and the Malawi government is considering a reform proposal. The NTMP also presents its own reform proposals. The NTMP particularly emphasizes reforms in the railroad and inland water transportation subsectors. For the road and aviation sectors, proposals have been made to establish a Road Traffic Authority and a Civil Aviation Authority, but these have not yet been realized.

Table 3-154 Overview and establishment of Corridor Management Institutions (CMIs) in Malawi

Corridor	Participating States	Corridor Management Institution
Mtwara Corridor	Tanzania, Mozambique, Malawi and Zambia	No
Nacala Corridor	Mozambique, Malawi and Zambia	Tripartite Agreement signed by Malawi, Zambia and Mozambique in 2010.
North – South Corridor Split into Dar-es-Salaam Corridor and Durban Corridor	South Africa, Botswana, Zimbabwe, Zambia, Malawi, Tanzania and Democratic Republic of Congo	Dar es Salaam Corridor Committee Agreement signed by Zambia, Malawi, and Tanzania

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

a) Road

As mentioned above, Roads Fund Administration and Roads Authority (RA) are responsible for road infrastructure development. However, District Roads and Urban Roads are the responsibility of each municipality under the guidance of RA. According to the NTMP, the total length of the national classified road network in Malawi is 15,451 km, of which 21.7% are Main Roads, 20.2% are Secondary Roads, 26.7% are Tertiary Roads, 22.7% are District Roads, and 8.7% are Urban Roads. Also, the NTMP describes that only 26% of the classified roads are paved, and regarding road surface, 30.3% of the paved roads were rated as "Good" (IRI < 3.5), 52.5% as "Fair" (IRI 3.5-5.0), and 17.2% as "Poor" (IRI > 5.0), with more than 80% rated as "Fair" (IRI > 5.0).

However, there is a need to improve the paving rate of other non-paved roads, as they become unusable in some weather conditions. According to the NTMP, 74% of the rural population lives in places where there is no road usable at all times within a radius of 2 km. The results of the survey on the road surface condition of Main Road M1 conducted in 2014 are shown in Table 3-155 Road surface conditions of Malawi Main Road M1 by section (2014 Survey). Main Road M1 runs through Malawi from north to south, connecting Lilongwe, the capital city, Blantyre, the second largest city in Malawi, and Mzuzu, the third largest city in Malawi, and constitutes the North-South Corridor and the Beira Corridor. It is the most important roads in Malawi. About 90% of the sections north of Lilongwe were rated as "fair" or higher, especially between Lilongwe and Blantyre, where 96% of the sections were rated as "fair" or higher. However, about 40% of the sections between Blantyre and Nchalo were rated as "poor".

Table 3-155 Road surface conditions of Malawi Main Road M1 by section (2014 Survey)

Section	Good (IRI < 3.5)	Fair (IRI 3.5-5.0)	Poor (IRI > 5.0)	Total
Karonga – Mzuzu	64.1 km (24%)	179.3 km (66%)	28.3 km (10%)	272.7 km
Mzuzu – Lilongwe	63.8 km (18%)	244.6 km (70%)	42.8 km (12%)	351.3 km
Lilongwe – Blantyre	180.2 km (59%)	113.6 km (37%)	13.3 km (4%)	307.1 km
Blantyre – Nchalo	11.0 km (15%)	34.2 km (47%)	27.9 km (38%)	73.1 km
Nchalo – Nsanje	33.3 km (40%)	48.9 km (59%)	1.0 km (1%)	83.2 km
Total	352.5 km (33%)	620.7 km (57%)	113.3 km (10%)	1,086.5 km

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

Figure 3-182 Main and Secondary Roads in the Malawi road network

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

Key issues raised by this Master Plan regarding road infrastructure are as follows.

- Presence of bottlenecks, causing congestion and delays on the road
- Lack of road capacity in some areas and limited segregated pedestrian facilities, causing major safety issues
- Insufficient non-motorized transportation friendly infrastructure
- Limited availability of all-weather roads, wichi constrains accessibility for road users, particularly in rural areas
- Lengthy and inefficient procedures at border crossings
- Lack of a comprehensive rural transportation stretegy
- Funding constraints hindering adequate construction and maintenance of roads
- Weakness in the relevant organizations' capabilities to adequately manage the road network

Figure 3-183 shows the inter-regional truck traffic volume in Malawi. Trucks to and from the Southern Region are the most common with 32%, followed by the Central Region, mainly Lilongwe, with 29%. The amount of truck traffic between regions is not very high, with 4% between the Central Region and the Southern Region. A total of about 17% of truck traffic is considered to be international cargo, with 11% to/from the Central Region and 5% to/from the Southern Region, while international cargo to/from the Northern Region accounts for only 1% of Malawi's truck traffic.

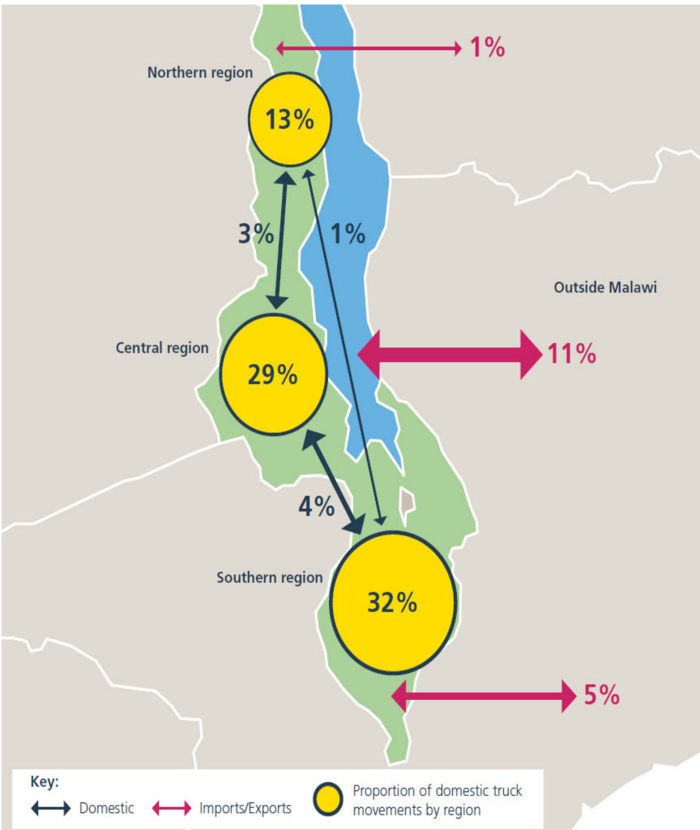


Figure 3-183 Inter-regional truck traffic in Malawi

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

b) Railroad

Figure 3-184 shows the rail network in Malawi. The country's railroad lines can be divided into two main routes. One is the north-south route that connects Chipata in Zambia, via Lilongwe, Salima, Nkaya, and Blantyre with Marka on the southern border, and the other is the east-west route that extends to Nacala Port in Mozambique via Mozambique's Tete Province, Kachaso, Nkaya, and Nayuchi. Currently, Malawi's rail network consists of only these two routes. These routes intersect at Nkaya.

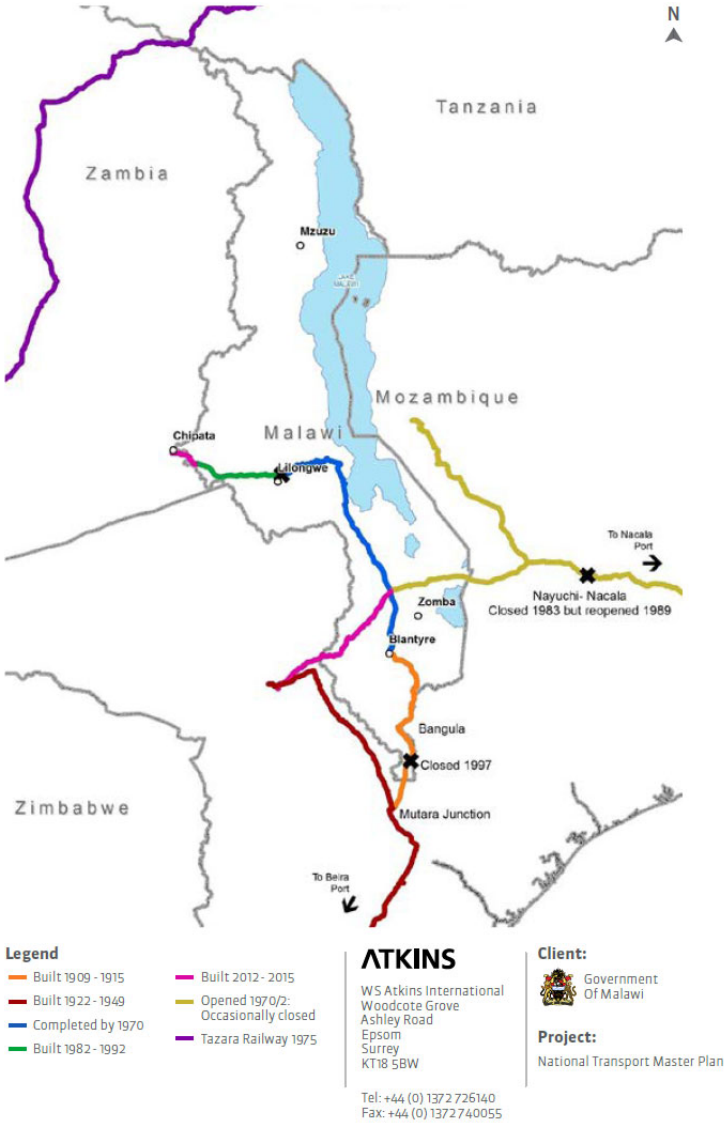


Figure 3-184 Status of railroad lines in Malawi

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

All railroads in Malawi are single track, narrow gauge (1,067 mm), and not electrified. A summary of each route is shown in Table 3-156. It explains four sections around Nkaya, where the two lines intersect. The north-south route, which has been under development for more than several decades, has a maximum speed of 50 km/h, and the recently developed east-west route has a maximum speed of 70 km/h, which is not very high. There is a speed limit section from Nkaya to Chipata in Zambia, and the journey takes 20 hours, which is a very low operating speed. There is service between Nkaya and Limbe in Blantyre, but the 120.6 km section south of Limbe has been out of service since the 1997 floods that washed away a railroad bridge near Bangula.

Table 3-156 Summary of the Railroads in Malawi

Key Features	Nkaya-Kachaso	Nkaya-Nayuchi	Nkaya-Limbe-Marka	Nkaya-Mchinji/ Chipata
Total length	130.5 km	99 km	297 km*	400 km
Maximum line speed	70 kmph	70 kmph	50 kmph	50 kmph
Haulage time	2-3 hrs	3-4.5 hrs	5-7 hrs	20 hrs
Maximum axle load	20.5 tonnes	20.5 tonnes	18 tonnes	15 to 18 tonnes
Track	Single	Single	Single	Single
Passing loops	5	6		
Concession	VLL/CLN	CEAR	CEAR	CEAR
Condition	Good	Good	Nkaya-Limbe: fair, ongoing improvement work Limbe-Makhanga: closed Makhanga-Marka: closed	Speed restrictions, spot improvements ongoing

* Including 120.6km of the non-operational section

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

In 2011, the government of Malawi entered into a concession agreement with Vale Logistics Limited of Brazil to build the Malawi section (138 km) of a new route between Nkaya and Moatize, Tete Province, Mozambique, via Chapita. In addition, an improvement project between Nkaya and Nayuchi has been completed. This east-west route of Chapita - Nkaya - Nayuchi is the trans-Malawi section of the Nacala railroad, the Mozambique section of which is between Tete Province and Nacala Port. Vale will maintain the Nkaya-Chapita section under a 30-year concession and will collect user fees from the operating companies.

As mentioned above, Malawi's railroad network is limited to the Central Region and Southern Region of the country, with only two lines (east-west and north-south) and low operating speeds. In addition, the section south of Limbe is out of service. According to the National Transport Policy (Government of Malawi, Apr. 2015), Malawi's railroads are unreliable to use and inefficient. The main reasons for this are that there are very few rail lines, the related infrastructure and facilities are not properly maintained, the condition of the Nacala port, which is to be connected by rail, is poor, and furthermore, the regulations of the governing and supervising bodies are weak. The National Transport Policy points out frequent train cancellations as a challenge for both track infrastructure and vehicles. This has worsened cash flow and profit generation in railroad operations. Because maintenance has not been done properly for the past several years, the entire rail network is now in need of major renovation work, including the refurbishment of the rails. It is estimated that the amount of freight using railroads will continue to decline unless immediate renovations are undertaken, including a replacement of the Chiromo Bridge.

The challenges of Malawi's railroad system as identified by the NTMP are as follows.

- Lack of extensive network coverage throughout the country
- Skill gaps and shortage of local expertise and resources in key areas of rail operation and management
- Need for strengthening the institutional framework of the MoTPW
- Lengthy and inefficient procedures at border crossings
- Gaps in the regulatory framework
- Lack of integration with other transportation modes in the country

Malawi's railroads have great potential for reducing transportation costs in the country. However, currently, the only port in the country for a transportation of international cargo by rail is the Port of Nacala, but the Port of Nacala is not yet fully equipped to handle anything other than coal exports, and therefore, the Port of Beira is still the most attractive international port for Malawi. However, at present, there is only a road connection from Malawi to the port of Beira. In order to take advantage of the advantages of railroads (reduced transportation costs) and to convert the means of freight transportation from road to rail, the Malawi National Transport Master Plan emphasizes the following two points.

- Maximizing CEAR's advantages through better operational techniques and improving teh state of the existing network
- Extending the railroad network into Malawi from ports other than Nacala, in order to offer choice and increased competition

c) Inland Water Transportation

Malawi's inland water transportation is based on Lake Malawi and the upper reaches of the Shire River. It serves both passengers and cargo. Although it was one of the very important transportation systems in Malawi in the past, the use of inland water transportation started to decline a few decades ago when the expansion of the road infrastructure was in full swing, and during that time, there was no proper investment in inland water transportation. For this reason, it is currently not used very much. The Shire River, extending about 400 km from Lake Malombe through the Southern Region, has high potential for use as an inland water transportation system. Figure 3-185 shows the ferry service routes on Lake Malawi operated by MV Ilala. Table 3-157 and Table 3-158 show the status of major inland waterway port facilities on Lake Malawi and the volume of cargo transported using Lake Malawi, respectively.

Figure 3-185 Ferry service routes on lake Malawi (MV Ilala)

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

Table 3-157 Status of major port facilities at Lake Malawi

Port	Machinery	Storage area	Condition
Monkey Bay	1 x mobile crane 1 x tractor 1 x trailer	Dry - 500m2 Liquid - N/A	Old and dilapidated. Rehabilitation in 2013.
Chipoka	1 x 35 mt gantry crane 4 x 3 mt forklifts	Dry – 800m2 Liquid - 923,000 litres	Old and dilapidated. Rehabilitation in 2013.
Nkhata Bay	Machine tools Cranes	Warehouses	Jetty is currently not operational.
Chilumba	1 x 35 mt gantry crane 1 x 20 mt mobile crane 1 x 6 mt forklift 5 x 3 mt forklifts 1 x tractor 1 x trailer	Dry- 800m2 Liquid - 583,000 litres	Gantry crane lost. Old and dilapidated.

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

Table 3-158 Cargo traffic using Lake Malawi (thousand tons)

Year	2012	2013	2014	2015	2016
Volume	29.57	21.24	2.4	2.02	5.13

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

The following are some of the issues identified by the NTMP for inland water transportation infrastructure.

- Lack of integration with other modes of transportation, and as a result Lake Malawi is not being used to its full potential
- Poor navigation systems resulting in slow vessel speeds
- Gaps in its regulatory framework, such as the absence of an independent safety regulator
- Lack of maintenance of both vessels and port infrastructure resulting in high inefficiency and safety issues
- Inadequate institutional capacity for the efficient operation and management of the infrastructure
- Unsuccessful participation of private sector investors to date

d) Airport

According to the NTMP, Malawi has 33 airfields across the country, of which two are international airports and five are not international airports but are available for secondary use of international flights. According to the National Transport Policy (Government of Malawi, Apr. 2015), most of the air transportation infrastructure and facilities in Malawi were developed 25 years ago (as of the time the policy was developed), and it is difficult to meet the current demand. Although Kamuzu International Airport, located in Lilongwe, the Capital of Malawi, was provided with air navigation systems and other equipment by JICA through “The Project for the Replacement of Air Navigation System at Kamuzu International Airport” in 2012 and “The Project for Expansion of the Terminal Building at Kamuzu International Airport” in 2018, most other infrastructure and facilities are past their endurance and design life, and there is an urgent need to address this issue. Due to this situation, the transportation of international cargo by air is limited in the country. Table 3-159 and Table 3-160 show the current status of Malawi's international airports and the volume of cargo handled, respectively.

Table 3-159 Current Status of international airports in Malawi

Features	Kamuzu (Lilongwe)	Chileka (Blantyre)
Aircraft parking facility	14	4
Runway length	3,540 m	2,325 m
Aircraft handling capacity	Code D & E	Code D & E
Passenger capacity	300,000 persons/year	200,000 persons/year
Cargo handling capacity	3,000 tons/year	550 tons/year
Runway condition	Good	Poor
Navigation aids	Radar not available Note ILS available and functioning	Instrument Landing System (ILS) or radar are not available

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.
Note. Radar was not available when the NTMP was published, but installed through grant aid by Japanese Government in 2019

Table 3-160 Cargo handled at Malawi's international airports (thousand tons)

Airport	2000	2001	2002	2003	2004	2005	2006	2015
Chileka	0.35	0.32	0.38	0.35	0.60	0.58	0.52	0.55
Kamuzu	3.80	2.50	2.20	1.80	2.20	2.00	3.90	3.20
Total	**4.15**	**2.82**	**2.58**	**2.15**	**2.80**	**2.58**	**4.42**	**3.75**

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

According to the NTMP, at the same time as upgrading the aviation infrastructure and facilities, it is required to plan, design, implement, and operate infrastructure that meets ICAO standards, in particular, to ensure international standard levels of security, and to establish a public corporation to operate the airport. Also, ICAO is concerned about the aviation safety in Malawi, as there is no agency that regulates, controls, or supervises the civil aviation sector in the country. Radar system is one of the navigation aid systems required for air traffic safety, and Kamuzu International Airport was equipped with the radar system in 2019. However, other airports in Malawi do not have the radar system.

The civil aviation sector in Malawi is not well developed. On the other hand, there has been a gradual investment in the aviation sector with the help of foreign donors. JICA is implementing a project to upgrade Kamuzu International Airport in Lilongwe, the capital city, and the EU has agreed to finance a project to expand the cargo terminal facilities at Chileka International Airport in Blantyre.

The challenges identified by the NTMP for civil aviation infrastructure include the following.

- Limited funds available for infrastructure maintenance
- Lack of world class safety standards
- absence of critical infrastructure including navigation aids
- Unprofitability of Malawi Airlines
- Small international and local markets
- Limited cargo operations
- Weakness in governance and deployment of modern regulations

2) Overview of Related Plans and Development Status

The three top national transportation-related plans in Malawi are as follows.

- The Malawi Growth and Development Strategy (MGDS) III (2017-2022)
  Cites transportation as one of the five key priority sectors. This strategy examines how the country's economic development can be accelerated by improving the transportation sectors to reduce the cost of imports and exports.
- The National Transport Master Plan (NTMP), Dec. 2017
  Provides guidelines for achieving a sustainable integrated transportation system for the next 20 years. Also describes the regulations necessary for the operation of each transportation system for this purpose.
- The National Transport Policy (NTP), April 2015
  This policy presents the objectives, strategies, and evaluation framework for each mode of transportation. There is no expiration date set for this policy, and it is expected to remain in effect for the next 5-10 years.

The NTMP is Malawi's first national transport master plan prepared with the support of the WB and covers the transportation sector for the 20 years of 2017-2037. This Master Plan presents a plan to achieve the three strategic goals of reducing transportation costs, improving traffic safety, and creating a state-of-the-art and sustainable passenger and freight transportation system, as shown in Table 3-161.

Table 3-161 Key components in the Malawi National Transport Master Plan

Sub Sector	Main plan components
Roads	▪ Maintenance of the road network ▪ Rehabilitation of all failing sections of the network ▪ Upgrading 1,418 km of rural roads to assist agricultural production and improve rural accessibility ▪ Introduction of over 500 km of segregated cycle/pedestrian facilities on high trafficked roads
Rail	▪ An extension of the railway line from Beira Port (Mozambique) northwards from Mutarara into Malawi, in stages ▪ A spur line from Mbeya to Chilumba
Inland Water Transport	▪ Improved port facilities at Nkhata Bay and roll-on roll-off freight services to Mbamba Bay on the Mtwara Corridor ▪ Introduction of a regular freight service between Chilumba and Liwonde ▪ Construction of a wet port at Liwonde
Civil Aviation	▪ Measures to improve safety and security to world class standards ▪ Runway and apron improvements at Chileka and Kamuzu International Airport to accommodate larger aircraft, and terminal capacity increases ▪ Developing some rural airfields for tourist use ▪ Handing over unused airfields to local authorities and the private sector

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017

In addition, the plan for the most important transportation infrastructure in the NTMP is shown in Figure 3-186. Infrastructure development of railroads and inland water transportation is targeted to reduce transportation costs and improve transportation efficiency of cargo for import and export. In terms of railroads, there are two points: (1) securing access to the port of Dar es Salaam by building a new railroad line between Mbeya, Tanzania and Chilumba, Malawi, and (2) securing access to the port of Beira by reviving the railroad line south of Blantyre, which has been suspended or abandoned. In terms of inland water transportation, the project will utilize the waterways of Lake Malawi, Lake Malombe, and the Shire River to: (1) develop a waterway and inland ports between Chilumba and Liwonde; (2) develop a waterway and inland ports between Nkhata Bay and Mbamba Bay, Tanzania as the Mtwara Corridor; and (3) develop a waterway and inland ports between Nsanje and Chinde, Mozambique, to connect Malawi directly to the Indian Ocean using the Shire River and the Zambezi River.

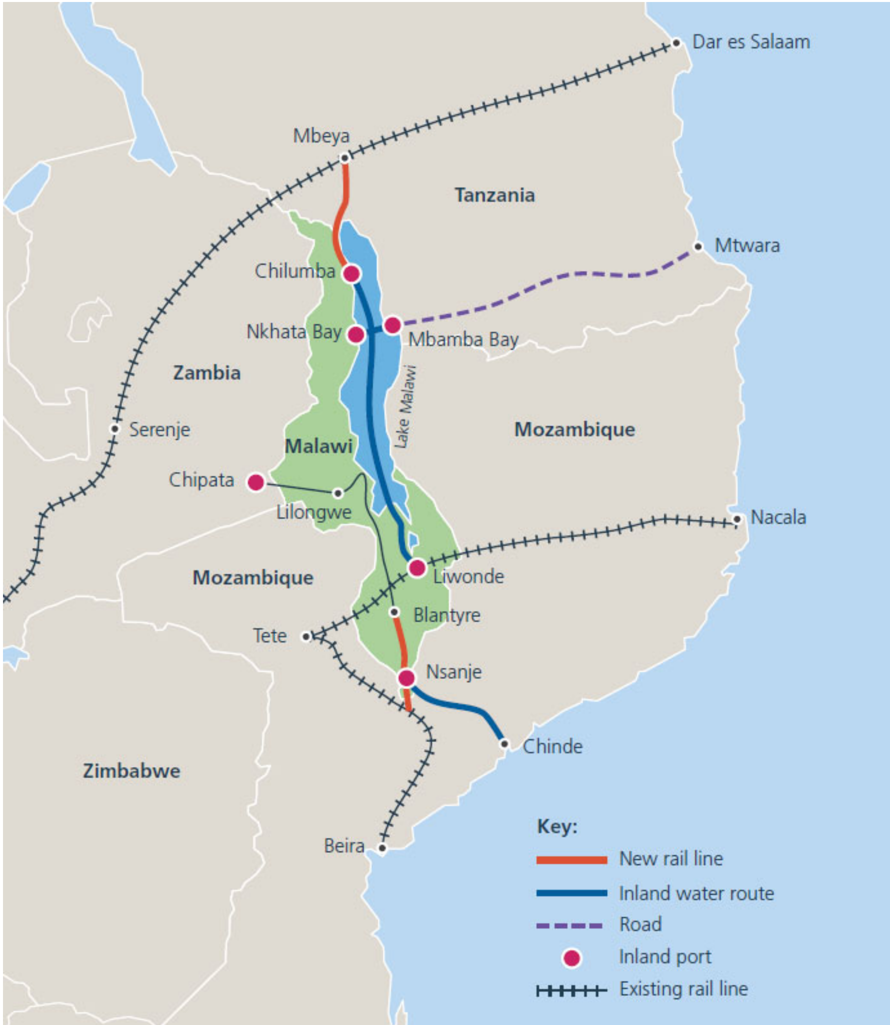


Figure 3-186 Key plans in the Malawi National Transport Master Plan (2017)

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017

Table 3-162 shows the implementation scenarios for infrastructure development presented by the Master Plan, including the major infrastructure development plans shown in Table 3-163. Further, Table 3-163 shows the status of the development of transportation corridors in Malawi.

Table 3-162 Key infrastructure development scenarios in the NTMP

Scenario	Schemes	Net Present Value (US$ million)*
Integrated Scenario 1	**Rail:** Beira-Nsanje **Dry port:** Salima **IWT:** Chilumba-Nkhata Bay-Salima-Liwonde	177
Integrated Scenario 2	**Rail:** Beira-Bangula **Rail:** Moatize avoiding line **Road:** M1 dualling – Songwe to Blantyre **IWT:** Chilumba-Nkhata Bay-Salima-Liwonde	70
Integrated Scenario 3	**Rail:** Belra-Limbe direct **Rail:** Chilumba-Mbeya **IWT:** Chilumba-Nkhata Bay-Salima-Liwonde **IWT:** Nkhata Bay-Mbamba Bay **Road:** Blantyre Expressway	212
Integrated Scenario 4	**Rail:** Beira-Limbe direct **IWT:** Chilumba-Nkhata Bay-Salima-Liwonde **IWT:** Nkhata Bay-Mbamba Bay	128

*Net Present Benefits minus Net Present Costs

Source:.Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017

Table 3-163 Recommended Transportation Corridor Projects in the NTMP

Mode	From/To	Corridor	Intervention	Status
Road, M1	Karonga-Songwe	North-South	Rehabilitation and safety initiatives	Ongoing
Road, M5	Mzuzu-Nkhata Bay	Mtwara	Rehabilitation	Ongoing
Road, M12	Lilongwe-Mchinji	Nacala, Mtwara, North-South	Provision of cycle lanes and capacity increase	Proposed
Road, M6	Blantyre-Mwanza	North-South	Provision of cycle lanes and capacity increase	Proposed
Road, M1	Mponela-Lilongwe	North-South, Mtwara	Provision of cycle lanes and capacity increase	Proposed
Road, M1	Lilongwe-Blantyre	North-South	Provision of cycle lanes and capacity increase	Proposed
Road	Lilongwe bypasses	North-South, Mtwara	New roads	Proposed
Road, M1	Songwe-Blantyre	North-South, Nacala, Mtwara	Dualling	Proposed
Inland Water	Nkhata Bay-Mbamba Bay	Mtwara	Provision of roll-on roll-off ferry service	Proposed
Inland Water	Liwonde	Nacala	Wet port and freight services	Proposed
Inland Water	Chilumba-Chipoka	North-South	Freight Service	Proposed
Rail	Mbeya-Chilumba	North-South	New rail line	Proposed
Rail	Nacala	Nacala	Rail Freight User Group	Proposed
Rail	Beira to Malawi	North-South	New rail options	Proposed

Source:.Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017

a) Road

Key road-related details in the NTMP are presented in Table 3-164, Table 3-165, Table 3-166, and Table 3-167.

Table 3-164 Road repair projects underway in Malawi

Name	Funding agency	Length (km)	Completion
Mzuzu-Nkhata Bay	AfDB	47	2017 to 2022
Liwonde-Mangochi	AfDB	75	2017 to 2022
Blantyre-Zomba endpoints	AfDB	60	2017 to 2022
Karonga-Songwe	WB	45	2017 to 2022
Total		**227**	

Source:.Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017

Table 3-165 Road improvement projects underway in Malawi

Name	Funding agency	Length (km)	Completion
Chiringa-Chiradzulu*	GoM	80	2017 to 2022
Lilongwe old airport – Kasiya Santhe (S117)	GoM	95	2017 to 2022
Jenda-Edingeni	GoM and Abu-Dhabi Fund for Development	38	2017 to 2022
Zomba-Jali-Phalombe-Chitakale (S144, S147, S148)	Kuwait Fund, BADEA and OFID	51	2017 to 2022
Thyolo – Thekerani – Makhanga (S151)	Kuwait Fund, BADEA and OFID	82	2017 to 2022
Chikwawa – Chapananga (S136)	GoM	76	2022 to 2027
Lirangwe-Chingale-Machinga (S139)	Kuwait Fund, BADEA and OFID	62	2022 to 2027
Lumbadzi-Dowa-Chezi (M7/M16)	GoM	18	2017 to 2022
Mzimba-Mzalangwe	GoM	62	2022 to 2027
Ntcheu-Tsangano-Neno-Mwanza turn-off (S118)	Government of China	140	2022 to 2027
Njakwa Livingstonia – Chitimba (S103)	GoM	75	2022 to 2027
Msulira – Nkhotakota (M5)	GoM	32	2027 to 2032

Source:.Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017

Table 3-166 Other road repair projects underway in Malawi

Name	Funding agency	Length (km)	Completion
Illovo roundabout to Midima roundabout (M2) – dualling	GoM	0.5	2017 to 2022
Area18 roundabout - Area 49 at Kaunda Road Junction -widening	GoM	3	2017 to 2022
Area18 roundabout - Parliament roundabout - KCH - Amina House – dualling	GoM	4.2	2017 to 2022
Kaunda - Chendawa and Area 25 - Nzenza – M1 Junction - widening	GoM	20	2017 to 2022
KIA turn off to Bunda turn off (M1): (i) KIA turn off to Kanengo (ii) Kanengo to Mchinji Road roundabout (iii) Mchinji Road roundabout to BIWI (iv) BIWI to Bunda turn off	GoM/JICA/ Government of People's Republic of China	14	2017 to 2022

Source:.Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017

Table 3-167 Plans for future road rehabilitation projects in Malawi

Road name	Potential funding agency	Length (km)	Completion
Nsanje-Marka (M1)	GoM	30	2022 to 2027
Ntcheu-Kasinje (M5)	GoM	50	2022 to 2027
KIA Junction-Kasungu-Jenda-Mzimba turn-off (M1)	COMESA	234	2022 to 2027
Mangochi-Chiponde (M3)	AfDB	138	2022 to 2027
Mzimba turn-off -Mzuzu-Kacheche (M1)	WB	138	2022 to 2027
Nsipe-Liwonde (M8)	GoM	55	2022 to 2027
Balaka-Salima (M5)	GoM	200	2022 to 2027
Kapatenga-Nkhotokota-Dwangwa (M5)	Chinese Government and GoM	150	2022 to 2027
Chiweta-Bwengu-Kacheche	World Bank and European Investment Bank	63	2022 to 2027
Rumphi-Hewe-Zambia Border (M24)	AfDB	65	2022 to 2027
Mangochi-Makanjira (S256)	Chinese Government and GoM	138	2022 to 2027

Source:.Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017

b) Railroad

In 2017, Vale and Mitsui undertook a redevelopment of the railroad line from Moatize in northern Mozambique through Malawi to the Port of Nacala, expanding opportunities for Malawi to transport import and export cargo by railroad. Currently, the Nkaya-Mchinji improvement project is underway with a target completion date of 2021, and once completed, it will connect to Chipata in Zambia. However, this project has not been completed as of February 2022 due to insufficient project budget.

The details of the rail infrastructure development plan as indicated by the NTMP are shown in Figure 3-187. The proposal says that the most economical way to connect Malawi to the port of Beira, Mozambique by rail is to use the existing lines between Beira and Moatize, Tete Province, and between Moatize and Nkaya, and to build a new section (Moatize Avoiding Line) to avoid going through Moatize. However, it is necessary to negotiate with the private company Vale in order to use the section constructed and in use by Vale, and it is also necessary to negotiate with CFM since the Beira Port – Moatize section is operated by CFM of Mozambique. Another option is to revive the old Sena railroad (the section south of Blantyre). The construction cost of this proposal is high.

Figure 3-187 Rail line development plan in the Malawi National Transport Master Plan (2017)

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

The following is a summary of the current status and plans for railroads in Malawi obtained from online interviews with MoTPW and DRS conducted in November-December 2021.

- To reduce transportation costs, the most important issue is to increase freight transportation by rail, and the most important project in the rail sector at present is to rehabilitate the railroad south of Limbe and transport freight by rail to the port of Beira, Mozambique.
- In accordance with the NTMP, a project is underway to rehabilitate the section south of Limbe. Construction work has already started on the Limbe - Sandama route, and contractor selection is underway for the Bangula - Marka route (as of December 2021). However, due to the high cost of rehabilitating the washed-out bridge in the Bangula - Chilomo section, the rehabilitation project between Bangula and Sandama has not been able to secure financial resources and the project has been delayed (*An interview with CFM of Mozambique conducted in November 2021 confirmed that the rehabilitation work between the Sena Line and Marka on the Mozambican side is in progress).
- Regarding the new railroad between Salima and Mzuzu proposed in the NTMP (see Figure 3-187), a feasibility study is currently underway to determine the route, of which options are Salima-Mzuzu route and Lilongwe-Mzuzu route.

c) Inland Water Transportation

Figure 3-188 shows the potential sites for the development of inland ports as proposed by the NTMP. Figure 3-189 and Figure 3-190 show the potential for freight transportation using Lake Malawi and the passenger transportation service for Lake Malawi proposed by the Master Plan, respectively.

Figure 3-188 Inland port development plan in the Malawi National Transport Master Plan (2017)

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

Figure 3-189 Potential for freight transportation by inland waterways in Malawi
Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

Figure 3-190 Proposed passenger transportation services on Lake Malawi

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

According to the National Transport Policy, Government of Malawi, Apr. 2015, the government of Malawi is developing the “Shire-Zambezi Waterway” through a concession agreement with the Malawi Ports Company. The project is to use the Zambezi River to connect Malawi and Zambia directly to the Indian Ocean, and its feasibility study was completed by AfDB in 2016. The implementing agency for this project is SADC, and Malawi is planning to build the “Nsanje World Inland Port” as part of this project.

d) Airport

The future plans for each airport as proposed by the NTMP are shown in Figure 3-191. There are three airports that need to be renovated, upgraded, expanded or otherwise developed: Kamuzu International Airport in Lilongwe, the capital city; Chileka International Airport in Blantyre; and Kasungu Airport in the Central Region of Malawi. Kasungu is a small regional city with a population of about 60,000, located about 130 km northwest of Lilongwe. There is no statement in the Master Plan regarding the reasons for developing Kasungu Airport or its current status. It is possible that the evaluation was made from the perspective of attracting tourists to Kasungu National Park. While most of the other airports were evaluated as maintaining the status quo, relocating, etc., nine airports were proposed for disposal, including a transfer to the military or police.

Figure 3-191 Airport plan in the Malawi National Transport Master Plan (2017)

Source: Malawi National Transport Master Plan Final Report, MoTPW, Dec. 2017.

3) Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Frequent heavy rains and floods cause damage to transportation infrastructure every year, especially in the Southern Region of Malawi. These damages are not only a hindrance to emergency relief efforts in times of disaster, but the cost of rehabilitation is also a huge burden on the finances for the development of the Malawi road network. For example, the damage caused by the floods in 2019 was US$36.1 million. The floods at that time partially or fully damaged 1,841 km of roads. Of these, 33 km were Main Roads, 274 km were Secondary Roads, 398 km were Tertiary Roads, and 1,136 km were District Roads. In addition, 129 bridges and 68 culverts were washed away as a result of this disaster. The hardest hit areas were Nsanje (US$10.1 million) in the southernmost part of Malawi, Chikwawa (US$4.6 million) south of Blantyre, Mangochi (US$2.8 million) between Lake Malawi and Lake Malombe, Phalombe (US$2.44 million) facing Lake Chilwa and the border with Mozambique, and Thyolo (US$2.43 million) south of Blantyre.

If such disasters occur every year, there is no doubt that the burden on the national economy will be great. There is no such concept as ensuring the redundancy of emergency transportation roads and major roads in the event of a disaster. The NTMP also points out that a common challenge for Malawi's transportation infrastructure in general is vulnerability to severe weather events, including those caused by climate change, and points out that the increasing number of floods and droughts each year are reducing the durability of transportation infrastructure and increasing the problem of aging. The Master Plan also points out that reliable, efficient, and safe transportation infrastructure is an essential component of sustainable economic and social development, that the solution to the above issues is essential, and that greenhouse gas emissions must be managed.

Figure 3-192 shows the risk of sediment disasters and floods in Malawi. The risk of sediment disasters is high in the Northern Region of Malawi, in the mountainous areas stretching north south along the eastern shore of Lake Malawi, in the mountainous areas near the border with Zimbabwe, and in the mountainous areas east of Mangochi near the border with Mozambique. Flood risk is very high in the lakeshore areas of Lake Malawi, the Shire River, and especially around the Shire River south of Chikwawa.

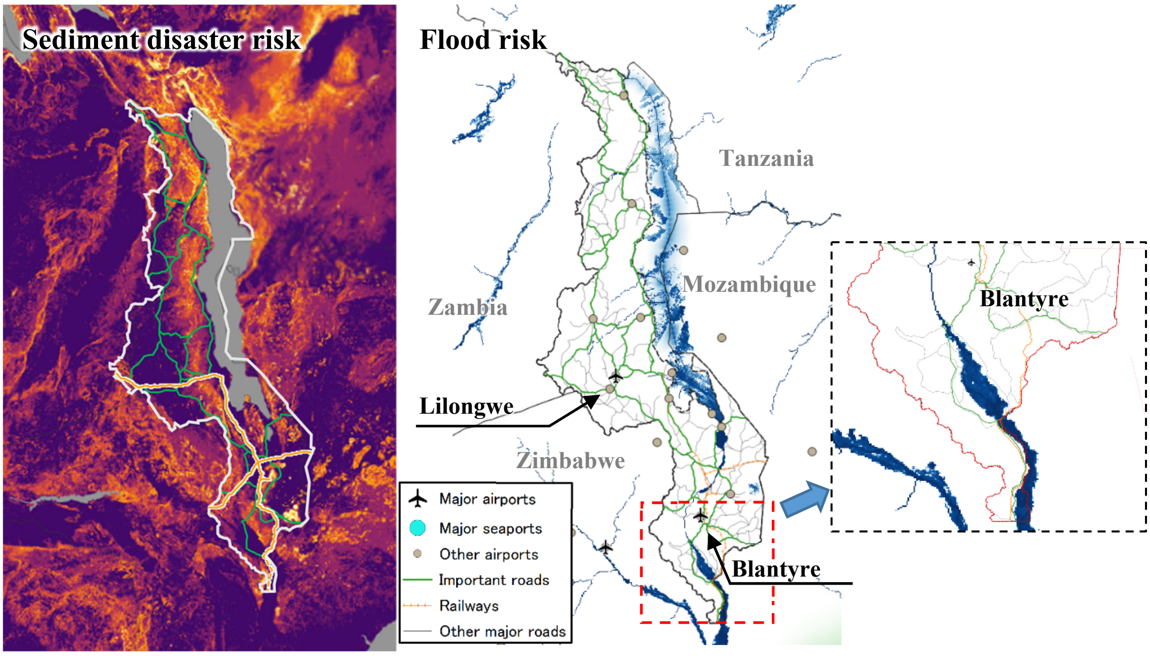


Figure 3-192　Sediment disaster and flood risks in Malawi

Source: JICA Study Team

Although it is necessary to collect information through on-site hearings to identify critical transportation infrastructure with a high risk of damage, Table 3-168 summarizes the important transportation infrastructures for disaster risk reduction based on the above study. Although the railroad line south of Limbe is in a state of suspension or abandonment, flood risks should be fully analyzed and reflected in the design and construction of the railroad construction project to connect with the Sena railroad in Mozambique.

Table 3-168　Critical transportation infrastructure for disaster risk reduction in Malawi

Subsector	Critical Infrastructure for Disaster Risk Reduction	Disasters the risk of which is high
Road	Main Roads M1, M3, and M5	Floods, sediment disasters
	Main Roads M9 and M29	Sediment disasters
	Main Road M10	Flood
Railroad	South of Limbe	Flood

Source: JICA Study Team

The following is a summary of the information on disaster occurrence on Malawi's roads obtained from the interviews with MoTPW and RA conducted in November-December 2021 (online).

- Main Road M1 is undoubtedly the most important road in Malawi, since it traverses the country from north to south, connects the capital Lilongwe, the second largest city Blantyre, and the third largest city Mzuzu, and forms part of the North-South Corridor and the Nacala Corridor. The northern section of M1 is also used as an international corridor, so that there is a lot of traffic.

- Main Road M5 is also important, since it also traverses Malawi from north to south and is the shortest route from Blantyre to Tanzania.
- Main Roads M3 and M12 are also important as they form the Nacala Corridor.
- As for bridges on important roads including Main Roads mentioned above, there have been no problems in the past, but due to the effects of land use changes and other factors, structurally weak bridges are appearing, and some bridges are at risk of damage such as washout and loss of abutments due to flooding.
- Situation of damages to Main Road M1:
- Frequent damages caused by flooding near the Shire River flood risk area to the southern section of Bangula
- Frequent damages caused by flooding to the section between karonga and the Tanzanian border.
- Frequent landslides at the section between Chiweta and Karonga, but the cause of the landslides is unknown.
- The M1 section of the Karonga-Tanzania border was rehabilitated in 2019, but abutments of some bridges were washed away in subsequent flooding (piers and superstructures were not damaged).

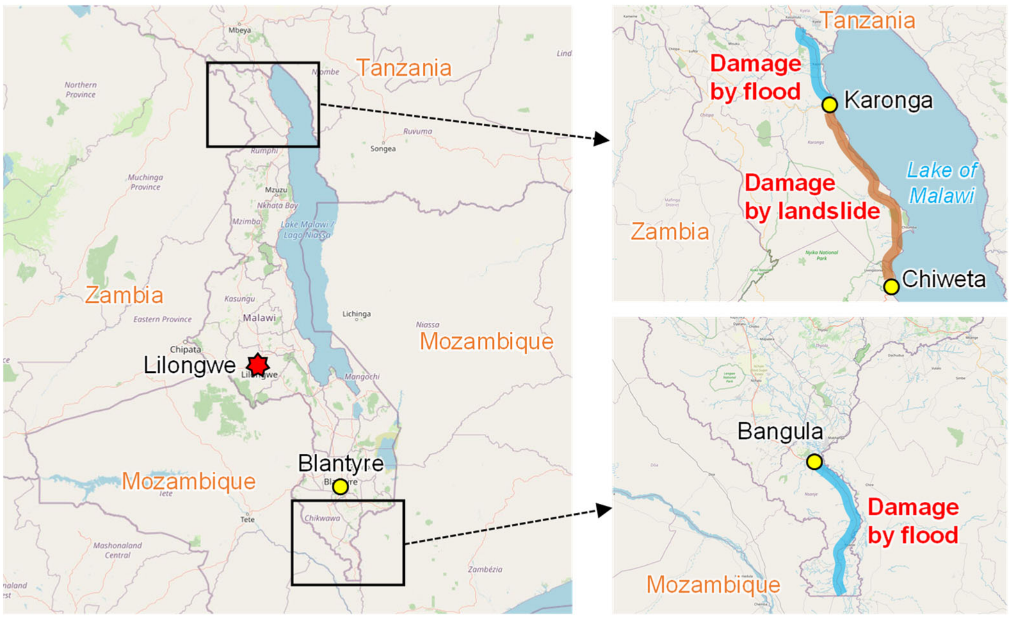


Figure 3-193 Vulnerable Road Sections to Disasters on M1 in Malawi

Source: JICA Study Team (map data: OpenStreetMap)

The following is a summary of the information on disaster occurrence in Malawi's railroads obtained during the online interview with the DRS conducted in December 2021.

- The Bangula to Chiromo section, where the Shire and Ruo Rivers meet, is the most flood-prone section along Malawi's railroad system. In 1997, the bridge was washed out by the floods and the railway section south of Makhanga was closed and trains had to turn around at Makhanga.
- The section south of Makhanga, including the bridge that was washed away, was left untouched, and in 2015, the section in Thyolo Province, including along the Ruo River, was damaged by several floods, and the front line south of Limbe has been suspended until now.
- On the Mtakataka - Abrahamu section between Lilongwe and Blantyre, heavy rains have resulted in the loss of railroad lines due to inadequate drainage facilities on the adjacent Main Road M5 (not due to flooding).
- The most disaster-prone sections of Malawi's railroads, including the suspended sections south of Limbe, are the Bangula to Chiromo and Mtakataka to Abrahamu sections. The Kachaso - Nkaya and Nkaya - Nayuchi sections have been newly constructed and upgraded in recent years, so the risk of damage from disasters is low.

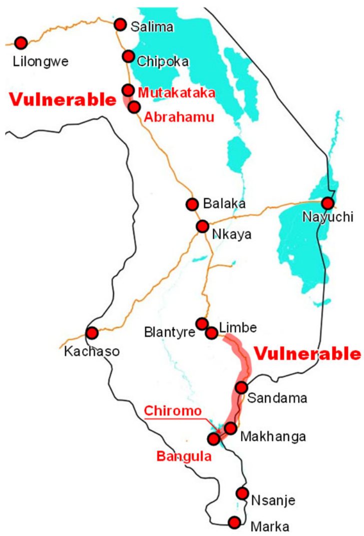


Figure 3-194 Railroad sections vulnerable to disasters in Malawi

Source: JICA Study Team

4) Consideration of Disaster Risk Reduction Measures

a) Disaster Risk Reduction Measures for Important Roads in the Southern Region of Malawi

Natural disasters such as floods occur frequently in the southern region of Malawi, and damages from cyclones have also been reported. In particular, the risk of river flooding is high in the Shire River basin, and there have been cases of road and railroad bridges being washed away by the Shire River, so that countermeasures are considered necessary for Main Roads M1 and M3 that cross the Shire River.

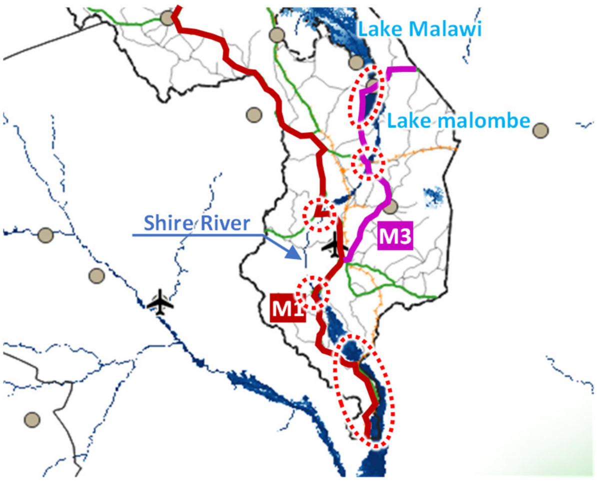


Figure 3-195　Important Main Roads (M1, M3) in the Shire river basin, Malawi

Source: JICA Study Team

The situation of damages caused by Cyclone Ana, which occurred in January 2022, is described below. Floods in the Shire River basin caused road disruptions and collapses at multiple locations, including nearby sections of Main Road M1. Many of those disrupted roads had been opened to vehicle traffic by emergency measures, but, as of February 16, 2022, there were road sections that were still cut off without being recovered due to repeated damage (see Figure 3-196 and Figure 3-197).

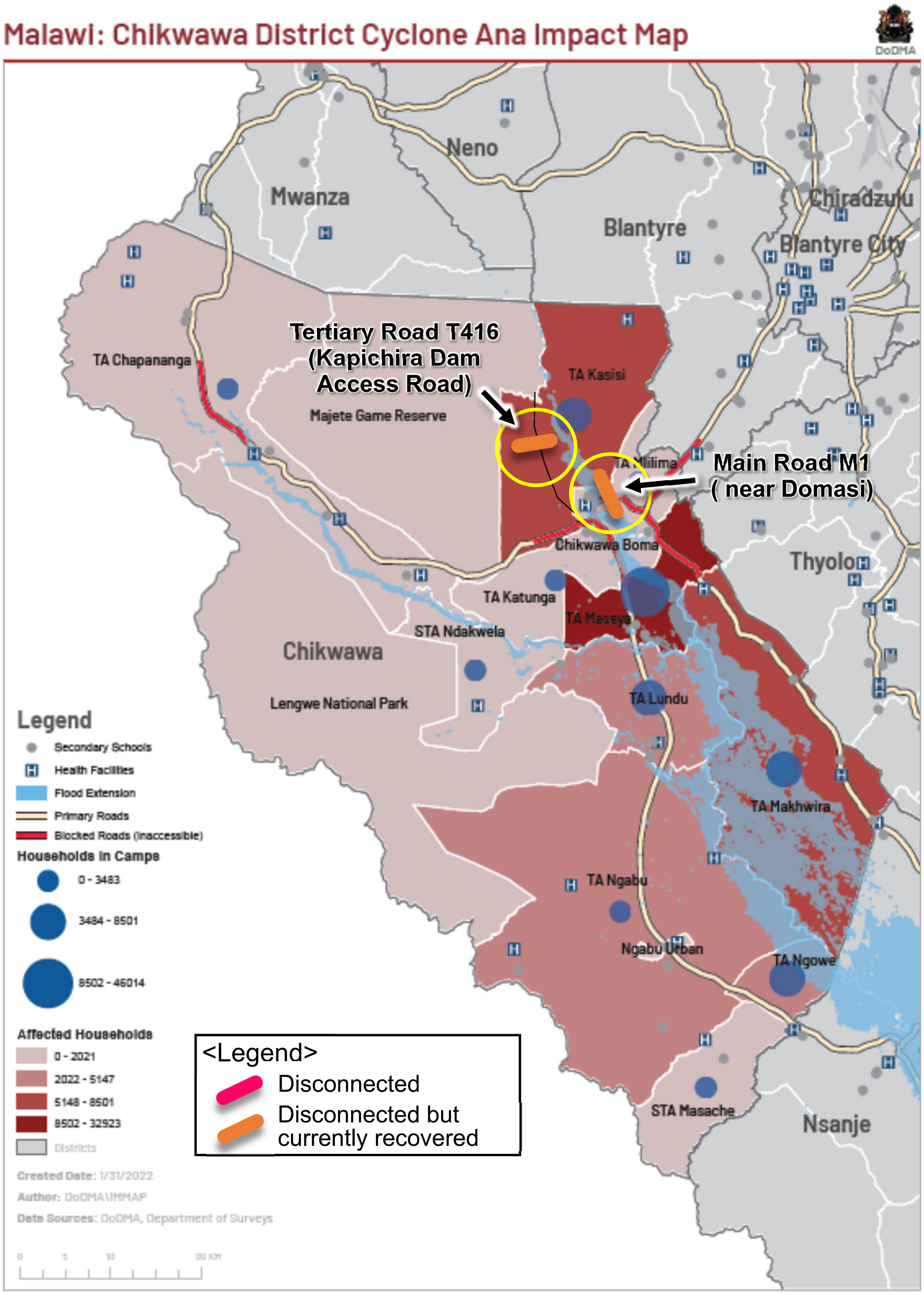


Figure 3-196 Important Roads Damaged by Cyclone Ana in Chikwawa District

Source: Prepared by JICA Study Team Utilizing Document Provided by DoDM

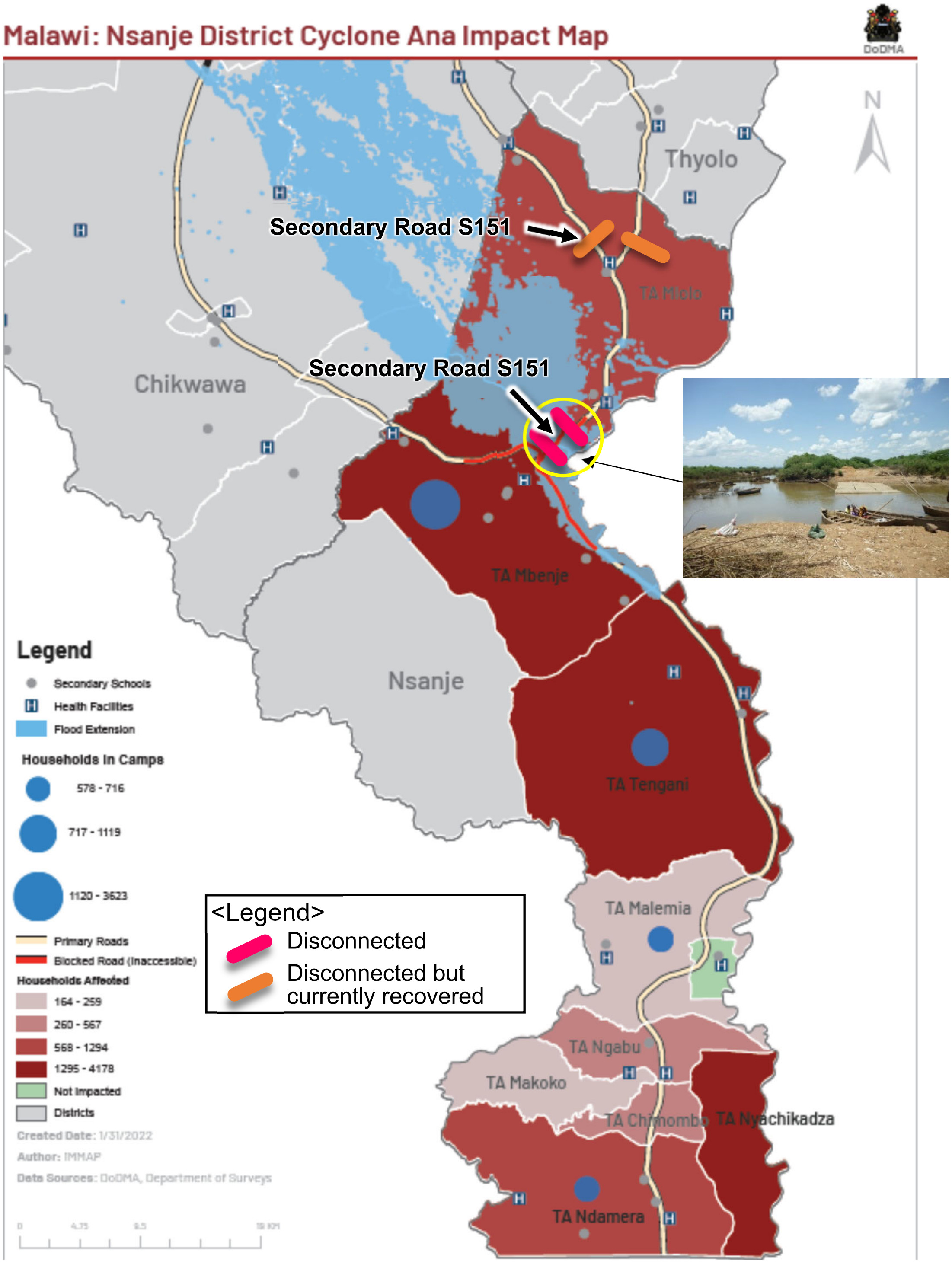


Figure 3-197 Important Roads Damaged by Cyclone Ana in Nsanje District

Source: Prepared by JICA Study Team Utilizing Document Provided by DoDMA

Situation of damages to Main Road M1 by Cyclone Anna

Main Road M1 crosses the Shire River at the section between Blantyre and Chikuwawa. No damage was seen on the bridges beyond the Shire River, but road disruptions and collapses occurred near Domasi. As of February 8, the disrupted sections had been partially restored by emergency works and were in a passable condition.

(a) Damages by Cyclone Ana

(b) Partially Restored (Feb. 8, 2022)

Figure 3-198 Damage to Main Road M1 by Cyclone Ana (near Domasi)
Source: (a) Consolidated Report CYCLONE ANA, DoDMA, (b) JICA Study Team (Feb. 8, 2022)

Situation of damages to Tertiary Road T416 by Cyclone Ana

A part of Tertiary Road T416 was disrupted, damaged by Cyclone Anna. It is a local road extending from Chikuwawa to the north, which is used as an access road to the Kapichira Dam, especially by those involved in the dam and those involved in irrigation construction works. The damage occurred in the section crossing the Mwambezi River, which is a branch of the Shire River. The Mwambezi River flows through four drainage pipes under the road, and it is considered that the insufficient capacity of the drainage pipes during heavy rain caused the damage to the riverbank outside the drainage pipes.

Figure 3-199 Damage to Tertiary Road T416 by Cyclone Ana (near the Mwambezi River)
Source: Prepared by JICA Study Team Utilizing Documents Provided by DoDMA

Situation of damages to Secondary Road S151 by Cyclone Anna

The section across the Shire River on Secondary Road S151 near Bangla was washed away multiple times in 1997, 2013, and 2015, and, as of February 2022, it is the situation that the road is impassable. Small boat is the only way to cross the Shire River, but it takes 45 minutes for one way, which is a big obstacle to move between areas. Although the importance of S151 is lower than that of M1, if it is restored, it can be expected to revitalize the eastern area of the Shire River and secure an alternative route to M1 when M1 is damaged.

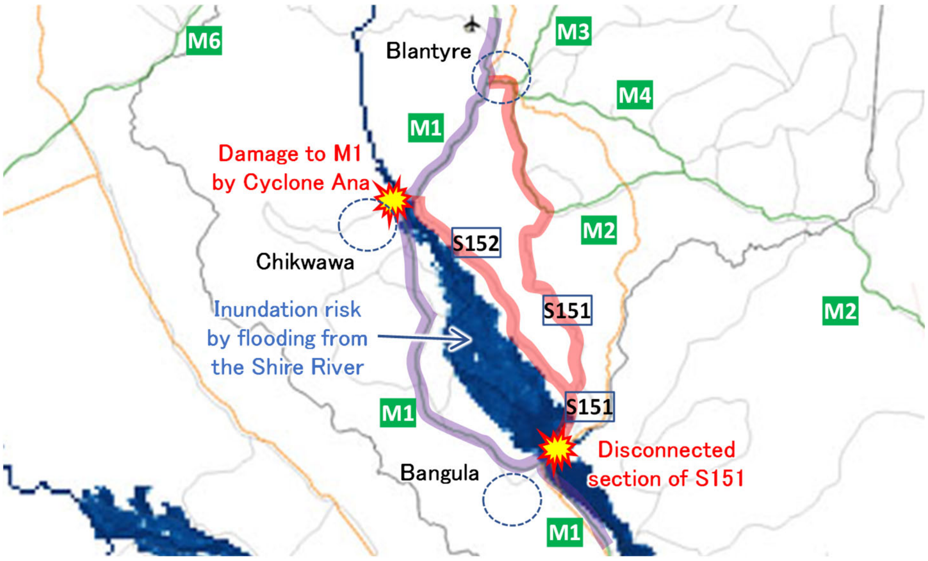


Figure 3-200 Disconnected Section of S151 and Alternative Routes to M1

Source: JICA Study Team

(3) Power

1） Overview of Relevant Organizations and Legal systems

The Ministry of Energy oversees the legal system and policy for electricity supply in Malawi. EGENCO (electricity generation) and ESCOM (electricity transmission and distribution), which operate the electricity business, were split in 2016 and are under the supervision of the Ministry of Energy.

The power generation facilities have insufficient capacity to meet demand, resulting in frequent blackouts in urban areas. The installed generation capacity is 442 MW, of which 391 MW is hydropower and 51 MW is a backup diesel power plant. The peak demand is estimated to be about 470 MW. Since the country depends on hydropower for its power supply, diversification of power sources is a goal of the energy strategy.

There are no other international interconnection lines at present, although there are interconnection lines with Zambia in some border areas.

Malawi's electrification rate is estimated at 12.0%, which is the lowest in the Southern African Development Community (SADC) region. The rural electrification rate is estimated at 3.9% and the urban electrification rate at 48.7%.

EGENCO currently operates four hydroelectric power plants at Nkula, Tedzani, Kapichira, and Wovwe, and thermal power plants at Lilongwe, Mzuzu, Mapanga, and Blantyre, but in addition to the lack of generation capacity, the lack of power transmission and distribution facilities is also a problem. As a result, there are frequent power outages in the country, making economic and social development difficult. As for hydropower generation, the major issues are the decreasing amount of rainfall, the decreasing amount of water available for power generation, and the progress of sand deposition due to the decrease in vegetation.

2） Overview of Related Plans and Development Status

A five-year mini-IRP is equivalent to an electricity MP. MNEP18 also promotes energy development and electrification, and the policy is to develop electricity, biomass, oil, biofuels, gas, coal, and nuclear power in that order. Since the country has coal and uranium reserves, these are expected to be developed.

The Southern African Power Pool (SAPP) has designated the international interconnection line with Mozambique as a priority PJ, and the goal is to have it connected by the end of 2023.

Diversification of power sources is the goal, and in addition to the DEG being enhanced, 1 GW of hydro, 500 MW of coal-fired power, and 160 MW of gas-fired power are planned to be developed by 2023. The coal-fired project is being supported by China. There are likely to be many needs for hydro design and project entities.

Power transmission and distribution facilities are being strengthened, and transmission capacity has already been increased to 1 GW.

The goal is to increase the electrification rate to 10=>30% by 2015-30 and to reduce annual power outages to 25 hours. Rural electrification has been prioritized on-grid, but off-grid will be considered in the future, and PV adoption is being promoted.

The third Malawi Growth and Development Strategy (MGDS III: 2017-2022) identifies energy as one of the key priority areas. the country's energy policy, released in November 2019, has the following goals

1) improve the efficiency and effectiveness of the commercial energy supply industry; 2) improve the safety and reliability of the energy supply system; 3) increase access to affordable and modern energy services; and 4) promote economic development and rural transformation to reduce poverty.

Based on these policies and strategies, the sector has an Integrated Resource Plan (IRP: 2017-2037) developed in 2017, which sets two major goals: to increase the capacity of transmission and distribution to a level where demand can be met, and to increase access to electricity from the current 10% to 30% by 2020. By 2020, access to electricity should increase from the current 10% to 30%. So far, the targets have not been met, and to achieve the 30% electrification target, the number of electricity connections per year needs to be increased from the current 8,000 to 90,000. To achieve this, power generation needs to be increased from the current 417 megawatts to 1,100 megawatts.

In addition, the Millennium Challenge Corporation (MCC) has liberalized the power sector and allowed Independent Power Producers (IPPs) to participate in power generation projects. thanks to the participation of IPPs and the efforts of the government and donors, many solar power projects are now underway. In Salima district, a 60 MW solar power plant owned by JCM Power has started operation in October of 2021. JCM Power has also started construction of a 20 MW solar power plant at Golomoti in Dedza district. The immediate issue regarding the introduction of renewable energy is the lack of capacity in the power transmission and distribution network.

3) Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Existing power plants are located mainly along the River Shire, which is susceptible to flooding, but little damage to power generation facilities due to flooding has been reported until 2021. On the other hand, according to the 2019 risk assessment, Cyclone Idai caused damage to power distribution lines in Chikwawa, Nsanje, Zomba, Mulanje, and Phalombe, including spills and collapses. The same area also experienced flooding in January 2007. In Malawi, the impact of the cyclone and floods on electricity supply was localized because the electrification rate in rural areas, which are often hit by natural disasters such as floods, is low and the damage was mostly to distribution lines at the end of the line, not to the main power lines.

However, in January 2022, Cyclone Ana caused major flood damage around Blantyre, shutting down and damaging the Tedzani, Nkula, and Kapichira hydroelectric power plants, which are the main power sources. Among them, Kapichira power plant, which is the largest power plant in the country with a total capacity of about 130MW, lost its water intake facilities and access roads due to the floods and has stopped generating power as of February 16, 2022. It is expected to take a considerable amount of time to restore the plant. Malawi has lost about 1/3 of the country's power generation capacity, resulting in rolling blackouts and other major impacts on both the public and private sectors.

Basically, the plant is located in six river basin systems in Malawi (Luo/Shire, Likangala/Tondwe, Limfasa/Lweya, Bwanje/Libresi, Songwe, and Rincipe) that regularly experience heavy flooding. According to the 2006 Red Cross-United Nations Flood Management Plan, the catchment areas are located where high levels of heavy rainfall occur, and the floods themselves have a greater impact because they flow through topographically flat areas.

According to the ESCOM and EGENCO websites, an overall business continuity plan has been developed, but the plan is not available online; there is no mention of business continuity planning in either EGENCO's strategic plan (2018-2033) or in the national energy policy.

<Information and discussion based on field survey>
From the perspective of improving the disaster resistance of important public facilities and establishing a BCP in light of frequent power outages, we will focus here on the situation of the Blantyre Water Corporation. The Water Authority has two water treatment plants in operation and one under construction.

The largest of these three, the Walkers Ferry Water Treatment Plant, takes its water from the middle reaches of the Shire River, 30 km west of Blantyre. In order to supply water to Blantyre City, the water is pumped up from the water treatment plant at an elevation of 394 meters to the distribution tank at an elevation of 1334 meters, a head difference of approx.1000 meters. The pumps are installed at the water treatment plant and at the Chileka reservoir located at an altitude of 785 meters in the middle of them.

This pumping consumes a lot of electricity and costs 2 billion Kwacha per month (about 290 million yen per month) at the Walkers Ferry Water Treatment Plant.

The Walkers Ferry Water Treatment Plant uses electricity from the Nukala Power Plant downstream of the Shire River, but the damage caused by Cyclone Ana shut down the Nukala Power Plant and also caused a nationwide power outage, disrupting the power supply to the plant and halting water transmission for two days. The voltage was not stable for five days. As a result, water supply in Blantyre City was restricted after the arrival of Cyclone Ana.

By the way, the Water Authority is aiming to build a new water treatment plant (apart from the one under construction) in the Shire River basin. In addition, it plans to secure 50MW of power generation capacity to power this new plant and the Walkers Ferry plant. At present, the company has secured 72 million USD (about 8 billion yen) from EXIM Bank and plans to use this budget to build a 30 MW power generation facility.

As shown above, there have been cases where the damage caused by Cyclone Ana has had a significant impact on the operation of critical infrastructure, and the BCPs of these facilities are attracting attention. The introduction of hybrid power generation systems (photovoltaic power generation + storage batteries + engine generators) will be effective as a power source that can operate even during unseasonable weather and emergencies, and as a way to introduce renewable energy to reduce fuel consumption and improve sustainability.
For this purpose, we will analyze the cost-benefit ratio by comparing the impact of the longer and shorter operating hours of the target facility due to the increased power supply and the fuel consumption of the hybrid power supply.

4） Consideration of Disaster Risk Reduction Measures

The previous part of this report explains that the key points for disaster risk analysis and disaster reduction in Malawi are Lilongwe and Blantyre, where important political and economic facilities are concentrated. Similarly, disaster reduction measures in the power sector can be better implemented in terms of cost-effectiveness by focusing on areas where the public sector and major industries are concentrated.

The concept of disaster reduction in the power sector is to enhance the resilience of important facilities and areas to disasters in order to maintain and sustain public services and industrial activities. For example, in the public sector, it is possible to create and operate facilities that can continue to supply energy to water treatment facilities, hospitals, and communication facilities even in the event of a disaster.

Also, as mentioned above, power generation facilities do not have enough capacity to meet demand, and blackouts are frequent in urban areas. The country relies on hydropower for its power supply, but with decreasing rainfall and less water available, as well as increasing sedimentation due to decreasing vegetation, diversification of power sources is a goal of the energy strategy. Malawi's electrification rate is estimated to be 12.0%, the lowest in the Southern African Development Community (SADC) region.

EGENCO owns the main power generation facilities and ESCOM owns all the transmission and distribution facilities, but there is a noticeable lack of capacity due to financial difficulties; the introduction of solar power generation facilities by IPPs is also underway, but grid constraints are putting the brakes on development.

In order to address these issues, we propose to pick up important facilities and areas in the public and private sectors, and introduce hybrid power generation equipment (solar power generation + storage batteries + engine generators) to them, which will be used as in-house power generation equipment including renewable energy (refer to Chapter 5). Improving the stability of electricity supply is important for improving the functions of government and industry, as well as for maintaining these functions in the event of a disaster. This proposal will also lead to the realization of a stable power supply while introducing renewable energy regardless of grid constraints. The first items to be implemented are as follows, and it is desirable to add capacity building and other items as appropriate.

- Survey of important public sectors that require stable power supply
- Survey of industrial sectors and industrial parks that require stable power supply
- Understanding the extent to which grid constraints are a problem for the introduction of renewable energy
- Investigating the possibility of augmenting the power supply and improving the operating rate by adding hybrid systems to existing diesel power generation facilities
- Technical and economic studies in cooperation with Japanese heavy industry manufacturers

(4) Water and Sanitation

1） Overview of Relevant Organizations and Legal systems

The Ministry of Agriculture, Irrigation and Water Development (MAIWD) is responsible for water supply and sanitation in Malawi.

The Ministry of Health and Population (MoHP) facilitates the development of the sewerage and sanitation sectors, while the Ministry of Local Government and Rural Development (MLGRD) is responsible for supporting the decentralization of ministries and the development of county governments.

The implementers of water services in urban areas are the District Councils and Water Boards. There are five Water Boards in the country, including the Lilongwe Water Board (LWB) and the Blantyre Water Board (BWB). In addition, the National Local Government Finance Committee is responsible for the distribution of the national budget to the district budgets. Rural water supplies are managed by Water User Associations (WUAs) with technical support from the Water Commissioner and the Department of Water and Sanitation.

The water relevant law is as follows.

- Water supply law

2） Overview of Related Plans and Development Status

In Malawi, water availability is a challenge, especially during the dry season, and the government attaches particular importance to irrigation and water resource management in terms of food production and domestic water supply.

The percentage of the population with access to safe water is 88.3%. At present, water resource development is a serious problem in Malawi to meet the rapidly increasing demand for water in urban and peri-urban areas due to the rapid population growth. The proportion of households with access to safe sanitation is 13.8%. (National Sanitation Strategy 2018 - 2024) The Government of Malawi aims to improve these rates with the Water Sector Investment Plan and National Sanitation and Hygiene Strategy 2018 – 2024.

Malawi has the following national plans in place for water and sanitation.

- National Water Policy
- National Water Resources Master Plan
- Malawi Vision 2063 (2020)

It states to ensure safe water and sanitation services, and to establish agricultural, industrial and domestic water supply networks throughout the country.

- Water Sector Investment Plan (2012)

In this Investment Plan, the Government of Malawi has identified the need for an average annual investment of over US$140 million between 2015 and 2030 to achive the followings.

- Ensure safe water supply to cities
- By 2025, 98% of the population will have access to an improved water supply.
- Increase access to improved sanitation to nearly 90% of the population by 2030.
- Improve sanitation facilities in schools.
- National Sanitation and Hygiene Strategy 2018 - 2024

In this strategy, the Government of Malawi has set the following sanitation targets, with no mention of urban sewerage.

- Increase the proportion of households with access to improved sanitation to 75% by 2030.
- Increase open defecation free rate (ODF rate) from 41.7% to 90% by 2030.
- LWB Strategic Plan 2020-2025

In the strategic plan, LWB has an estimated implementation budget of US$483 million over five years starting in 2020. The need to establish a disaster management mechanism for water shortage is mentioned, as the risks include diminishing catchment areas and diminishing surface water sources due to the effects of climate change. In addition to the construction of new surface water sources, well mapping around Lilongwe is planned.

JICA continues to provide support to Malawi, such as the formulation of the National Water Resources Master Plan with MAIWD as a C/P, support for strengthening the capacity for maintenance and management of local water supply facilities in the central region, technical cooperation projects on toll collection and NRW measures for LWB, and the dispatch of short-term volunteers and long-term experts. In addition, a basic information survey on BWB is currently being conducted as part of the "Data Collection Survey on the Urban Water Supply Sector".

- Project for National Water Resources Master Plan in the Republic of Malawi (JICA, 2014)
- The project for enhancement of operation and maintenance for rural water supply in the Republic of Malawi (JICA, 2015)
- Detail planning for strengthening the capacity of non-revenue water reduction for Lilongwe water board (JICA, 2017)

- Pre-survey for groundwater development and strengthening the capacity of non-revenue water reduction (JICA, 2018)
- The project for strengthening the capacity of non-revenue water reduction for Lilongwe water board (LISCaP) (JICA, 2020)
- Data Collection Survey on the Urban Water Supply Sector (JICA, on going from 2020)

The support programmes for water supply and sanitation implemented by the international donors are as follows. They implement rehabilitation and extension of urban and rural water supply and sanitation services, reduction of NRW rates, improvement of hygiene, technical cooperation and strengthening of institutional capacity in these areas.

- Water Supply and Sanitation Project as a part of National Water Development Program (AfDB / AusAid)
- Nkhatabay Town Water Supply and Sanitation Project (AfDB, 2020)
- NRWB Water Efficiency Project (Government of the Netherlands, 2021)
- Lilongwe Water and Sanitation Project (P163794) (World Bank, on going from 2018)

3) Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

a) Lilongwe City

Although it is the most densely populated city in Malawi and has the highest concentration of water and sewerage assets, hazards are low and the challenge is to secure sufficient water sources to meet climate change and rapidly increasing demand, and to increase revenue through NRW measures.

An online interview was conducted with an urban planner and a disaster management officer at Lilongwe City Council on 2 December 2021 to identify frequent flood points in the city. The provision of analytical materials is under request. The results of the interview, we checked that the LWB's water purification facilities (water treatment plant) and water transmission and distribution facilities (pumping stations and reservoirs) as of 2017, confirming that the facilities are located in low-risk areas.

b) Blantyre City

(i) Key facilities for water and sanitation in Blantyre

Blantyre City, which is at the economical center of the country, is served by BWB, which operates 3 water treatment plants and needs to manage water resources during the dry season and establish an management system to ensure a stable water supply even during flooding.

The water treatment plants for Blantyre City and surrounding areas operated by BWB are Walkers Ferry Water Treatment Plant (WTP) (water treatment capacity: 96,000 m^3 /day), which takes water from the Shire River, Mudi WTP (water treatment capacity: 5,000 m^3 /day), which takes water from the Mudi Dam in Blantyre and Mulanje WTP (water treatment capacity 20,000 m^3 /day), which takes water from the Likhubula River. The Walkers Ferry WTP is responsible for 79% of the water supply. The capacity of each facility was verified via the BWB website.

The Walkers Ferry WTP intakes water from the middle reaches of the Shire River, which passes 30 km west of Blantyre. As a feature, the water is pumped from the WTP at an elevation of 394 m to the distribution reservoir at a maximum elevation of 1334 m, a difference of about 1000 m, in order to supply water to Blantyre City. Pumps are installed at the WTP and at the intermediate point, the Chileka reservoir at an altitude of 785 m (see figure below). The pumps use a lot of electricity, and the Walker's Ferry WTP costs 2 billion kwacha/month (approximately 2.46 million US$/month).

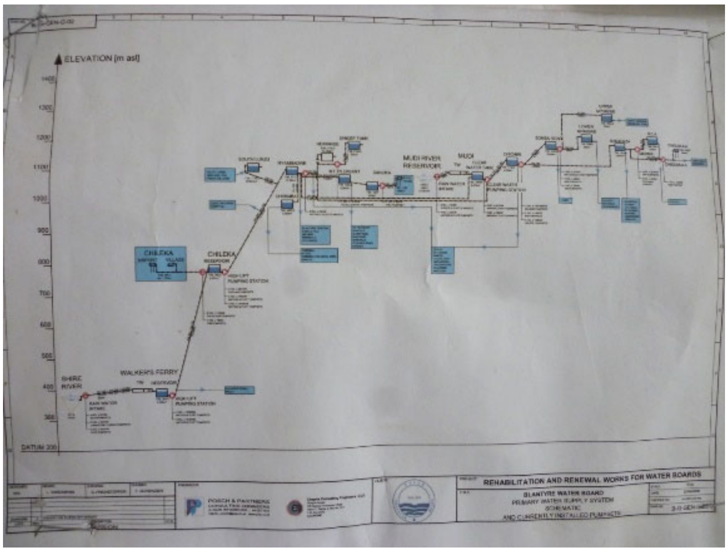


Fig. 3-1 Drawing of elevation of Walker's Ferry Water Treatment Plant and major reservoirs

Source: JICA Study Team

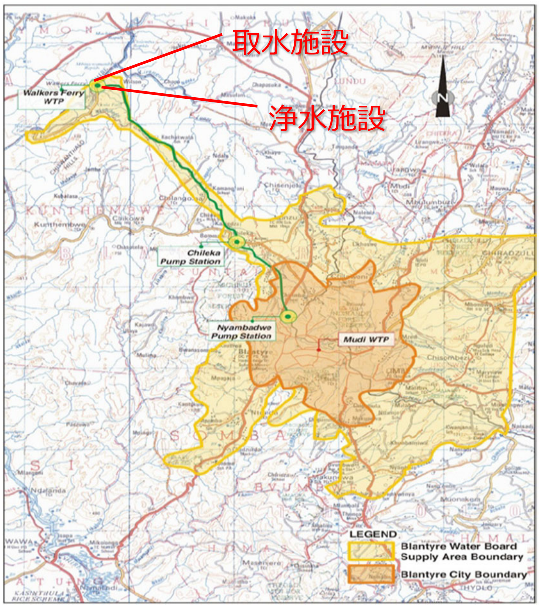


Fig. 3-2 Facility location of Walker's Ferry Water Treatment Plant

Source: Blantyre Water Board Annual Report 2017 (left), JICA Study Team (right)

(ii) Blantyre Water Board's future development plan

According to the BWB website, the future development plan includes 3 facility improvements: i) securing a new water source on the River Sire, ii) construction of an own power generation facility to secure power for the pumps, and iii) renovation of the Mudi water treatment plant.

As for i), one water intake facility, one water purification plant (planned capacity of 230,000 m^3/day), pumping facilities, reservoirs and pipelines, out of the planned construction cost of US$ 165 million, US$ 78 million has been secured from the Export Import Bank of India (EXIM Bank).

As for (ii), at present, US$ 72 million has been secured from EXIM Bank, which will be used to build a facility with a generation capacity of 30 MW. The plan is to eventually secure a generation capacity of 50 MW for pumping and the expansion of the water source in i).

As for (iii), the status of the Mudi WTP is being confirmed under JICA's "Data Collection Survey on the Urban Water Supply Sector".

(iii) Damage caused by Cyclone Ana

Interviews were conducted with Blantyre City Council and BWB officials in February 2022.

Cyclone Ana washed away and destroyed, making it unusable a dredge boat at the Walker's Ferry

WTP (see below/left), installed to prevent the blockage of the water intake facility (see above). According to an interview with the WTP manager, no direct damage was observed to the main water treatment facilities. The intake is not blocked within a few days. In the past, sediment has been manually scraped out of the intake by making water level lower. (see figure below/right).

Fig. 3-3 Damaged dredge boat (left), Scean of sediment scraping (right)

Source: JICA Study Team

In addition, the Walker's Ferry WTP uses electricity from the Nukala Power Plant downstream on the Shire River, but due to blackout at the power plant, as well as a nationwide power outage, water supply was stopped for two days. Its voltage was also unstable for five days. This resulted in restricted access to water in Blantyre immediately after Cyclone Ana attack.

(iv) Disaster risk management issues for the Blantyre Water Board

Interview was conducted with the JICA Study Team of the "Data Collection Survey on the Urban Water Supply Sector" to confirm the issues in disaster risk management in water and sanitation sector in Blantyre.

Increasing of turbidity and sedimentation volume due to sediment inflow into the Mudi Dam have become a problem. Although tree planting has started to reduce the sediment inflow around the dam since 2016, high turbidity levels have not improved.

At the time of the interview (January 2022), no major damage due to flooding had been found of at key water supply facilities, including the Walkers Ferry WTP. However, as noted above, Cyclone Ana, which struck in January 2022, affected the dredge boat and electricity supply. The risk of concern in the event of a similar or larger cyclone to Ana striking in the future is the long-term suspension of water purification and transmission functions as a result of power supply interruptions. The challenge is to improve both hardware measures, such as securing back-up power supply, and software measures related to early restoration of functions and rapid emergency response.

A COVID-19 committee has been set up within BWB in response to the impact of the pandemic on the operational structure. No BCP for disasters has been developed.

Blantyre City Council has not yet developed a disaster risk management plan and BCP, but is preparing to conduct a hazard analysis with the support of the World Bank. The result of the hazard analysis in the city is essential to develop the plans for BWB.

c) Rural areas

Malawi has a higher proportion of rural population than neighbouring countries and access to improved water supply is lower in rural areas at 63% compared to 87% in urban areas. (UNICEF)

Rural water supply systems were affected by the floods associated with Cyclone Idai. The damage to the WASH sector is estimated at approximately US$3.7 million.

In addition to risk reduction through flood control projects, it is necessary to secure spare parts and improve repair capacity by improving water supply revenue through capacity building of WUAs and other suppliers.

JICA implemented technical cooperation on rural water supply with MAIWD, Central Region Irrigation and Water Development Office and Mchinji District Office as counterpart agencies under the "Project for enhancement of operation and maintenance for rural water supply" in 2015. It is expected that the maintenance framework implemented in the project will be rolled out on a national scale to improve resilience to disasters.

It is also envisaged that there will be a need to drill 100m class wells across the country that are less vulnerable to drought.

4) Consideration of Disaster Risk Reduction Measures

The projects to strengthen the disaster risk management capacity of BWB are proposed as a candidate project for disaster management measures.

a) Ensuring back-up electricity supply.

In view of the past damage and the impact on Blantyre's drinking water supply, it is assumed that stabilising the water supply through stabilising the electricity supply would be effective. As BWB is already considering the construction of its own power generation facilities, a stable supply of electricity is urgently needed to supply water to Blantyre City.

For this reason, it is assumed that hybrid power generation facilities (solar power + storage batteries + engine generators), which are being considered as a disaster prevention measure by the power sector, can be used as an emergency power source to shorten the time during which water supply is suspended.

b) Support for BCP development

As securing drinking water in the event of a disaster not only saves lives and maintains sanitation, but also forms the basis for economic activities, it is envisaged that the formulation of a BCP will prevent the suspension of water supply services in the event of a disaster, shorten recovery times and contribute to minimising the impact on human lives and the economy.

Support proposals for BWB are under consideration in the ongoing the “Data Collection Survey on the Urban Water Supply Sector”, but according to the JICA Study Team, there are no plans to include a disaster management component. It is necessary to avoid creating confusion in BWB by making proposals that have not been presented in the current study, and it is desirable to clarify the disaster management issues of BWB and build a support proposal based on the results of hazard and risk analysis and disaster management planning for the entire city of Blantyre, while continuing support and dialogue with BWB.

(5) Telecommunication

1） Overview of Relevant Organizations and Legal systems

The basic law for the telecommunications sector in Malawi is the COMMUNICATIONS ACT (Cap. 68:01). The Ministry of Information and Communications Technologies is responsible for formulating Malawi's ICT policy and provides policy guidance on media, access to public information, broadcasting, telecommunications, postal services and ICT matters. The Malawi Communications Regulatory Authority (MACRA) is responsible for the regulation of the telecommunications industry. MACRA was established in 1998 as the sole and independent regulatory authority, and although it is legally independent, its board members are appointed by the government[64].

2） Overview of Related Plans and Development Status

Malawi's telecommunications sector is underdeveloped and expensive. According to the ITU's Measuring the Information Society Report 2016, the country's telecom sector ranked 168th out of 175 countries in the world, mainly due to low per capita income and high prices for telecom services. In 2014, ITU reported that the average expenditure on cell phones by Malawians exceeded 56% of their average monthly income, which is very high compared to other countries[65]. As of 2016, there were 110,000 fixed-line phones in the country, with a penetration rate of 0.7%, and approximately 7.18 million cell phones with a penetration rate of 15.7%. International calls cost US$0.3 per minute, cell phone calls cost about US$0.3 per minute for domestic calls, US$0.9 per minute within the African region, and about US$1.50 per minute for intercontinental long-distance calls (although various packages are available from US$0.30 per minute). As of 2019, Malawi's Internet penetration will be only about 15%. Internet access costs around US$50 per month for a 20MB package (as of 2016).

[64] https://hojo.keirin-autorace.or.jp/seikabutu/seika/21nx_/bhu_/Folder_2/21-125koho-03.pdf
[65] https://en.wikipedia.org/wiki/Communications_in_Malawi

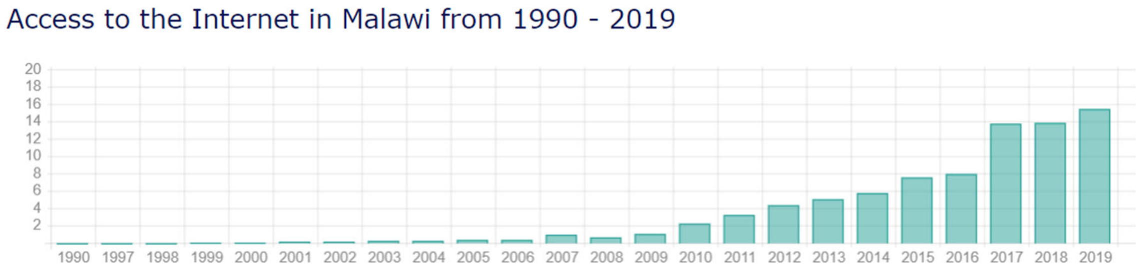


Figure 3-201 Percentage of Population with Access to the Internet (1990-2019)

ource: Worlddata.info[66]

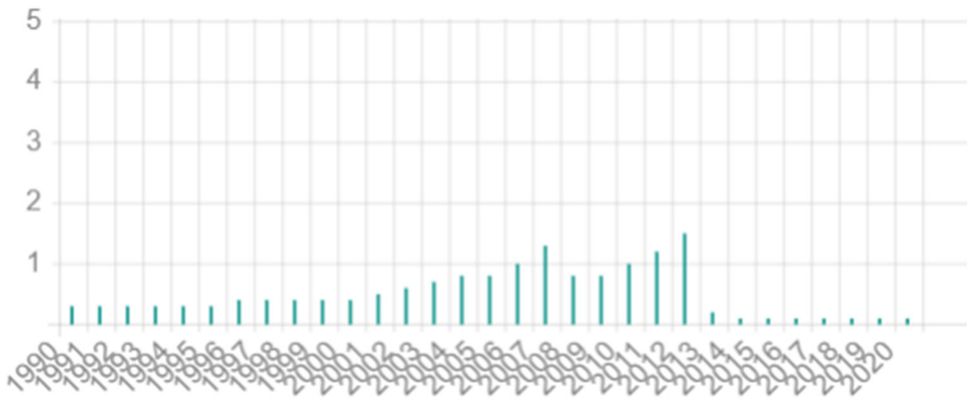


Figure 3-202 Percentage of Polulation with Fixed-line Subscriptions

Source: Worlddata.info

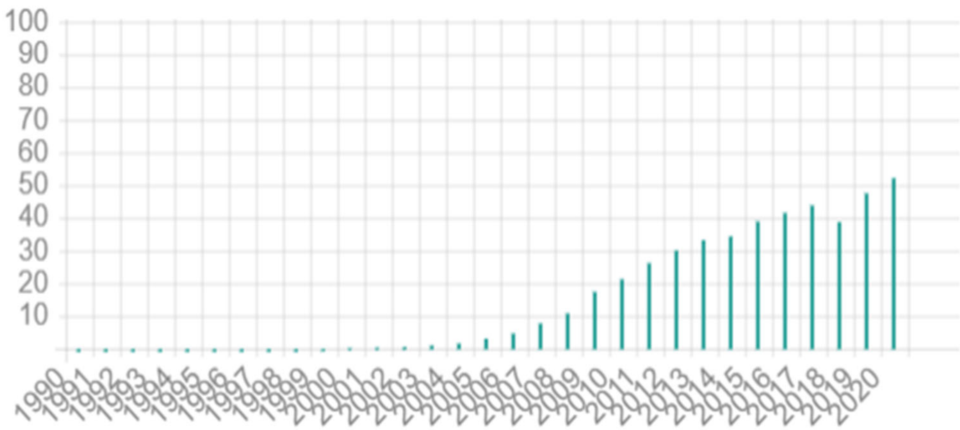


Figure 3-203 Percentage of Population with Mobile Line Subscriptions

Source: Worlddata.info

[66] www.worlddata.info/africa/

Table 3-169 Key indicators for Malawi's Telecommunications Sector (ITU Estimation, 2017[67])

Indicator	Malawi	Africa average	World average
Number of fixed-line subscribers (per 100 population)	0.1	0.9	13.0
Number of mobile subscribers (per 100 population)	41.7	74.4	103.6
Number of mobile broadband subscribers (per 100 population)	25.5	24.8	61.9
3G population coverage (%)	50.0	62.7	87.9
LTE/WiMAX population coverage (%)	30.0	28.4	76.3
Internet access population rate (%)	13.8	22.1	48.6
Percentage of households with PCs (%)	6.3	8.9	47.1
Percentage of households with Internet access (%)	11.1	19.4	54.7
Average Internet bandwidth per user (kbps)	3.6	11.2	76.6
Number of mobile broadband subscribers (per 100 population)	0.06	0.6	13.6

Source: ITU

There are two mobile operators in Malawi, Airtel Malawi Limited (Indian company) and Telekom Networks Malawi Limited (TNM). Airtel Malawi Limited provides only mobile services, while TNM provides fixed-line and mobile services. TNM was established in 1995 as a joint venture between the existing Malawi Telecommunication Limited (MTL) and Telecom Malaysia. TNM then acquired the shares of Telecom Malaysia in 2007, and in 2008, it listed some of its shares on the local stock market. The remaining shares are owned by local companies in the private sector in Malawi. Airtel Malawi Limited, on the other hand, is a subsidiary of the Bharti Group and was established in 1999.

Although cell phone penetration has increased since around 2008 as a result of investment in networks and equipment by telecom operators, access to cell phones has been relatively low, partly due to taxes, coupled with relatively high prices. Only slightly less than half (45%) of households had a cell phone in 2015. Mobile broadband services were launched by TNM in 2009 with 3G services, followed a year later by Airtel. TNM launched commercial 4G (LTE) services in 2016 and Airtel Malawi in late 2017.

On the other hand, the fixed-line service market in Malawi is very small, with the two main operators being Malawi Telecommunications Limited (MTL) and Access Communications Limited (ACL). MTL has a 95% market share in the trunk line and is also dominant in the upstream transmission service market. MTL was privatized at the end of 2005 and sold to a

[67] https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2018/MISR-2018-Vol-2-E.pdf

consortium led by Press Corporation, the country's largest conglomerate, with the Malawian government owning 20% and the remaining 80% is owned by the conglomerate which also owns 41% of TNM. MTL and ACL also operate CDMA-based fixed wireless networks that support full mobility and broadband access with Evolution-Data Optimized technology. MTL is also deploying WiMAX Worldwide Interoperability, currently used by ISP resellers. In 2016, however, MTL's fiber optic backbone operations were spun off into a new company called Open Connect Limited (OCL). Fixed broadband options include ADSL, fixed wireless broadband, and fiber optics for urban businesses and governments.

As an inland state, a nationwide fiber optic network is essential for Malawi. OCL operates the largest fiber optic backbone, which is connected to the EASSy (East Africa Submarine System) submarine cable via Tanzania. The fiber optic network was monopolized by OCL until recently, but with the development of the optical backbone network by Huawei (see below), new backbone operators such as SimbaNet, Electricity Supply Corporation of Malawi, and Airtel have entered the market. In 2008, Malawi Internet Exchange, an IXP (Internet Exchange Station), was established in Blantyre.

MACRA, the telecommunications regulator, has released its Strategic Plan 2015-2020. This plan is aligned with the higher level plan, Malawi Growth and The Way, and consists of two pillars: Development Strategy (MGDS II) and National ICT Policy. According to MACRA, it adopted the Balanced Score Card (BSC) methodology to improve on the 79% progress of its earlier Strategic Plan 2010-2015. The plan identifies the following issues for the telecom sector.

- The need to promote fair competition, consumer protection, and facilitate access and usage of ICT services
- The need to enhance ICT operational technology and pursue research, innovation, and best practices
- Development of effective and reliable systems through the implementation of secure ICT systems and services
- Strengthening relationships and communication with stakeholders
- Promoting regional and international cooperation in the ICT field
- Strengthening human capital and sharing timely and reliable information
- Strengthening of revenue growth and management, and optimization of resource allocation
- Improving institutional capacity and corporate governance for better service delivery

Malawi is connected to the international Internet through Tanzania and Mozambique via fiber optic cables, but the available bandwidth is narrow and the network speed is low, resulting in slow communication speed within the country. For this reason, Malawi, like other sub-Saharan countries, is developing an optical fiber backbone throughout the country with the support of China. Specifically, after the entry of the Chinese-owned Huawei into the Malawi market in 2008, the National Fiber Backbone Project (Phase 1) started in April 2017 with a loan of US$23 million from the Chinese government and was completed in February 2018. This is a fiber optic network along the transmission line constructed by Huawei and operated by ESCOM, with a total length of 1,230 km of fiber optic backbone connecting 28 regions from Mapanga to Chiradzulu and Zomba to Liwonde. This has dramatically improved the level of information and communication in Malawi, and 4G services have been launched in the country. Furthermore, in June 2021, President Lazarus Chakwera announced the launch of the National Fiber Backbone Project (Phase 2) from Lilongwe. Phase 2 will also be implemented by Huawei and will involve the deployment of 3,000 km of fiber optic cable over four years and the construction of a nationwide data center. The project aims to improve connectivity nationwide through the deployment of broadband services that will connect government ministries, over 100,000 businesses and households[68]. In addition to investing in ICT infrastructure, Huawei has also provided ICT training to six Malawian youths through its "Seeds of the Future" program in Malaysia.

Figure 3-204 Then President Mutharika of Malawi and Huawei Senior Vice President Yi Xiang

Source: Huawei Website[69]

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Malawi's domestic optical trunk cable network connects Mzuzu, Lilongwe (capital city), and Blantyre (international GW station). These three cities have a high concentration of important

[68] https://www.commsupdate.com/articles/2021/06/30/malawi-kicks-off-second-phase-of-national-backbone-project/
[69] https://www.huawei.com/cn/news/2018/8/huawei-malawi-national-ict-construction

facilities in the telecommunications sector. If the communication hubs in these three cities were to be damaged or the optical cable routes connecting the three cities are interrupted due to a disaster, not only would mobile subscribers be severely affected, but in the worst-case scenario, the international Internet connection would be interrupted, making it impossible to check the situation in the affected areas. Also, there are no backup lines on this trunk line route according to the results of the desk survey. Therefore, focusing on the fiber optic cable network connecting these three cities and other cities will be a better measure in terms of cost effectiveness. However, as already mentioned, it is important to note that the fiber optic cable network in Malawi is being developed by foreign companies.

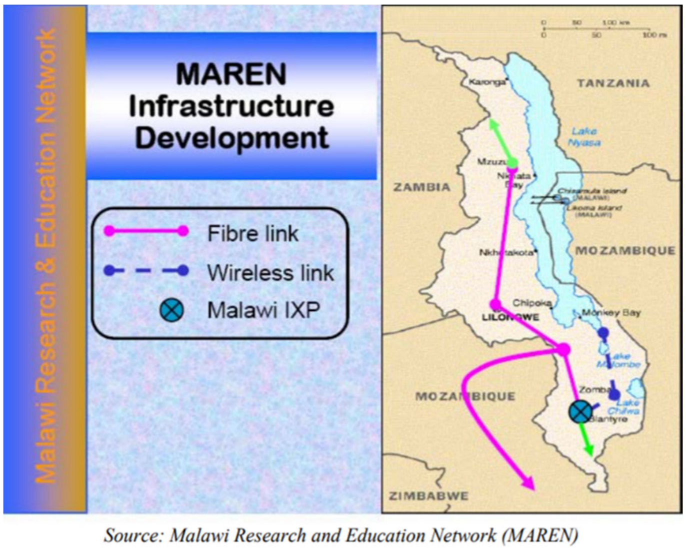


Figure 3-205 Malawi's Domestic Optical Trunk Cable Network (MAREN)70
Source: IDRC(International Development Research Centre, Canada)

4) Consideration of Disaster Risk Reduction Measures

Documents obtained by the field survey team from MACRA[71] states that "The licensee shall develop a business continuity plan that includes a disaster recovery plan (DRP) for the electronic communications hub. The DRP should include an emergency contingency team to work on hub recovery in the event of a disaster or national emergency, as well as priorities and procedures for recovery. Furthermore, if the electronic communication network hub is considered to be

[70] https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/40489/128889.pdf
[71] COMMUNICATIONS (ELECTRONIC COMMUNICATIONS FACILITIES INSTALLATION)) RULES, 2022

nationally and socially important, the hub's administrator shall prove that the hub has the ability to survive a failure.” For this reason, a web conference was held with TNM (Telekom Networks Malawi Limited), the largest telecom operator, in an attempt to obtain information about the DRP, but the specific information was not available because it could not be disclosed until after the NDA is signed. When considering disaster prevention measures in the future, it is necessary to check the DRPs of telecommunications operators including TNK.

(6) Agriculture

1) Overview of Relevant Organizations and Legal systems

a) Ministry of Agriculture (MA)

MA's mission is to promote and facilitate strides that increase agricultural productivity and sustain good management and efficient use of land based natural resources to ensure food security and increased income. MA has the following technical divisions.

Table 3-3 Department of MA

Department	Role
Department of Animal Health and Livestock Development, AHLD	・ To promote sustainable livestock development and protect the general public from zoonotic diseases through the delivery of animal production and veterinary services.
Department of Agricultural extension services	・ To coordinate all technical departments of the ministry of agriculture, irrigation and water development in the delivery of agricultural extension services.
Department of Agricultural Planning Services	・ To provide guidance on preparation and implementation of agricultural policies; ・ To identify and prepare projects and programme proposals for the ministry; ・ To monitor and evaluate agricultural sector projects and programmes; ・ To coordinate agricultural marketing issues; ・ To collect, analyze and maintain agricultural statistics and databank; ・ To coordinate the implementation of food security programmes; and ・ To analyze and advise the Ministry on sectoral policies.
Department of Agricultural Research Services	・ To research cereals, horticulture, grain legumes, livestock and pastures, Soils and Agricultural Engineering, and plant protection.
Department of the Crop Development	・ To address the knowledge gap at frontline extension workers level and specialized crop based farmer organizations; ・ To provide crop production technical services in order to enhance effective diffusion of technologies released by the Agricultural Technology Clearing Committee (ATCC); and ・ To provide services for farm mechanization, migratory pest control and seed certification.
Department of Irrigation	・ To develop new irrigation schemes to foster sustainable irrigation development; ・ To manage and rehabilitate existing irrigation schemes; ・ To implement a project aimed at building the capacity of its staff and other stakeholders for sustainable irrigation development and management; ・ To promote introduction of gravity-fed technology cost-effectiveness which is cost-effective.
Department of Land Resources Conservation	・ To development of policies and strategies relating to land resources management; ・ To planning and coordination of programmes on land resource management;

Department	Role
	・ To planning and coordination of programmes on agriculture adaptation and mitigation to the effects of climate change ・ To providing land resources information services; ・ To monitoring and evaluating land use/cover changes; ・ To provide training in land resources management, and ・ To provide technical support in land resource management.

The following organizations are set under the MA: (i) Agriculture Development Division (ADD), (ii) District Agriculture Office (DAO), and (3) Extension Planning Areas (EPA).

b) Water Resource Board

It is responsible for water rights licensing and monitoring compliance with water rights. For the development of irrigation schemes, water rights must be licensed by the board.

2） Overview of Related Plans and Development Status

a) Related plans

i) Malawi Growth and Development Strategy III, MGDS III (2017 ‐ 2022)

The MGDS III focuses on agriculture as one of its key priority areas. In order to achieve a sustainable agricultural transformation that adapts to climate change and improves ecosystem services, the strategy's outcomes are: i) increasing agricultural production and productivity; ii) increasing land under irrigation; iii) agricultural diversification; iv) improving nutrition and food security; and v) developing agricultural market development, agro-processing and value addition.

ii) National Agriculture Policy, NAP (2016-2021)

The goal of the NAP is to achieve sustainable agricultural transformation that will result in significant growth of the agricultural sector, expanding incomes for farm households, improved food and nutrition security for all Malawians, and increased agricultural exports. The NAP has identified eight policy priority areas: i) sustainable agricultural production and productivity; ii) sustainable irrigation development; iii) mechanization of agriculture; iv) agricultural market development, agro-processing and value addition; v) food and nutrition security; vi) agricultural risk management; vii) empowerment of youth, women and vulnerable groups in agriculture; and viii) institutional development, coordination and capacity strengthening. Strategies for agricultural risk management include coordinating and strengthening key institutions in agricultural risk management such as ADMARC, Department of Disaster Management Affairs, National Food Reserve Agency, grain reserves, increasing farmer adoption of drought and flood tolerant crop varieties, and promoting the use of agricultural insurance.

iii) National Agricultural Investment Plan, NAIP (2017-2022)

NAIP was formulated to operationalize the NAP by guiding investment focus in the sector to accelerate i) agriculture transformation, ii) economic growth and iii) poverty reduction. To strengthen resilience to disasters, a policy priority area of the NAP, the plan proposes to i) train farmers on climate resilient agroforestry practices, ii) extend new agricultural technologies and climate resilient approaches, iii) reduce agricultural carbon emissions, and iv) increase resilience of production systems and promote sustainable management of natural resources.

iv) National Irrigation Master Plan and Investment Framework, NIMPIF (2015-2035)

NIMPIF consists of four mutually supporting components including the development of selected new irrigation schemes, sustainable management of existing schemes, building the capacity of Malawi's relevant institutions and human resources, and management of master plan implementation.

The master plan will be implemented in three phases: Phase I (2015-2020), phase II (2021-2025) and Phase III (2026-2035) comprising approximately 20,000 hectares, 28,500 hectares and 67,500 hectares of new irrigation schemes in Phases I, II and III respectively. These targets comprise a combination of schemes already in the pipeline and new schemes which have been identified as part of the IMP process but are yet to undergo feasibility and design studies.

b) Development status

i) Japan's Assistance Policy

Bearing in mind Japan's technological comparative advantage and past cooperation, the goals set at TICAD 7, and support for "transformation to sustainable agriculture that adapts to climate change and promotes ecosystem services," which is a priority area of MGDS III, Japan will promote industrialization of agriculture and contribute to economic growth through cooperation in (1) irrigation development and capacity building, (2) extension of market-oriented agriculture and strengthening producer organizations empowerment and supporting business mindset development, and (3) agricultural infrastructure development (such as irrigation and logistics).

The main assistance provided from Japan in the agricultural sector related to this project in recent years are summarized below.

Table 3-4 Japan's Assistance

Project	Summary	Duration
Project for Enhancing Capacity for Medium Scale Irrigation Scheme Development, Operation and Maintenance (Technical Cooperation)	The previous project, "Project for Development of Medium Scale Irrigation Schemes (MIDP)", promoted capacity building of irrigated agriculture project officials at the field level and the establishment of a monitoring and evaluation system, and the capacity building process was organized as the "MIDP Training Approach". The project supported the establishment of a system for training irrigation engineers for the development of medium-scale irrigation projects, mainly in Department od irrigation, Ministry of Agriculture, Irrigation and Water Development at the central level. This was expected to promote the development of medium-scale irrigation projects at the national level.	2015 - 2020
Middle Shire Catchment Management Activity Promotion Project (Technical Cooperation)	In a previous project, more than 30,000 households in two Traditional Authorities in Blantyre Province were trained in soil conservation and forestry techniques, which contributed to soil conservation and increased yields. This project supported the institutionalization of watershed conservation activities by farmers and contribute to the implementation of appropriate watershed management in the target areas, aiming for the widespread implementation of watershed conservation activities in the four provinces in the middle reaches of the Sire River.	2013 - 2018

Source: JICA Study Team

ii) Assistance by related donors and private sectors

Assistance by related donors and private sectors in the agricultural sector related to this project in recent years are summarized below.

Through Feed the Future, USAID is coordinating with the Malawian government to: (i) develop enabling agricultural policies; (ii) improve nutrition through behavior change and increased access to food; and (iii) Invest in crops, like dairy and legumes, with high potential for domestic and export markets.

Table 3-5 Assistance by related donors and private sectors

Project/Donor	Summary	Duration/Cost
Shire Valley Transformation Programme (SVTP) Phase 1 / WB	The program will improve the sustainable management and utilization of natural resources to increase agricultural productivity and commercialization for targeted households in the Shire Valley. It focuses on four key areas: (i) irrigation service; (ii) land tenure and natural resources management; (iii) Commercialization of Agriculture; and (iv) landscape and environmental conservation. In fase-1, the Main Canal and Main Canal 3 will be constructed from the intake at Kapichira dam. In fase-2, Main Canal 2 will be constructed (Extension to Bangla in Nsanje District）. These canal will provide gravity irrigation without the use of pumps.	2018 - 2023 US$ 234.59 million

Source: JICA Study Team

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Loss and damage to the agricultural sector caused by recent disasters are summarized in the following table.

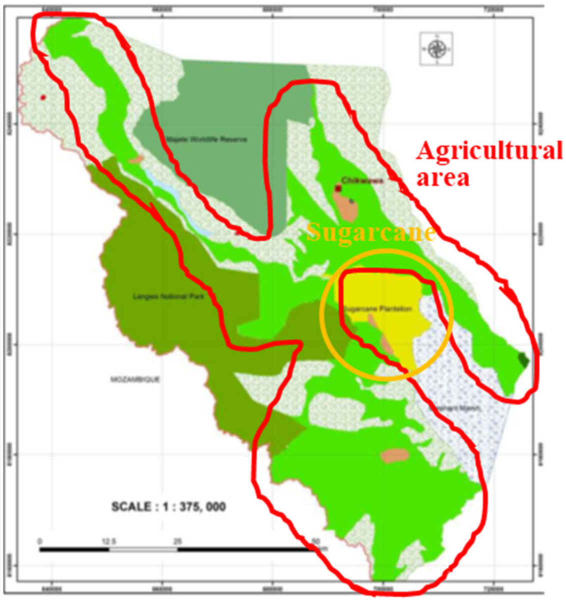
Table 3-6 Damage and loss to agricultural sector (Flood)

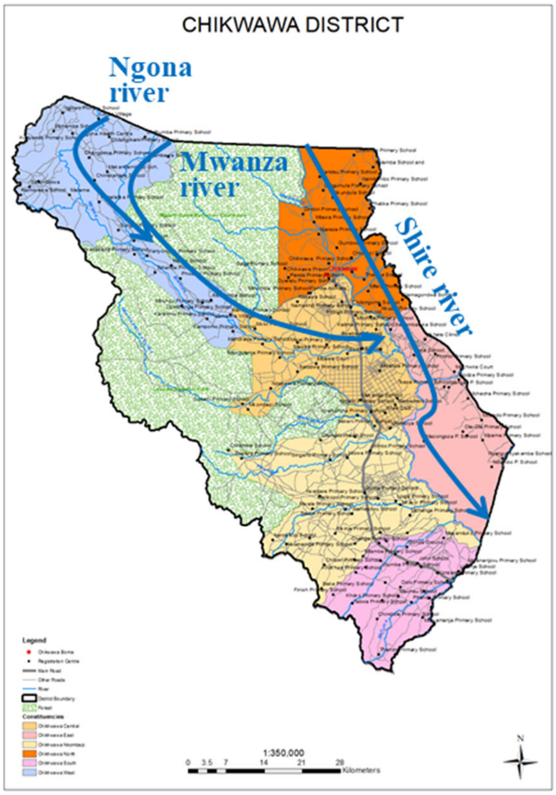
Year	Area	Outline
Jan. 2022 Tropical Storm Ana (Preliminary data)	19 Districts (Chikwawa and Nsanje districts have suffered significant damage to the agricultural sector)	・ Total damaged area: 71,716 ha (Chikwawa district: 42,276.7 ha) ・ Affected irrigation systems: Further investigation is needed (Chikwawa district: 11 irrigation scheme, headworks, pipeline for irrigation and irrigation canal) ・ Affected livestock: 36,803 heads (Chikwawa district: 500 cattle, 533 goats, 201 pigs and 10,127birds)
Mar. 2019 Cyclone Idai	15 Districts（Balaka, Blantyre, Chikwawa, Chiradzulu, Dedza, Machinga, Mangochi, Mulanje, Mwanza, Neno, **Nsanje, Phalombe,** Thyolo, Zomba） 2 City (Blantyre and Zomba) * Districts in bold are those with significant crop losses *Underlined are districts with the most damage to irrigation infrastructure.	・ Total damaged area: 91,638 ha ・ Affected irrigation systems: Further investigation is needed (headworks: 64, irrigation canal: 67,734m, embankment for irrigation: 19m , pump station: 134, well for irrigation: 607 and drainage canal: 47m) ・ Affected livestock: 47,504 heads ・ Total cost of damage: US$ 4.3 million (irrigation infrastructure) ・ Total cost of loss: US$ 20.7 million ・ Total recovery and reconstruction cost: US$ 37.5 million

Year	Area	Outline
Jan. 2015	15 Districts (**Nsanje**, **Chikwawa**, Phalombe, Zomba, **Mangochi**, Blantyre, Chiradzulu, Thyolo, **Mulanje**, Balaka, Machinga, Ntcheu, Salima, Rumphi and Karonga) * Districts in bold are those with the most damage in the agricultural sector	・ Total damaged area: 89,110 ha ・ Affected irrigation systems: Further investigation is needed (headworks: 56, irrigation canal: 46,776m, embankment for irrigation: 173m , pump station: 121, well for irrigation: 2,707 and drainage canal: 280m) ・ Affected livestock: 195,032 heads ・ Total cost of damage: US$ 54.4 million (irrigation infrastructure: US$ 5.6 million) ・ Total cost of loss: US$ 20.7 million ・ Total recovery and reconstruction cost: US$ 78 million

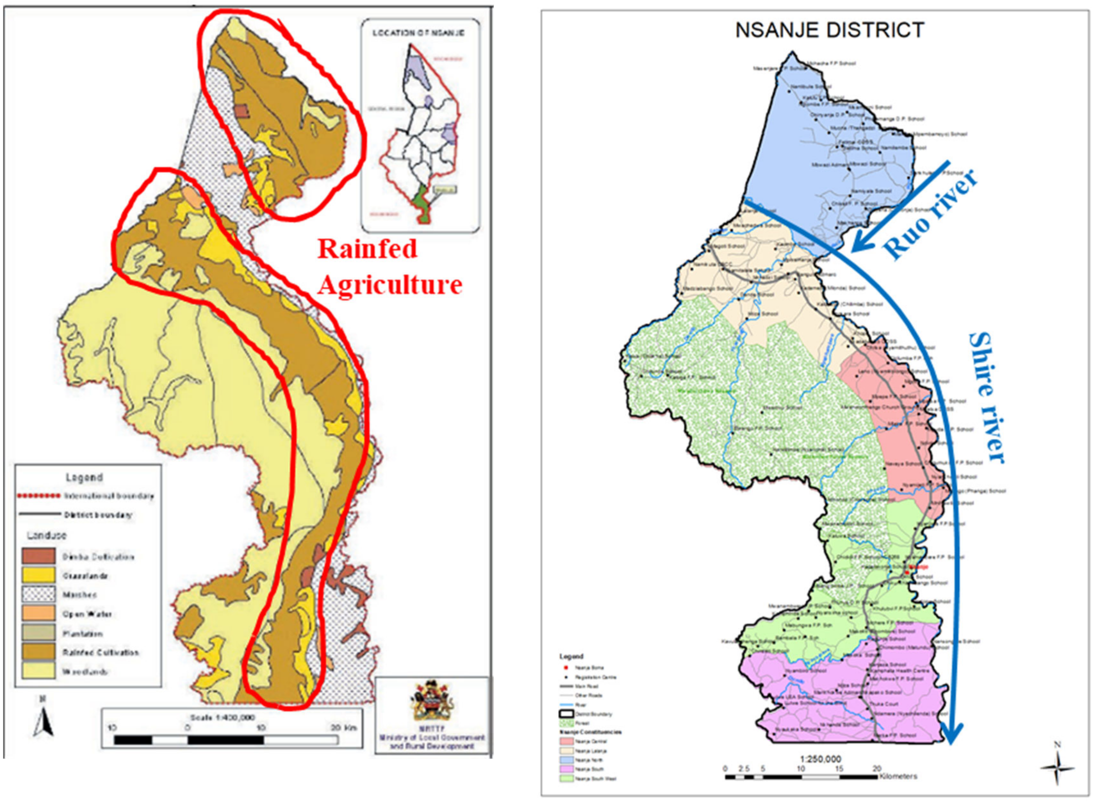
Source: JICA Study Team

The flood-affected areas in the agricultural sector in recent years are Nsanje, Chikwawa, Phalombe, Zomba, and Mangochi districts. According to DLRC, damage is particularly severe in Chikwawa and Nsanje districts. The figure below shows that agricultural land and irrigation systems are spread along the Shire River and its tributaries in the two districts.





Chikwawa district



Nsanje district

Figure 3-4 Land use in Chikwawa and Nsanje districts

Source: Chikwawa District Physical Development Plan
Nsanje District Council Socio-Economic Profile

According to interviews with Chikwawa DAOs, the main cause of damage to agricultural land and irrigation systems in Chikwawa District is due to the overflowing of the Shire River. However, the damaged areas during Tropical Storm Ana in January 2022 and Cyclone Idai in March 2019 were found to be different as shown in the figure below. The flooding in the steep gradient tributaries during Tropical Storm Ana occurred due to the heavy rain with 240 mm rainfall in 24 hours, which was much higher than the 150 mm rainfall in 24 hours during Cyclone Idai.

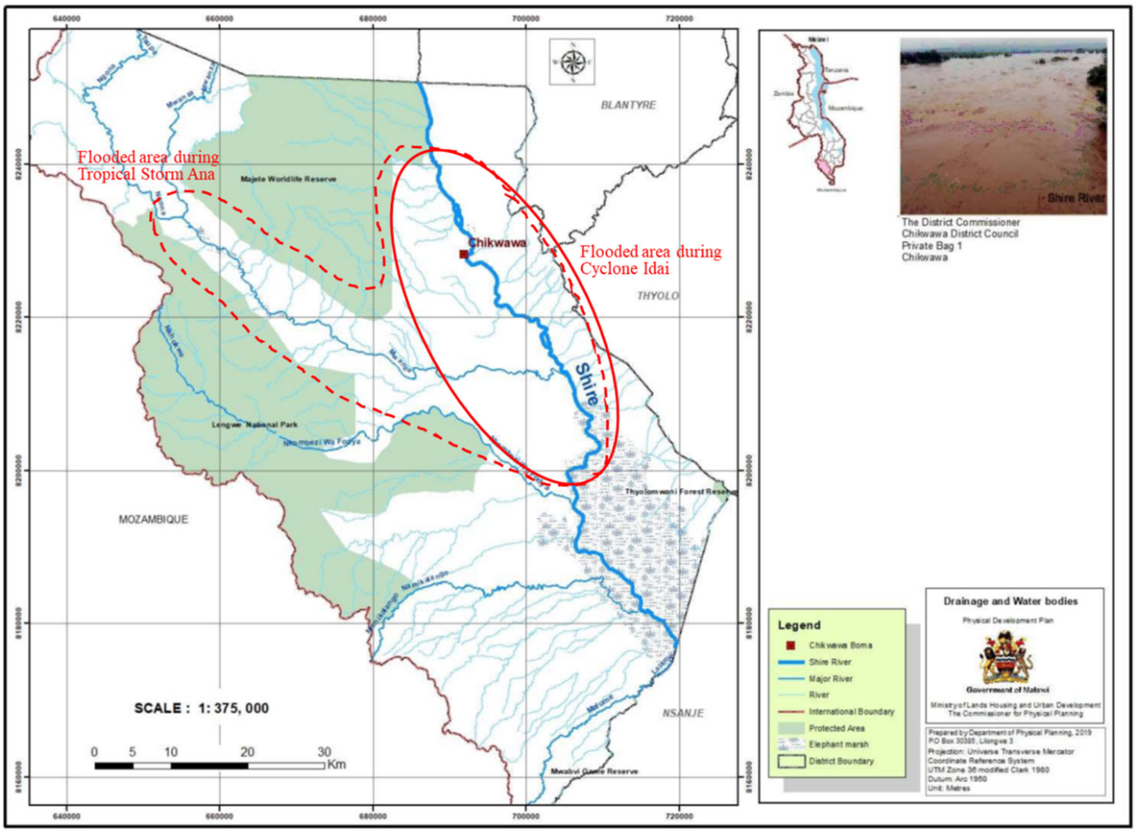


Figure 3-5 Comparison of flooding areas between Cyclone Idai and Tropical Storm Ana (Chikwawa District)

Source: Chikwawa District Physical Development Plan

Damaged irrigation facility

Flooded maize fields

Figure 3-6 Damage by Tropical Storm Ana

Source: Provided from Chikwawa DAO

Chikwawa and Nsanje districts have abundant water resources such as the Shire River and fertile soil, and are said to have high potential for irrigation. In Chikwawa, there are 4 large sugarcane plantations and 1 large cotton plantation other than small farmers, which are irrigated. In addition, solar energy is actively used for irrigation. The Mbande Solar Powered Irrigation Scheme and Mthumba Irrigation Scheme along the old M1 road use electricity generated by solar cells to irrigate and grow various crops. In many irrigation schemes, the pumps are used to transport water from the source to the fields. Flooding affects the canals and pipes during the rainy season.

The irrigable area in Nsanje Province is estimated at 42,000 hectares, and irrigation is promoted through foot pumps using shallow wells, direct use of water from rivers, electric sprinklers and surface irrigation.

Since the SVTP Phase 1 by WB has been implemented across both districts (see figure below) and irrigation development is expected to expand in the future, disaster risk reduction measures are needed for protecting agricultural land and irrigation facilities along the Shire River and its tributaries that join the Shire River.

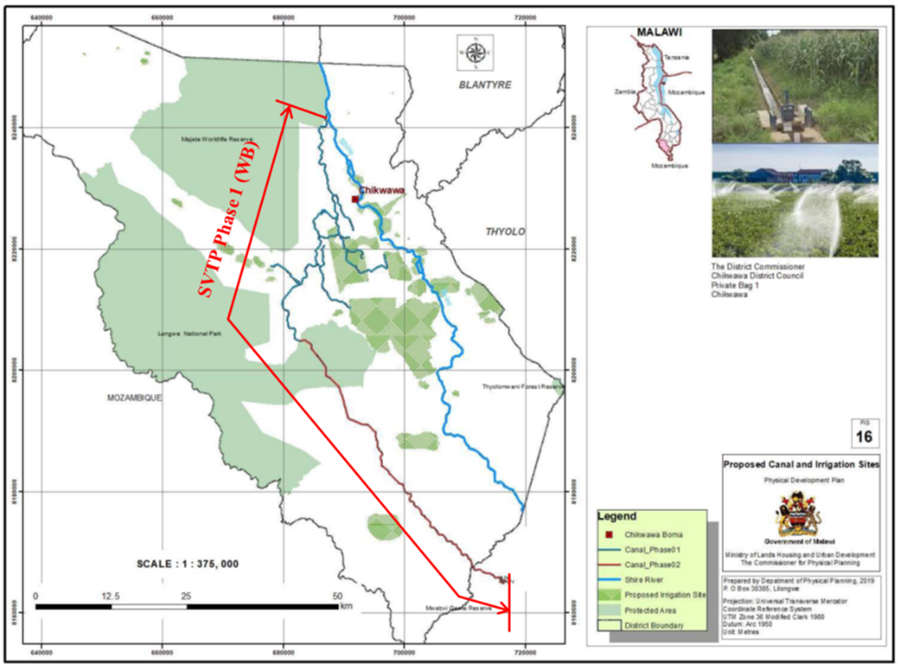


Figure 3-7 Current status and plan of irrigation system in Chikwawa district

Source: Chikwawa District Physical Development Plan

4) Consideration of Disaster Risk Reduction Measures

In order to prevent flooding of agricultural lands and irrigation facilities in the Shire River basin, improvement of the operation of the Kapichila Dam in Chikwawa District and river improvement (e.g., levee improvement) that could be effective.

a) Improvement of Kapichila dam operation

It is proposed that the Kapitira Dam, currently used for hydropower generation and irrigation, be given a flood control function and its operation revised. The dam will be operated in such a way that flood flows will not affect downstream by discharging water to downstream in advance when the flow of the Sire River is expected to increase due to disasters such as cyclone. It should be noted that the water level should not be lowered below a level decided since this dam is used for power generation. Therefore, it is desirable to build a data management and data-based flow forecasting system related to meteorological observation and river flow observation at the same time as the dam operation revision.

b) River improvement in consideration of flood discharge (such as levee improvement)

It is proposed that a Sire River Basin Water Master Plan be developed and river improvements be implemented based on this plan. Generally, measures to safely carry river flow downstream during floods include river embankment, river channel widening, construction of retarding basin, and ring levees.

(7) River management and coastal management

1) Overview of Relevant Organizations and Legal systems

There are several institutions responsible for river management in Malawi. The DoDMA（Department of Disaster Management Affairs,） which reports directly to the Office of the President and Cabinet, is responsible for formulating policies and strategies for river management, including flood control and disaster management. The Department of Water Resources (DWR) and the National Water Resources Authority (NWRA), both under the Ministry of Water and Sanitation (MoWS), would take over water resources management from the DWR to the NWRA after 2013. In addition, the Department of Climate Change and Meteorology (DCCMS) under the Ministry of Natural Resources and Climate Change (MoNRCC) is responsible for meteorological and hydrological observations.

Although the system for river management involves several ministries and agencies, the DoDMA has established policies and strategies for disaster countermeasures in rivers, and the National Resilience Strategy formulated by the DoDMA provides policies for the development of flood control measures. For the implementation of flood control measures, the DoDMA secures the budget and allocates it to the following implementing ministries and agencies. The ministry responsible for flood control measures such as design and construction of levees is the National Water Resources Authority (NWRA) under the MoWS. The DCCMS, under the MoNRCC, is the ministry responsible for observation and disaster management, including the construction of meteorological and hydrological observation facilities and early warning systems.

Table 3-170 List of agencies involved in river management

Abbreviation	English name	Japanese name	Summary
MoAIWD	Ministry of Agriculture, Irrigation and Water Development	農業・灌漑・水開発省	It is the central government agency responsible for the development and management of water resources in Malawi, and consists of four technical departments and three administrative departments for water resources.
DWR	Department of Water Resources	水資源局	It is one of the technical departments of the MoAIWD, responsible for the management of surface water, groundwater, water quality control, and water resources management concerning international rivers.
NWRA	National Water Resources Authority	水資源機構	It is based on the 2013 Water Resources and has been functioning since 2018 with the support of the World Bank. It was supposed to take over the work related to water resources management from the MoAIWD after 2013, but the details of the transition to the NWRA are not known.
DCCMS	Department of Climate Change and Meteorological Services	気候変動・気象局	An organization under the Ministry of Natural Resources, Energy and Environment (MoNREE) that is responsible for climate action and meteorology.
DoDMA	Department of Disaster Management	災害管理業務局	It is the ministry in charge of disaster risk reduction in Malawi and development of the national resilience strategy including flood control measures.

Source: JICA Study Team

2） Overview of Related Plans and Development Status

a) Plans for river management

The central policy for water resources development in Malawi is the National Water Policy (NWP) 2005, which is a comprehensive water sector plan developed in 2005. [72]It sets out a policy objective concerning disaster management to develop a Preparedness and Contingency Plan for water related disasters (floods and droughts) and emergencies.[73]

The National Resilience Strategy (NRS) 2018-2030 is a plan to achieve comprehensive development, including poverty reduction and food security, and one of the four pillars of the plan is about disaster risk reduction, flood control measures, and preparation of early warning systems and emergency response measures. The strategy was developed by DoDMA for a target period from 2018 to 2030, and will be managed in three phases: 2018-2022, 2023-2028, and 2029-2030.

---

[72] https://www.mofa.go.jp/mofaj/gaiko/oda/shiryo/hyouka/kunibetu/gai/malawi/pdfs/kn12_04_01.pdf
[73] https://wesnetwork.org/wp-content/uploads/2020/07/National-Water-Policy-2005-1-1.pdf

Table 3-171 Descriptions concerning river management in related plans

Plan	Positioning for river management
National Water Policy	Disaster preparedness measures are included in the 13 areas related to water resources management, and advance preparation for water-related disasters (floods and droughts) is mentioned as a disaster preparedness measure. On the other hand, there is no description in connection with investment in disaster risk reduction infrastructure with relation to river management and flood control. Policy objectives in the area of disaster management Develop a Preparedness and Contingency Plan for water-related disasters (floods and droughts) and emergencies. [Objectives in the field of disaster management] Promote impact assessment concerning water-related disasters for the implementation of effective emergency response measures to reduce the risk of death and injury in disaster-affected communities. Provision of drinking water and sanitation to vulnerable populations with limited access to water during water-related disasters Provide basic access to water by supplying drinking water to all affected areas. Provision of relevant information to riverine areas and the public during floods and droughts [Strategy in the field of disaster management] Preparation of data necessary for analysis and planning, including mapping of population movements, logistical capacities, and support groups during disasters using GIS Development of an early warning system for floods, droughts and pollution due to disasters Consideration of measures to reduce the impact of climate change and climate vulnerability with relation to disaster preparedness and disaster management Promote cooperation and coordination with other organizations related to disaster management Preparation of contingency budget for the timely mobilization of personnel and supplies Provision of emergency water supply systems such as wells, hand-dug wells, and mobile water purification systems Implementation of afforestation in water source areas where soil degradation is high [Basic Policy] No agriculture or infrastructure development will be undertaken in areas around Lake Malawi below 477 meters above sea level and within the areas of 100-year probability of riverine flooding without written permission from the responsible ministry's minister.
National Resilience Strategy	One of the four pillars of the strategy is Pillar 2, which includes disaster risk reduction, flood control measures and preparation of early warning systems and emergency response measures. [Output Objectives in Pillar2] Output 2.1: Mainstreaming of disaster risk reduction in all sectors and at national, regional and community levels Output 2.2: Flood protection and control (river management) Output 2.3: An effective early warning system Output 2.4: Advance preparation for disasters, emergency response and recovery [Objectives in Output 2.2 above] Improve disaster risk assessment, training and monitoring systems for flood protection and control at communities Improvement of study and planning capacity for the construction of levees and dams and river improvement Development of multipurpose infrastructure for flood management and plans concerning land use and landscape (landscape design).

Source: National Water Policy 2005, Study report for the development of details of the Project for National Water Resources Master Plan in Malawi, National Resilience Strategy 2018-2030.

b) Status of support by donors

Shire River Basin Management Program (Phase-I) 2012-2018 (supported by the World Bank)

The Shire River Basin Management Program (Phase-I) 2012-2018, supported by the World Bank, is a project that aims to develop a five-year plan to strategically implemented flood management in the Shire River Basin, and is being implemented in three components. [74]

- Support for capacity building for watershed management planning and development of the Shire River Basin Plan, and development of an information management system for water resources, including installation of water level and rain gauges and early warning system (planned budget: 41.6 million USD; executed budget: 42.1 million USD)
- Implementation of community-based resource management and soil erosion and water source protection measures, support for community livelihood improvement, and strengthening of the capacity to develop and implement of national park management plans (planned budget: 45.0 million USD; executed budget: 26.1 million USD)
- Development of infrastructures such as Kamazu weir and bank erosion control measures, embankment, culverts, spillways, etc., implementation of flood area fencing through community awareness in the Elephant wetland and FS for infrastructure measures identified in Shire River Basin Plan (planned budget: 59.0 million USD; executed budget: 52.9 million USD)

In addition, the final report of the study conducted earlier in the project, "Shire Integrated Flood Risk Management Project Volume I - Final Report", contains more detailed descriptions of the components of the “hard” measures and the results of the analysis, which are shown for reference.

In the study, aside from conducting a hazard analysis concerning floods in the Shire River basin, verifying the effectiveness of feasible flood control measures, and capacity building for Malawi government agencies, an action plan for the initial phase of the Shire IFRMP was developed.

Based on hazard analysis, countermeasures were considered from both “hard” and “soft” measures perspectives. According to the Shire Integrated Flood Risk Management Project Volume I-Final Report, the final report of the project published in 2012, the following actions were to be implemented in the Shire River Basin Management Program (Phase-I) 2012-2018.

[74] Implementation Completion Report Review of the Shire River Basin Management Program (Phase-I) Project, WB, issued on January 6, 2020 (https://documents1.worldbank. org/curated/en/855661578339132242/pdf/Malawi-MW-Shire-River-Basin-Management-Program.pdf)

In addition, the flood control measures considered in the Shire River Basin Management Program (Phase 1) have been incorporated and implementing necessary measures in the National Resilience Strategy of Malawi. On the other hand, according to the interview with DoDMA (as of February 2022) that some of the revetments and river embankments on the left bank of the Shire River have been implemented, but information on the implementation status of other measures is not yet available. Therefore, it is necessary to understand the plans of the Malawi government and prioritize the development of flood control infrastructure.

Table 3-172 Implementation Items and Budget for the World Bank's Shire River Basin Management Program (Phase-I) (Planning Phase)

	Item	Budget	Responsible body	Amount (USD)
Hydrological Analysis	Preparation of elevation data	SRMBP-I*1	MWDI*2	2,480,000
	Development of a hydraulic analysis model	SRMBP-I, GFDRR*3	MWDI	
	Information sharing	SRMBP-I, ECRP*4, GFDRR, UNDP	MWDI, DCCMS, DNRDM	
	Update and revise the hydraulic analysis model	SRMBP-I	MWDI	
	Conduct hydraulic analysis for FS	SRMBP-I, JICA	MWDI	
	Analysis on hydraulic analysis	SRMBP-I	MWDI, DCCMS, DNRDM	
Flood Forecasting and Early Warning System (FFEWS)	Preparation of TOR for design and supervision of FFEWS	SRMBP-I, ECRP, UNDP	MWDI	
	Installation and renewal of water level gauges (15 locations)	AfDB, NWDP*5, SRMBP-I, SADC*6, ECRP, GFDRR, UNDP	MWDI	
	Installation and renewal of rain gauges (15 locations)	SRMBP-I, DCCMS*7,	DCCMS, MWDI	
	Communication expenses (for 5 years)	AfDB, NWDP, SRMBP-I, SADC	MWDI, DCCMS	
	MWDI's communication equipment	AfDB, NWDP, SRMBP-I, SADC, UNDP	DCCMS, MWDI, DNRDM	
	Development of wireless communications	SRMBP-I	MWDI, DCCMS, DNRDM	
	Dissemination of early warnings	SRMBP-I, UNDP, ECRP, GFDRR, AfDB, WB SDI*8, NWDP	MWDI	
	Development of flood forecasting systems and models	SRMBP-I	MWDI, DCCMS	
	Formulation of future development plan for FFEWS	UNDP. SRMBP-I	MWDI, DNRDM, DCCMS	
Strengthening organizational capacity	Strengthening the capacity of MWDI	SRMBP-I, AfDB, UNDP, SADC	MWDI	
	Strengthening the capabilities of DCCMS	SRMBP-I, DCCMS	DCCMS	
	Strengthen weather forecasting capabilities	SRMBP-I, UNDP?, WMO?	DCCMS	
	Strengthening the capacity of DNRDM	UNDP PSD*9 , SRMBP-I	DNRDM	
	Monitoring and evaluation	SRMBP-I	External organization	
	Formulation of guidelines	SRMBP-I	MWDI	
"Hard"	Installation of embankment with gabions	ECRP. SRBMP-I	MWDI	
	Installation of embankments with	ECRP. SRBMP-I	MWDI	

	Item	Budget	Responsible body	Amount (USD)
	sandbags			
	River improvement	ECRP. SRBMP-I	MWDI, MoAFS Forestry Dep.	
	Food and grain storage	ECRP. SRBMP-I	MWDI	
	Dredging	SRBMP-I	MoT*10	
	Verifying the effectiveness of flood-resistant buildings	SRBMP-I	MWDI	

[Supplemental notes on Terminology]
* 1SRMBP-I: Items to be implemented in the Shire River Basin Management Program (Phase-I) 2012-2018
* 2MWDI: Ministry of Water Development and Irrigation, the predecessor of the Ministry of Agriculture, Irrigation and Water Development.
*3GFDRR: Global Facility for Disaster Risk Reduction
*4ECRP: Enhancing Community Resilience Program
* 5NWDP: National Water Development Program (AfDB-supported water purification and supply project)
* 6SADC: SADC-HYCOS (Southern African Development Community Hydrological Cycle Monitoring System Project)
* 7DCCMS: Project funded by the Department of Climate Change and Meteorological Services
* 8WB SDI: Spatial data Initiative of the World Bank
* 9UNDP PSD: Activities identified in the Programme Support Document (PSD) developed by the United Nations Development Programme.
*10MoT: Ministry of Transportation

Source: Shire Integrated Flood Risk Management Project Volume I - Final Report

Malawi Watershed Services Improvement Project (supported by the World Bank)

The project will be implemented as Phase 2 of the above-mentioned Shire River Basin Management Program (Phase-I) 2012-2018 (supported by the World Bank) and will be implemented from 2020 to 2026. The program components and estimated budget are as follows.

- Promote watershed management (mainly soil erosion control for afforestation and agriculture) (estimated budget: 53,000,000 USD) [Scaling up Landscape Restoration:(Cost $53.00 M)]
- Improvement of irrigation facilities (estimated budget: 82,000,000 USD) [Improving Watershed Services:(Cost $82.00 M)]
- Strengthen management capacity and procurement support for monitoring and evaluation and information management systems (estimated budget: 25,000,000 USD)

According to the World Bank's interview with Malawi's disaster risk reduction staff (conducted in December 2021), the project was implemented to continue to drive the soil erosion and water source protection component out of the Phase 1 components of the Shire River Basin Management Program (Phase-I).

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

a) Topographic and climatic conditions in Malawi

The southern plains of Malawi are a flood plain of the Shire River, where wet grasslands called "tambo" spread. The area around Lilongwe is a highland area, with a steep slope towards the western shore of Lake Malawi. The northern part of the country is mountainous.

As for climate, Malawi's climate is classified as subtropical, with three seasons in a year: a warm and humid season from November to April, a cool and dry season from May to August, and a hot and dry season from September to October. The warm and humid season is the rainy season, when about 95% of the annual precipitation is concentrated. Average monthly rainfall maps from two stations (Lilongwe and Blantyre) available on the Internet are shown. From this, we can see the following.

- The average monthly rainfall data shows that rainfall is concentrated in the period from November to April, with very little rainfall in the rest of the year.
- Looking at the average annual total rainfall, it is low at about 800 mm. However, according to previous reports, the average annual rainfall ranges from 700 mm to 1,200 mm, and analysis shows that the southern region has higher variability in annual rainfall than the other regions. (Project for National Water Resources Master Plan in Malawi / JICA / 2014)

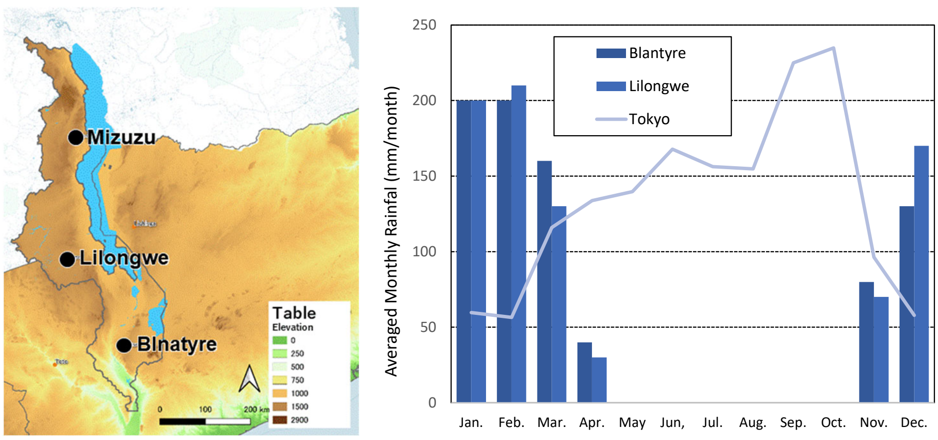


Figure 3-206 Average rainfall in Malawi

Source: weatherbase (http://www.weatherbase.com), graphs created by research team

b) Overview of rivers in Malawi

The rivers and lakes in Malawi, with the exception of Lake Chilwa and Lake Chiuta, are considered tributaries of the Zambezi River. In the northern and central parts of the country, there are relatively small rivers flowing into Lake Malawi from the mountains and highlands, and in the south, there are only the Shire River that flows out of Lake Malawi and its tributaries. The Shire River flows from Malawi downstream into Mozambique, where it joins the Zambezi River.

In addition, Malawi is divided into 17 Water Resource Areas (WRAs) based on river basins, and water resource management is divided into multiple Water Resources Units (WRUs) as shown in the figure below.

The Shire River has the largest catchment area, with a catchment area of 18,910. 6^{m2} and a large number of water resource units (16) according to previous reports, making it an important river for water resource management and river management.

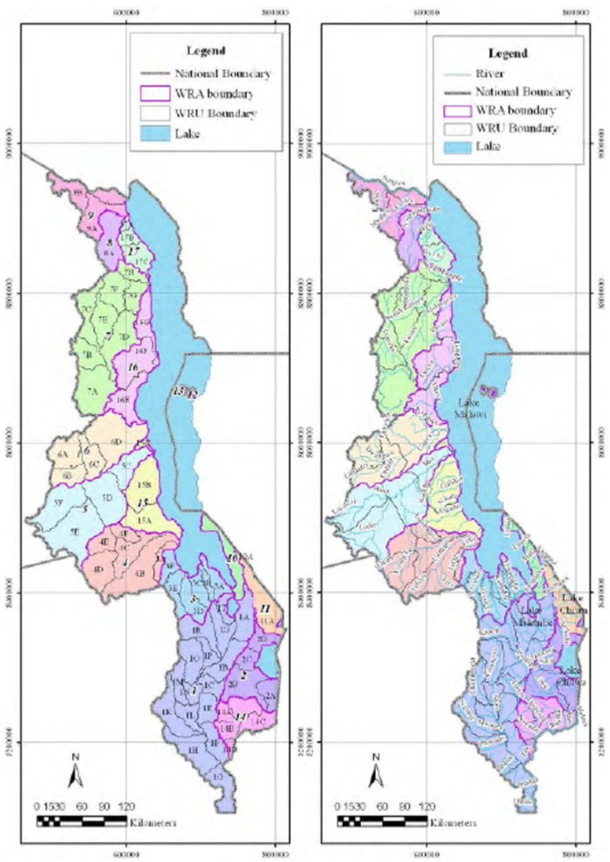


Figure 3-207 Map of river management units and locations of rivers and lakes in Malawi

Source: Final report of the JICA Project for National Water Resources Master Plan in Malawi, Summary Version

Table 3-173 Classification for water resources management in Malawi

WRAs (Water Resource Areas)		WRUs (Water Resources Units)			
No.	Name	Number of units	Unit name	Watershed (km^2)	Watershed (km^2)
1	Shire	16	A to T	18,910.6	18,945
2	Lake Chilwa	4	A to D	4,567.6	4,981
3	South West Lakeshore	6	A to F	4,997.8	4,958
4	Linthipe	6	A to F	8,884.8	8,641
5	Bua	4	A to F	10,658.1	10,654
6	Dwangwa	4	A to D	7,750.5	7,768
7	South Rukuru/North Rumphi	8	A to H	12,719.2	12,705
8	North Rukuru	1	A	2,088.3	2,091
9	Songwe/Lufira	2	A to B	3,729.7	3,680
10	South East Lakeshore	1	A	1,658.7	1,540
11	Lake Chiuta	1	A	2,442.7	2,462
12	Likoma Island	1	-	17.3	18.7
13	Chizumulu Island	1	-	3.3	3.3
14	Ruo	4	A to D	3,518.9	3,494
15	Nkhota-kota Lakeshore	3	A to C	4,819.2	4,949
16	Nkhata-Bay Lakeshore	3	A to G	5,532.7	5,458
17	Karonga Lakeshore	3	A to C	1,945.1	1,918
			Total (Continental Area)	94,244.6	94,276
			Lake area total	23,855.8	24,208
			Total for all areas	118,100.4	118,484

Source: Final report of the JICA Project for National Water Resources Master Plan in Malawi, Summary Version

c) Flood damage in the past

According to the report, "Spaces of vulnerability and areas prone to natural disaster and crisis in six SADC countries" published by the International Organization for Migration (IOM), the table below summarizes the EM-DAT information on Malawi's flood history from 2000 to 2016. Flooding was particularly frequent in Koronga district in the north, Chikwawa district in the south, and Nsanje district and mentioned in red in the below table.

Table 3-174 Flood History in Malawi, 2000-2016

Year	**Classification**	**Area of occurrence**		
		Southern region	**Central region**	**Northern region**
2000	Flood	Chikwawa, Nsanje	Nkhotakota	Karonga
2001	Coastal flood	**Chikwawa, Nsanje,** Blantyre, Machinga, Mangochi, Mwanza, Phalombe, Thyolo, Zomba	Dedza, Kasungu, Mchinji, Nkhotakota, Salima	Karonga
2002	Riverine flood	**Chikwawa, Nsanje,** Balaka, Blantyre, Machinga, Mangochi, Phalombe, Zomba	Dedza, Dowa, Kasungu, Nkhotakota, Ntcheu, Salima	phi
2003	Coastal flood Flash flood	**Chikwawa, Nsanje,** Balaka, Machinga, Mwanza, Phalombe	Dedza, Dowa, Lilongwe, Ntcheu Salima,	**Karonga,** Mzimba, Rumphi
2005	Riverine flood	**Chikwawa, Nsanje,** Machinga , Mangochi	Ntcheu	Nkhata Bay
2006	Riverine flood Flash flood	Chikwawa, Mangochi	Salima	

Year	Classification	Area of occurrence		
		Southern region	Central region	Northern region
2007	Riverine flood Flash flood	**Chikwawa, Nsanje,** Balaka, Blantyre, Chiradzulu, Machinga, Phalombe	Lilongwe, Mchinji, Ntchisi	Chitipa, **Karonga,** Mzimba, Nkhata Bay
2008	Riverine flood	**Chikwawa, Nsanje**, Balaka, Blantyre, Chiradzulu, Machinga, Mangochi, Mulanje, Neno, Phalombe, Thyolo, Zomba	Dowa, Kasungu, Lilongwe, Mchinji, Ntcheu, Nkhotakota	**Karonga**, Mzimba, Nkhata Bay, Rumphi,
2010	Riverine flood		Dedza	Karonga, Rumphi
2011	Riverine flood	**Chikwawa, Nsanje,** Mulanje, Phalombe, Thyolo,	Dedza, Salima	**Karonga,** Nkhata Bay, Rumphi,
2012	Riverine flood	**Nsanje**, Mangochi, Phalombe Zomba		
2013	Riverine flood	**Nsanje**, Mangochi, Phalombe		
2015	Riverine flood	**Chikwawa, Nsanje**, Balaka, Blantyre, Chiradzulu, Machinga, Mangochi, Mulanje, Phalombe, Thyolo, Zomba	Lilongwe, Ntcheu, Salima,	Karonga, Rumphi
2016	Flash flood			**Karonga**, Mzimba

Source: Report on "Spaces of vulnerability and areas prone to natural disaster and crisis in six SADC countries"

- The Shire River, which flows out of Lake Malawi, is frequently flooded, and for reference, satellite imagery analysis of the 2015 and 2007 floods was used to analyze the area of flooding, as shown in the figure below. It can be seen that the flooding spread widely from Chikwawa upstream to Nsanje downstream.

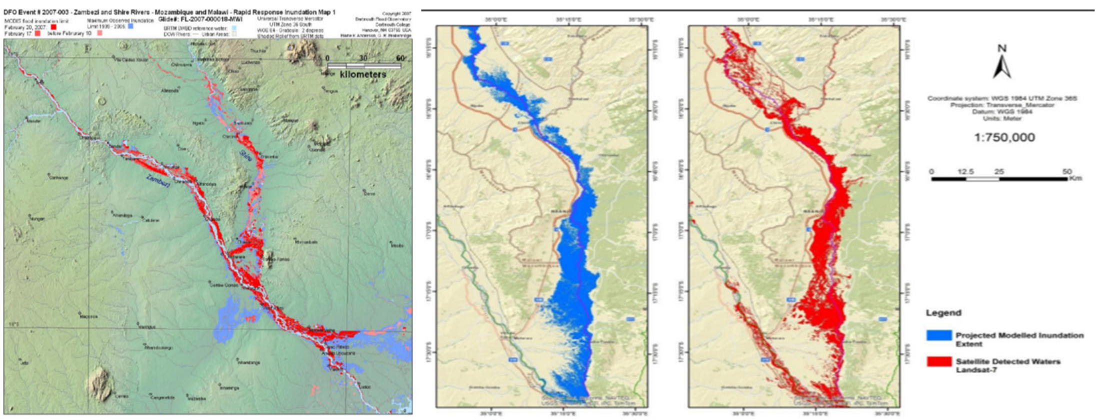


Figure 3-208 Inundation in the Shire River basin in past floods

Source: Dertmouth Flood Observatory, USA (2007); UNOSAT (2015).

Regarding the actual situation of flooding in the Shire River basin, the following information was obtained from the interview with the World Bank staff (as of December 2021).

- Flooding has occurred at the confluence of the Shire River and its tributary, the Ruo River. One type of flood here occurs when the Ruo River overflows due to the large flow of the Shire River and the backwater effect, and the other occurs when the fast flow of the Ruo River at the confluence, which is due to the steepness of its upper basin, impedes the flow in the Shire River, resulting in overflows.
- Similarly, the Mwanza River, a tributary of the Shire River, may also overflow at its confluence due to the backwater effect from the Shire River.

d) Actual situation of flooding caused by cyclone Ana

Cyclone Ana hit Mozambique on January 24, 2022, causing widespread flooding in southern Malawi, and when I visited the area in February 2022, I checked the situation of flooding caused by Cyclone Ana and the flooding in the past when large scale flooding was observed. The following figure shows the areas where damage occurred most frequently.

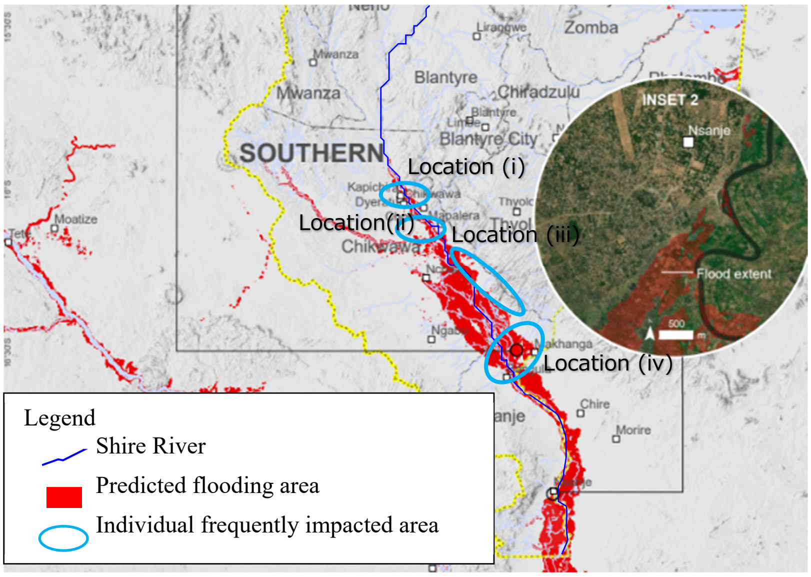


Figure 3-209　Cyclone Ana Predicted range of inundation by satellite image analysis (South region of Malawi)

Source：Complied by JICA Study Team based on UNOSA's data

The actual conditions of flooding and damage at each of the locations shown in the above figure are summarized in the following pages.

The intersection of the Shire River and Route 1 near Chikwawa

The area shown in the figure below is the intersection of the Shire River and National Highway No. 1 in Chikwawa District. In terms of inundation, this is an area where the riverbed gradient of the Shire River shifts from steep to flat floodplain, and diffuse flooding occurs downstream of this point.

The right bank of the Shire River is a cliff, and the elevation of the Chikwawa side is higher. Although there is no damage to the bridge crossing the Shire River, the road east of the bridge passes through an area with a high possibility of flooding.

One of the major damages in the district is the disruption of roads due to the flooding of the Shire River. National Highway 1 was also cut off at this point during Cyclone Ana, and is currently under temporary restoration as of February 8, 2022. If this point is cut off, the only road from Nsanje to Blantyre will be cut off and the impact will be great.

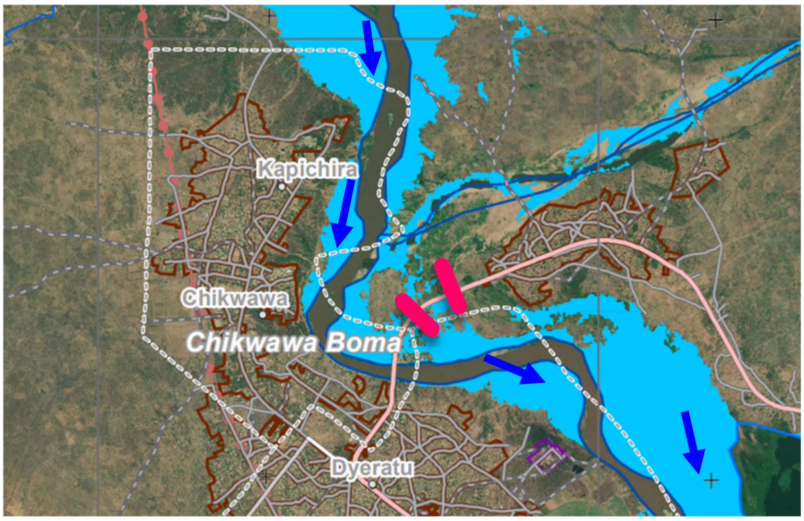


Figure 3-210 Flood status of the intersection of Shire River and M1 near Chikwawa
Source : Coperunicus, Delineation Overview map 01(Chikwawa)

i) The confluence of the Shire and Luo rivers near Bangla

The confluence of the Shire and Luo rivers near Bangla has been frequently hit by flood disasters.

In this area, the flow from the Luo River splits into southeast and northeast directions at the confluence, and the flooded area spreads out.

According to interviews with WB officials and DoDMA officials, the area is located at the confluence of the Ruo River, a rapid tributary, and the Shire River, a large river. According to interviews with World Bank officials and DoDMA officials, this area is a confluence of the Ruo River, which is a rapid tributary, and the Shire River, which is a large river, and is a frequent flooding area due to two factors: (1) the effect of the fast flow from the Ruo River blocking the flow of the Shire River, and (2) the backwater phenomenon from the Shire River blocking the flow of the Ruo River.

One of the major damages in the district is the disruption of roads, bridges and railroads between Bangla and Makhanga, located at the confluence of the two rivers. In this area, although roads, bridges, and railroads were initially constructed, they were damaged intermittently in 1997, 2015, and 2019, and although they were restored, they were damaged again and have not been restored. It is said that the area is a frequent flooding zone due

As shown in the figure below, the Makanga village is surrounded by the flooded area and cannot be accessed from either the Bangla side or the left bank of the northern Cire side road. As a result, the village of Makanga will be isolated and will not be able to provide assistance in the event of a disaster.

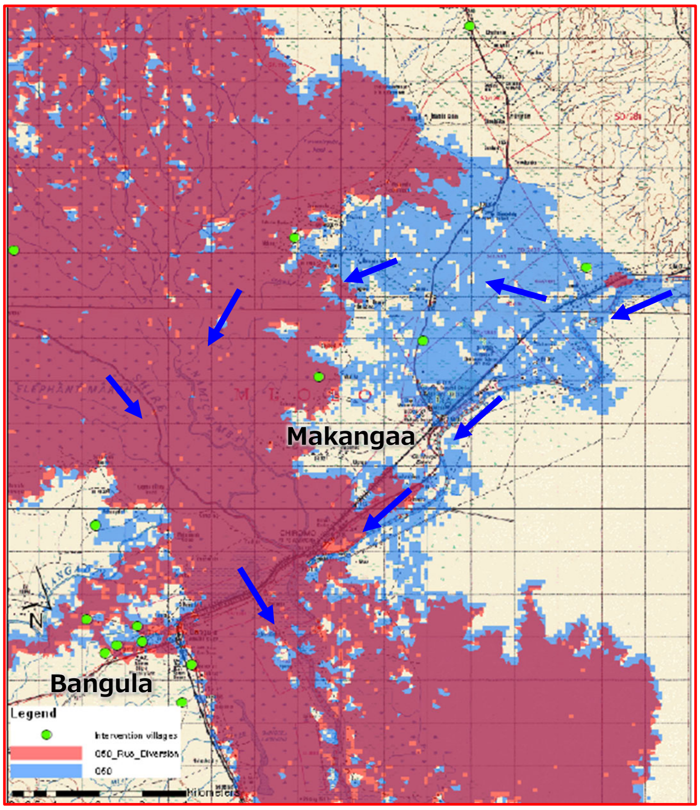


Figure 3-211　Flood status of the intersection of the Shire River and　Ruo　River

Source：JICA Study Team add comments on the Atkins, Shire Integrated Flood Risk Management Project Report

ii)　Areas along the Shire River south of Chikwawa

South of Chikwawa on the Shire River, settlements are located in the inundation zone of the Shire River.

As for the actual flooding situation in this area, the villages are located near the Shire River in the area of diffuse flooding, and they are inundated during the flooding. As of February 9, 2022, when the field survey was conducted, some areas were still flooded, and although this could not be determined by the satellite image analysis in the figure below, it was confirmed in the field that the village would be inundated.

As National Highway No. 1 passes away from the Shire River between the south of the district and Bangla, and the villages are located along National Highway No. 1, there is no inundation damage like in the district.

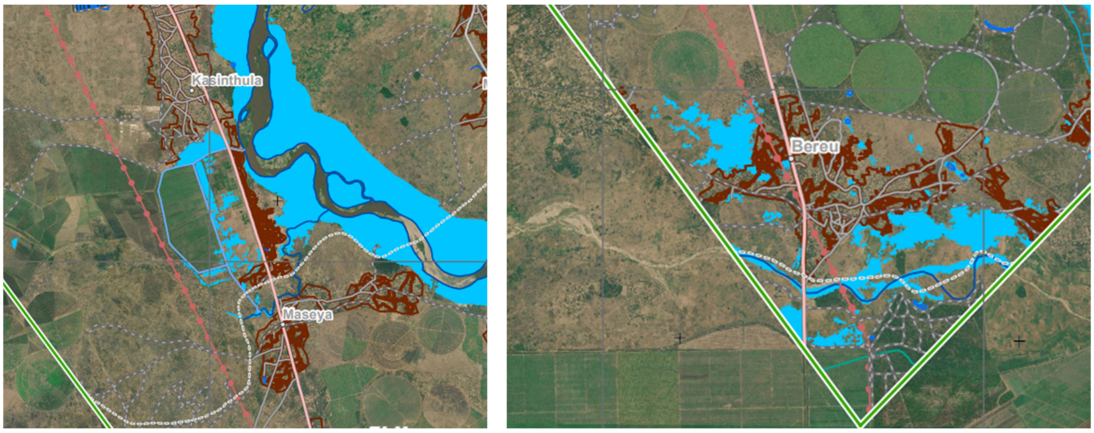


Figure 3-212　Flooding in the area along the Shire River south of Chikwawa

Source：Coperunicus, Delineation Overview map 01(Chikwawa)

iii)　Left bank of the Shire River along the tributary

On the left bank of the Shire River, several tributary rivers (Mapelera, Nkhate, Limphangwi, Livunzu, and Chizimbi) flow in from the north-eastern mountains.

As for the actual flooding in the area, the swelling of the branch river causes flooding of bridges and roads that intersect with the branch river, as well as flooding of houses along the branch river at the confluence with the Shire River.

In addition to the flooding to houses in the villages scattered along the tributaries, the intersection of the left bank road (East Bank Road/S152) of the Shire River and the tributaries has been flooded and the riverbanks have been eroded. The local situation is shown in the next section.

View of the intersection of the S152 and a branch river

Areas where river embankment construction is being carried out

Damage to the river embankment

Figure 3-213　Shire River left bank along the tributary local view

Source：JICA Study Team photo

e) Damage status of Kapichira Dam

The damage to Kapichira Dam, which is the location of the largest hydroelectric power plant in Malawi, due to the impact of Cyclone Ana, which made landfall on January 24, 2022, will be organized as damage to critical facilities.

i) Kapichira Dam Summary

Kapichira Dam is a rock-fill dam in the middle reaches of the Shire River, where the Kapichira hydroelectric power plant is located and where the intake for irrigation water in the Shire River basin is planned to be constructed. In 2022, a levee collapse by the Cyclone Ana caused the shutdown of the hydropower plant due to difficulties in withdrawing water from the intake for hydropower generation, and the irrigation water intake under construction was severely damaged.

The specifications of KapichiraDam are as follows

Table 3-175 KapichiraDam Specifications

Top length (m)	**Dam hight (m)**	**High water level above sea level (m)**	**Min. operation water level above sea level (m)**	**Discharge waterlevel above sea level (m)**	**Capacity of facility (MW)**	**Max. Discharge volume (m^3/s)**
820	30	147	144	86	32.4×4	67.3×2

Source：JICA Water Resources Master Plan Development Capacity Development Project Final Report (Summary Version)

ii) Summary of the damage to the main body of the dam caused by Cyclone Ana

As of January 24, 2022, the water level exceeded the full level (147m above sea level) by more than 149m above sea level, causing overflow from the top of the embankment. 1 of the 5 normal flood vents was out of order and 2 were under maintenance, so only 2 were functioning on that day.

On the right bank, construction of the intake for the irrigation facility of the Shire River Valley Transformation Project was underway, and the area under construction became a weak point and collapsed.[75]

[75] We could confirm the remains of the temporary construction, but still need precise inspection of the construction

Locations of damage are as follows, At the right hand of the body of levee has been collapsed for about 200m（Below Figure Right A）

A structure extending north-eastward from the upper right bank of the embankment to prevent sediment from flowing into the reservoir from the upstream area (see Figure B below)

Collapse of the top of the embankment where the overflow occurred and scouring of the downstream surface (Figure C below)

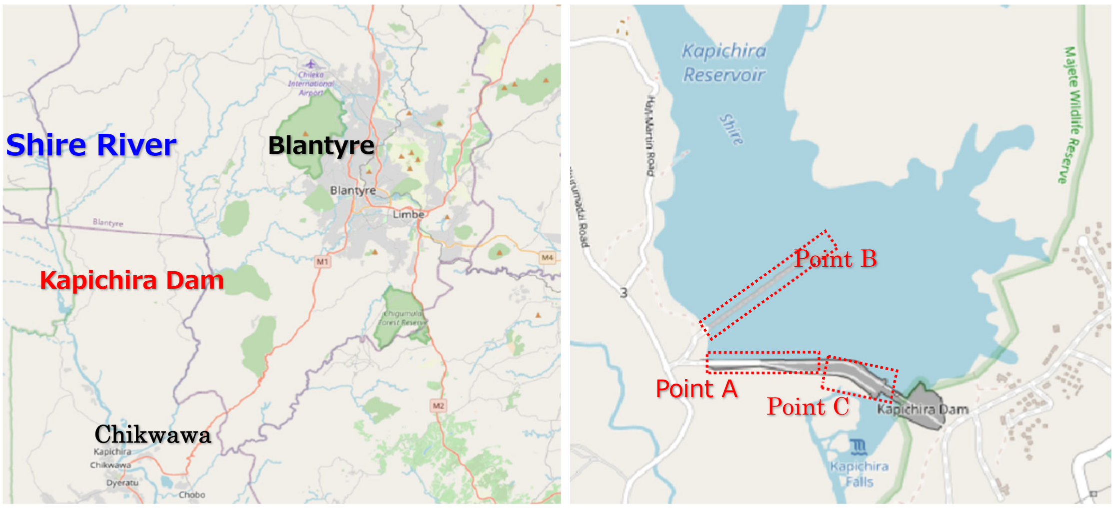


Figure 3-214　Location of the Kapichira Dam Figure and damaged area

Source：Added explanations to the Open Street Map by JICA Study Team

In addition, followings are the pictures taken on site regarding the status of damage

Location A：original body of levee (red line) has completed wasted away

status and actual status of damage


Pictures taken by the Drone by the dam operator (Left：Location A right ：Location B)


Location B：all of the structure circled by the red line was washed away 赤点


Location C：downstream scouring （Left）upstream top of the structure collapse（right）

Figure 3-215 Kapichira Dam on site photos of the damaged area

Source：（Above 2 photos）EGENCO Kapichira Dam management institution material ,JICA Photos taken by the JICA Study Team

iii) Impact for the power generation plant

The Kapichira hydropower plant has lost about 130 MW of generating capacity due to a significant drop in the water level at the intake for power generation, accounting for nearly 30% of the 442 MW that EGENCO provides to the national grid. EGENCO officials said it will take more than six months to repair the damaged Dam, which is estimated to cost about 18 billion kwacha (about 2.6 billion yen).

In addition, due to the loss of a large amount of power generation capacity, Blantyre has been subjected to rolling blackouts, where power is cut off for a set period of time in each district, which has had a significant impact on power supply.

iv) Damage situation of other facilities

As mentioned above, only two of the five regular flood gates were functioning. The situation on that day according to the Nyasa Times report (Figure II below). From the post-disaster scene (Figure I below), it can be seen that there was no major damage to the facilities themselves, but three of the five flood gates were not functioning, so the issue of operational management needs to be examined.

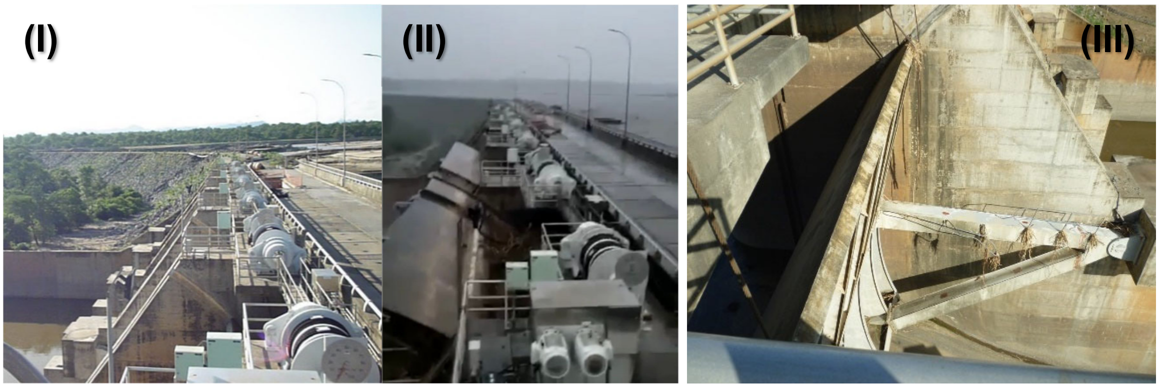


Figure 3-216 The situation of the regular flood gates

Source：Photo taken by JICA Study Team, (Central) Nyasa Times

In addition, the water level at the intake of the hydroelectric power plant has dropped and water intake is not possible (Figure 4). In addition, according to the interview with Dam management staff, it was reported that the flow had overflowed the top of the Dam embankment, but traces of the overflow, such as remnants of straw and other plants, remained at the top of the embankment.

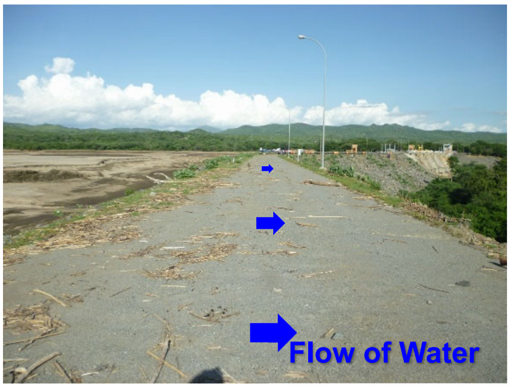


Figure 3-217 Intake of the Hydroelectric power plant (Left), Flood marks in the top of the embankment (straws are left on top / right)

Source：Photo taken by JICA Study Team

f) Situation of Hazard Map Preparation

Flood hazard mapping under the conditions of 5-year, 10-year, 20-year, 50-year, 75-year, 100-year, and 500-year probability scales plus the 100-year probability scale and climate change impacts is being conducted in the Shire River Basin Management Program (Phase-I).

In addition, as mentioned above, according to interviews with World Bank officials (as of December 2021), hazard maps have been prepared for the Mwanza River, a tributary, as well as for the Shire River, because flooding has occurred at the confluence of the Mwaza and Shire Rivers. Since the hazard maps developed in the project are not available to the public, the hazard map prepared in the preliminary study of the Shire River Basin Management Program (Phase-I) is shown in the figure below for reference.

The left side of the figure below shows the results of the analysis on the confluence of the Shire River and its tributary, the Ruo River. The right side shows the results of the analysis near Nsanje, showing the flood prone area for each probability scale.

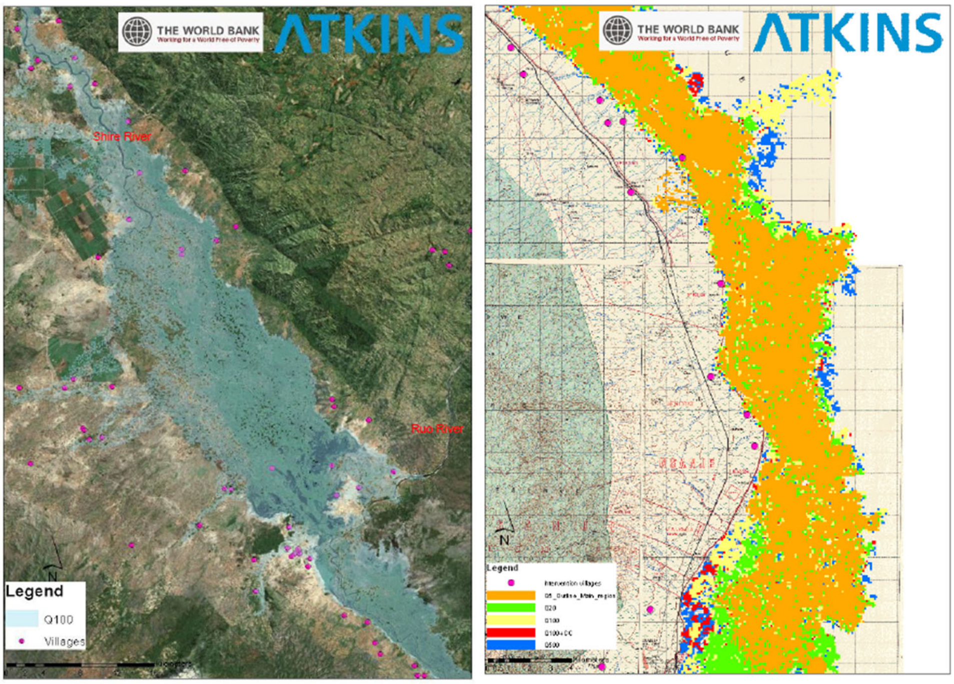


Figure 3-218 Image of the results of hazard analysis conducted with the WB support.
Source: Shire Integrated Flood Risk Management Project Volume I - Final Report

In addition, with the support of the EU, hazard maps have been prepared for the pilot districts. The hazard maps clearly show the flood hazards based on the results of inundation analysis as well as the extent of inundation from previous floods based on interviews with local residents.

In addition, the hazard map shows the location of evacuation sites, hospitals, health centers, and other facilities that should be utilized in the event of a disaster. The following figure shows an example of the preparation in Mangochi District, located in the southern part of Lake Malawi.

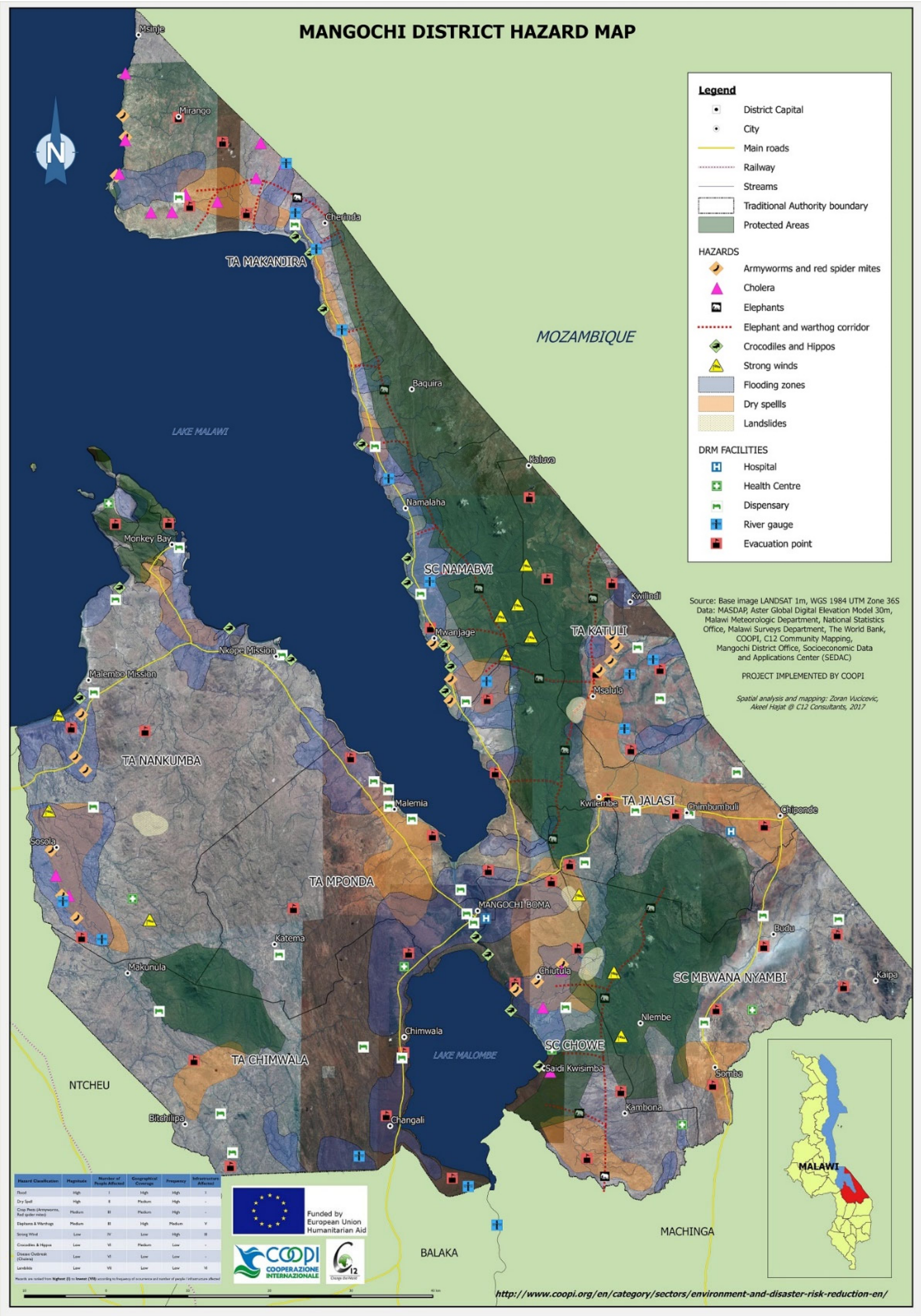


Figure 3-219 Example of Hazard Map prepared in Mangochi district

Source: Shire Integrated Flood Risk Management Project Volume I – Final Report

g) Flood risk based on an overlay map of estimated inundation with population distribution

Using the data collected as described in "2.1.2 Methodology for assessing disaster risk," an overlay map of population distribution and inundation areas based on 100-year flood probabilities was prepared.

As shown in the figure below, the lower basin of the Shirr River (south of point (B)) are dotted with small and medium-sized settlements, although there are no large cities that can serve as population centers, and these settlements overlap with the expected inundation areas. As described in "(2) Calculation of Economic Loss Potential due to Disasters" in the section on understanding the general situation of hazards, Chikwawa and Nsanje districts in the lower reaches of the River Siré have limited population size, but have high economic loss potential due to flood hazards.

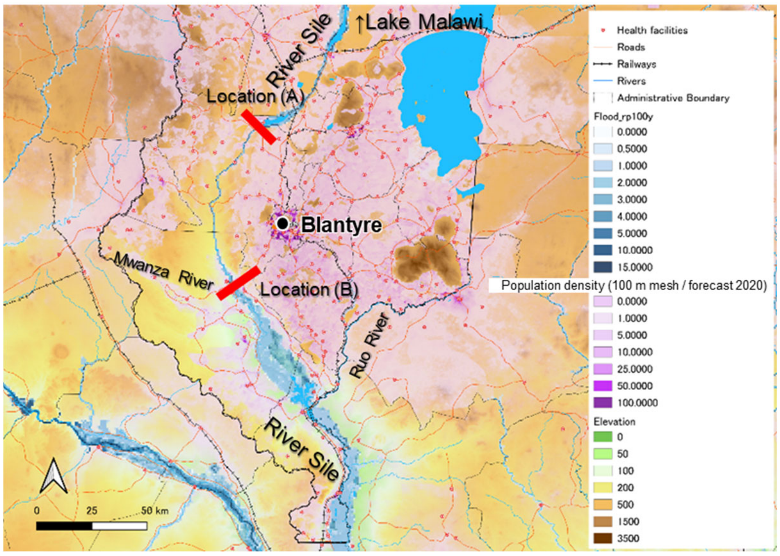


Figure 3-220 Overlay of flood risk and population distribution in the Shire River basin

Source: WorldPop, NASA SRTM Terrain Data, (Flood Risk) JRC Data Catalogue, Aqueduct Floods Hazard Maps

4) Consideration of Disaster Risk Reduction Measures

a) Study on the possibility of countermeasures based on hazard distribution and the general condition of the rivers

Based on the above mentioned overlay of flood hazards, population distribution and transportation infrastructure, measures that can be implemented in the Shire River basin were studied. In order to understand the general condition of the Shire river, the riverbed was divided into sections and the slope of each section was calculated also using Google Earth. The river gradient is about 1/5,000 in the sections in the upstream of point (A) shown in the previous paragraph Figure 3-220 Overlay of flood risk and population distribution in the Shire River basin, and the narrowing area from point (A) to point (B) is as steep as 1/250. Downstream from point (B), the river slope is about 1/5,000, and the floodplain is frequently flooded.

Based on the general condition of these rivers, the possibilities for assistance in the Shire River basin are summarized as follows As for the Kamazu weiri in the upstream, its position as a road crossing the Shire River is important, but since it is a water-stopping weir and cannot be used for flood control, it is difficult to imagine an improvement project from the perspective of flood control. From point (A) to point (B), the river gradient is steep, the extent of inundation is limited, and population is not much concentrated, so the priority for implementation of countermeasures is low.

On the other hand, in the downstream from point (B), the risk of flooding in the floodplain is high, population is concentrated in some medium-sized cities, and the area is also used for agricultural production, so the priority for implementing countermeasures is high. Possible measures that could be implemented include the following.

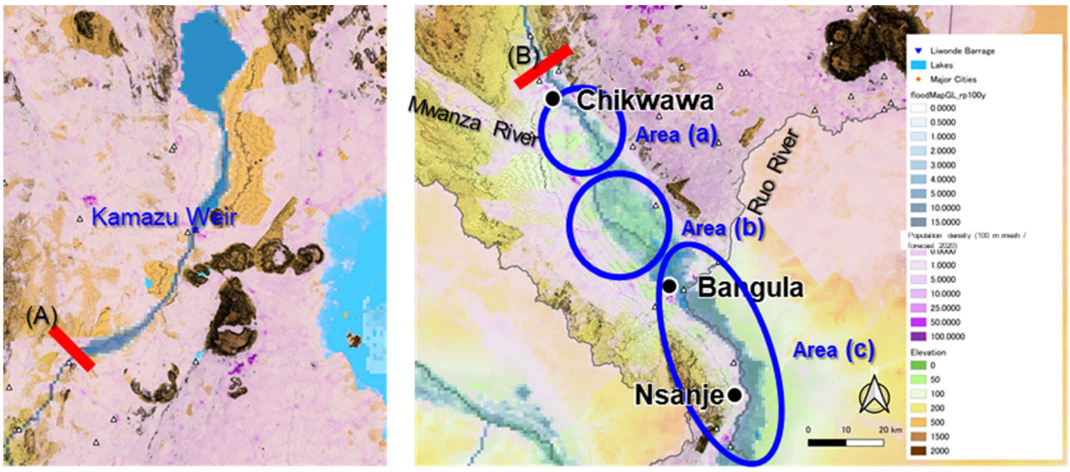


Figure 3-221 Consideration Map of flood control measures in the Shire river
Source: World Population Review、NASA SRTM landscape data（Flood risk）JRC Data Catalogue、Aqueduct Floods Hazard Maps

b) Situation of flood control measures in Malawi

In the area downstream from point (B), necessary flood control measures are being implemented based on the WB project and DoDMA's National Resilience Strategy. According to the interview with DoDMA, the only structural measures that have been implemented as flood control measures are embankment improvement (using meander baskets and sandbags) at the confluence with the branch river on the left bank of the Siré River, and sediment runoff control measures by restoring vegetation in the watershed.

Figure 3-222　Areas where river embankment construction is being carried out

Source: Photo taken by JICA Study Team

On the other hand, since several measures were proposed in the WB-supported Management Program for the River Shire Basin (Phase 1), it is necessary to review the master plan for flood control measures in the lower Shire River basin in order to priority the necessary support, fully taking into account the history of these studies.

The measures considered in the WB support are as follows[76].

[Structure Measures]

- Construction of embankments to protect vulnerable villages from flooding (using gabion and sandbags)
- Construction of food storage and evacuation facilities that will not be damaged during floods
- Soil runoff control by restoring vegetation in the watershed
- Dredging and revetment of a tributary of the Shire River, and rehabilitation of bridges (to protect flow crossing point)
- Construction of a divergent channel from the Ruo River, a tributary of the Shire River, to the floodplain of the Shire River (Elephant Marsh)
- Construction of a reservoir in the Mwanza River basin, a tributary of the Shire River

[76] World Bank Shire River Basin Management Program Project, Implementation Completion and Results Report, June 2019

[Not-structure Measures]

- Land use regulation to control development in flood prone areas
- Flood insurance
- Agroforestry in flood plains
- Development of disaster response plans
- Development of early warning systems

c) Identification of issues in the river sector in previous studies

The JICA Project for National Water Resources Master Plan in Malawi recommends Integrated Flood Management (IFM) as the basic policy for future measures related to water-related disasters. As a background idea, it mentions as follows: "the goal should be to reduce flood damage in all flood-prone areas. However, the areas that could be affected by floods are too extensive and scattered. The efficiency of large-scale structural measures in Malawi is very low due to the underdevelopment of the flood-prone areas and the small population. Therefore, appropriate flood management, made up of a best mix of structural and non-structural measures, should be applied to build a flood resilient society. “

The study identifies the following three strategies for integrated flood management as described above.

- Flood prevention and mitigation in areas prone to frequent floods
- Creating flood resilient land use
- Ensuring safe evacuation

In addition, the following points are listed as an action plan for the realization of Integrated Flood Management (IFM).

- Improve flood risk management strategies considering the status of DRM development
- Development of land use regulations and hazard maps for rivers
- Risk assessment for priority area selection and development of plans for future flood mitigation
- Strengthen the information management system to smoothly provide information to relevant government agencies and water users for the purpose of integrated water resources management.
- Conduct feasibility studies for major vulnerable areas to identify temporary measures and ideas that should be implemented by local governments before flood mitigation works are undertaken.

- Investigation of conditions leading to flash floods
- Development of technical guidelines for flood protection works
- Capacity building for flood protection and mitigation activities
- Development of flood warning systems
- Implementation of flood protection works
- Implementation of disaster recovery work

d) Direction of cooperation

As a direction of cooperation in Malawi, based on the results of the survey, the JICA study team propose the revision of the Master Plan for Flood Control in the Lower Shire River Basin, taking into account the information on the current situation and the list of structural and non-structural measures developed by the WB assistance. It would be particularly useful to consider the revision in response to the actual damage caused by Cyclone Ana (2022) and Cyclone Idai (2019).

As for the detailed support components, in addition to understanding the details of the progress of flood control infrastructure developed with WB support and the results of hazard analysis, it is essential to align with the flood control infrastructure planned to be developed in the National Resilience Strategy formulated by DoDMA.

For this reason, it is necessary to coordinate the necessary support by examining and discuss the areas where support is insufficient and the priority of measures to be taken, and by coordinating the strategies with the WB and DoDMA when examining the Flood Control Master Plan.

According to the Deputy Director of DoDMA's Disaster Response Department, who was formerly in charge of reviewing strategies for flood control measures in the Mitigation (including flood control) Department, among the flood control measures considered in the WB support, the one that has not received sufficient support and for which there is a high need for support is "construction of a divergent channel from the Ruo River, a tributary of the Shire River, to the flood plain of the Shire River (Elephant Marsh).

In addition, as will be described later, the Kapichira Dam, is the largest hydroelectric power plant in Malawi was severely damaged by Cyclone Ana. It is assumed that the dam will be repaired in the future, but the dam is located directly above the lower reaches of the Sire River, and if it can be used as a dam to control inflow to the lower basin, and its effect is expected to be significant. For this reason, a proposal to improve the operation of the Kapichira Dam is also described below, and details are provided in "e) Possible support related to the damage to the Kapichira Dam".

Based on the above, the flood control measures that are expected to be implemented at present are listed as follows.

[Structure Measures]

- Construction of embankments to protect vulnerable villages from flooding in the left (eastern) bank of the Shire river by using gabion and sandbags and implement appropriate design of the bridges crossing the rivers to secure enough space for the flood water to flow
- Construction of river embankment to protect the villages frequently affected by flooding in the right bank of the Shire rive
- Construction of a divergent channel from the Ruo River, a tributary of the Shire River, to the floodplain of the Shire River (Elephant Marsh)
- Countermeasures to prevent the cut-off of the National Road M1 in the section where the M1 crosses Shire river near Chikwawa
- Construction of flood resilient road and bridge of the S 151 road in the section where the S 151 road crossed Shire river near Bangula
- Repair work and management emprovement in Kapichira dam

[Not-structure Measures]

- Development of disaster response center in the Macanga district where it is frequently isolated with the surrounding area due to flooding from Shire river and Ruo river.
- Land use regulation to control development in flood prone areas near Nsanje
- Improvement of the management and operation in Kapichira dam to secure flood control capacity.

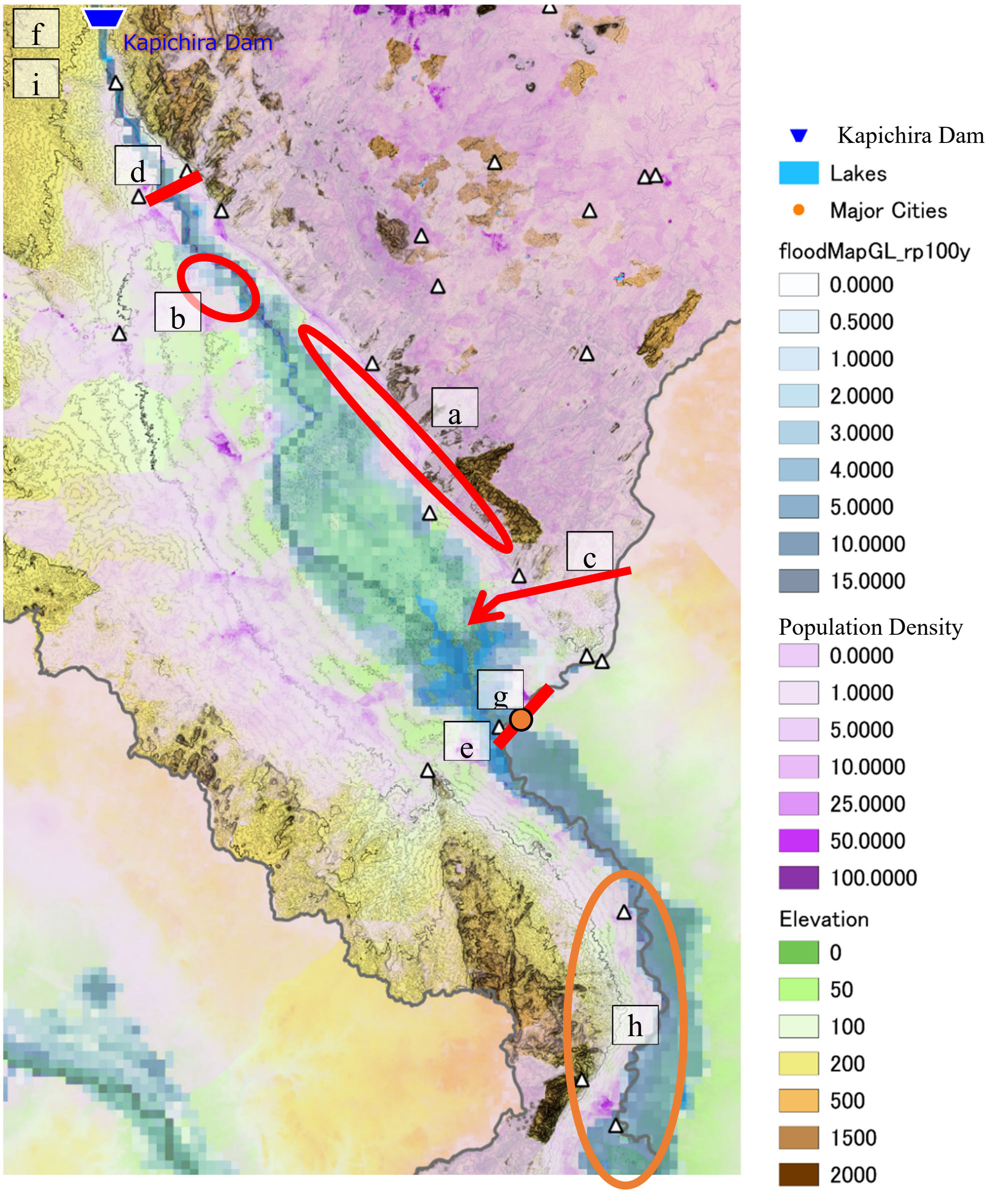


Figure 3-223 Location of the flood control countermeasures in the lower Shire river basin

Source: JICA Study Team

e) Possible support related to the damage to the Kapichira Dam

i) Emergency repair of the embankment and damaged facility

According to the interview to the director of DoDMA disaster risk reduction department, Malawi government is preparing the flash appeal and PDNA to call for support after Cyclone Ana damage. The repair of the embankment shall be emergency to secure the capacity for hydroelectric power station.

On the other hand, update of the facility could be considered with taking into account the idea of Build Back Better (BBB)

ii) Update on the structure of the flood gate

On January 24th, 2022 when the dam was damaged by Cyclone Ana, three out of five flood gates did not function. And it is considered that this is one of the causes for the incident that flood water run over the embankment which is a dangerous situation.

Therefore, capacity building for the operation and maintenance of the flood gate and improvement of the structure of flood gate facility such as adding the function of emergency spill way could be considered to reduce the possibility for a dangerous incident to happen.

iii) Secure flood control capacity by improving dam operation

In the lower basin of Shire river, flooding is happening frequently and by controlling the inflow from the upstream of Kapichira dam could be effective to reduce the inflow to the lower basin and thus effective as a flood control measures.

However, since Kapichira dam is the largest Hydroelectrical power station in Malawi, the priority could be to secure the power supply capacity. By improving the capacity of dam operation, it is expected to also secure the flood control capacity and utilized as a multi-purpose dam.

3.4 Zimbabwe

3.4.1 Disaster Risk Profile

(1) Qualitative Evaluation of Hazard Distribution

1) Situation of Hazard Distribution in Zimbabwe

The hazard data described in "2.1.2 How to identify overview of disaster risk" was visualized in GIS to identify the profile of hazard as shown in the figure below.

- Although the impact of cyclone is limited, flooding happens by rainfall caused by cyclones.
- River-line flood occurs in some of the rivers.
- Mountainous areas in the west are at high risk of landslide.

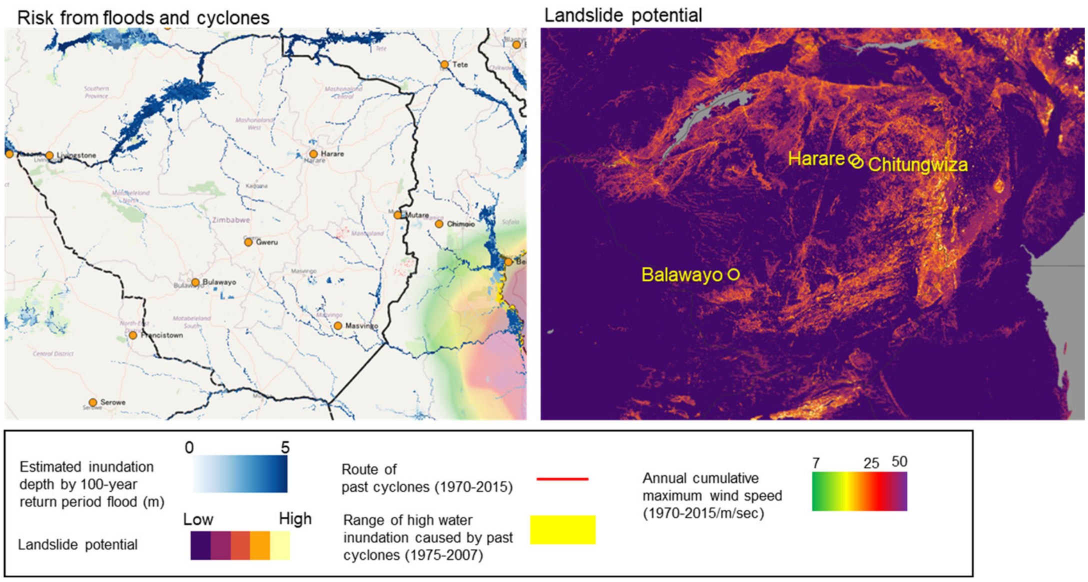


Figure 3–224 Hazard distribution in Zimbabwe
Source: Each data source is listed in Chapter 2, Open Street Map (background map)

2） Situation of Hazard Distribution in Major Cities of Zimbabwe

Situation of hazard distribution in each major city was identified according to the criteria shown in "2.1.2 Basic Idea and Methodology to Identify Disaster Risk Profile ". The population of major cities was confirmed based on UN-Habitat and World Population Review, and the major cities with large population sizes were sorted out.

Table 3-176 Hazard status in major cities in Zimbabwe

City name	Population size (thousand person)	Hazard Status			
		Flood	Cyclone	Storm Surge	Landslide
Harare	1,379	✓	✓	–	✓
Bulawayo	638	✓✓	✓	–	✓✓
Chitungwiza	312	✓	✓	–	✓

Source: JICA Study Team

a) Harare and Chitungwiza

Harare is a capital city located in northern Zimbabwe and the Chitungwiza is a satellite city located to the south of Harare, and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "–" since inundation area is not distributed in the city area (Figure bellow (1)). Storm surge hazard was evaluated as "-" since it is an inland city. Hazard of the strong wind was evaluated as "-" since the Annual accumulative wind speed is not distributed in the city. Landslide hazard was evaluated as "✓" since area with high landslide potential score over the medium level exists in the city area (Figure bellow (2)).

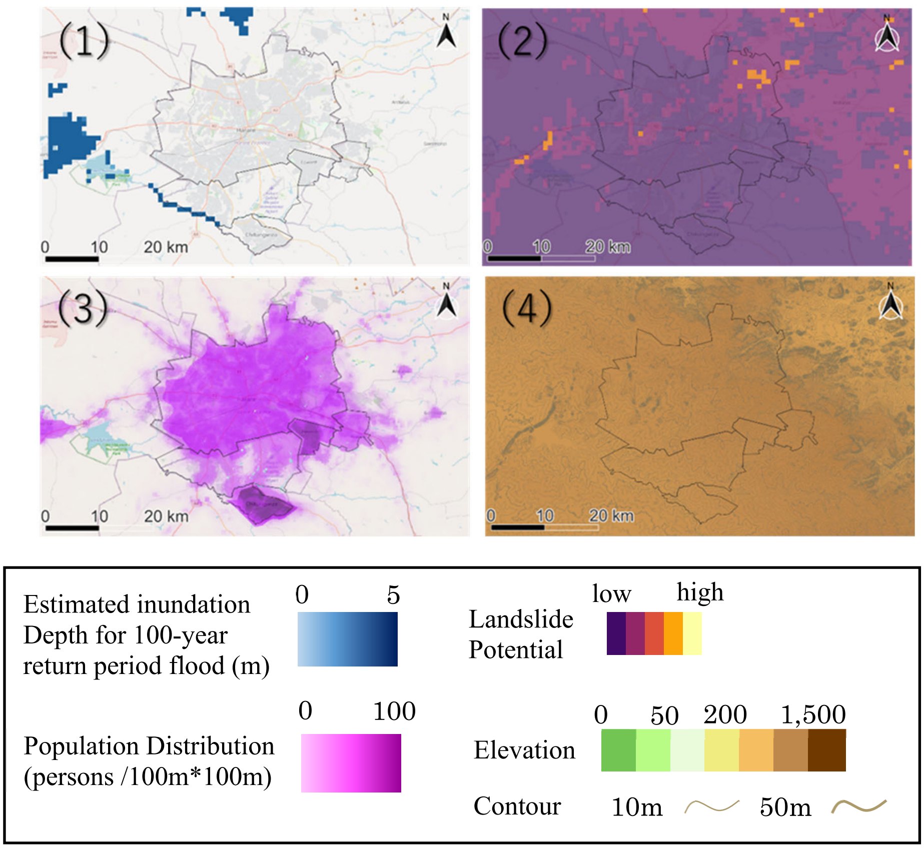


Figure 3–225 Situation of Hazard Distribution in Harare and Chitungwiza

Source: JICA Study Team

b) Bulawayo

Bulawayo is a city located in southern Zimbabwe, and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "–" since inundation area is not distributed in the city area. Storm surge hazard was evaluated as "-" since it is an inland city. Hazard of the strong wind was evaluated as "-" since the Annual accumulative wind speed is not distributed in the city. Landslide hazard was evaluated as "–" since area with high landslide potential score over the medium level do not exists in the city area (Figure bellow (1) and (2)).

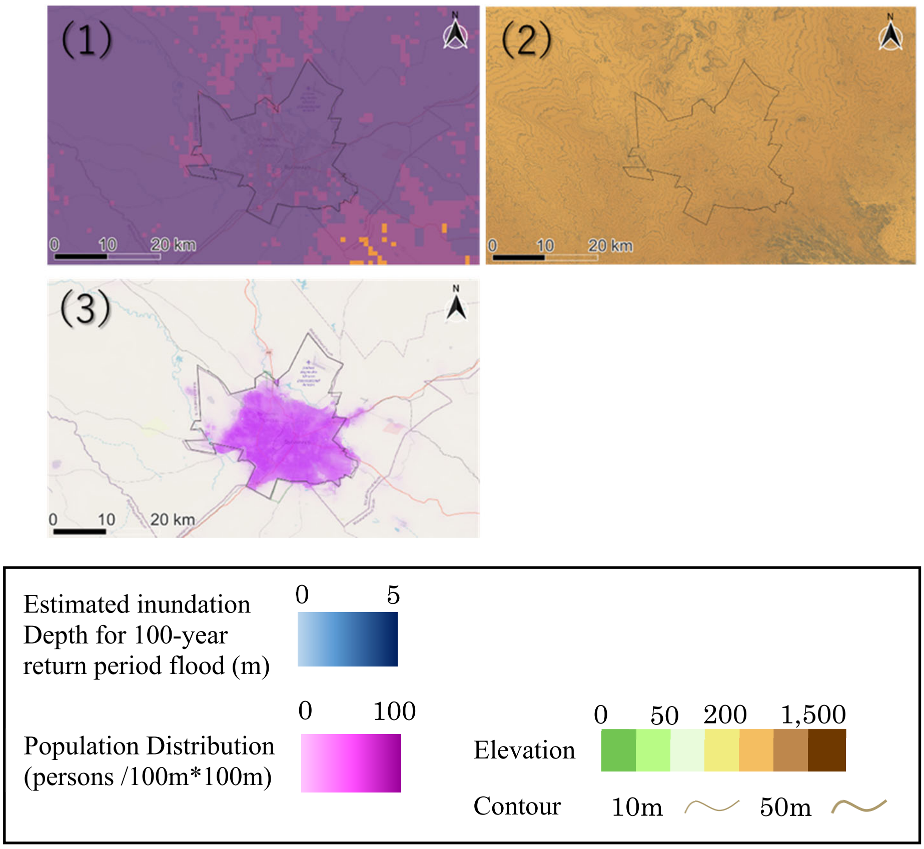


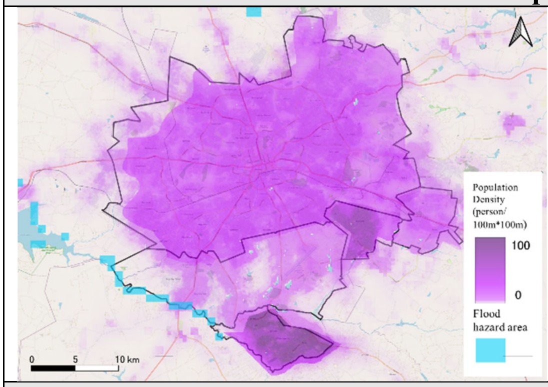
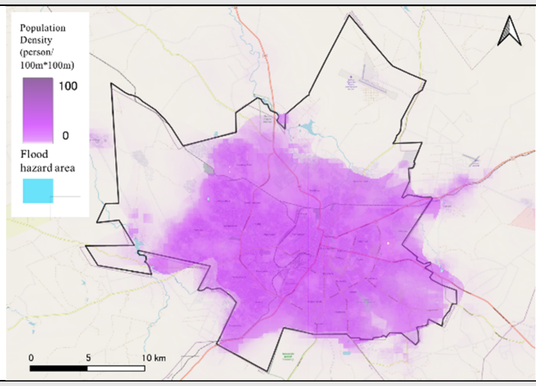
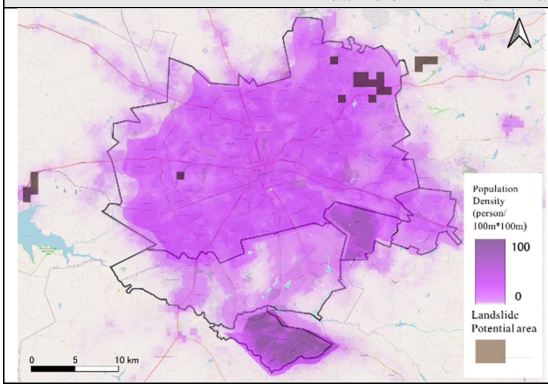
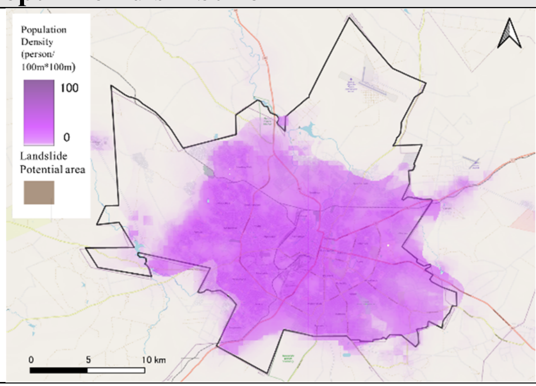
Figure 3–226 Situation of Hazard Distribution in Bulawayo

Source: JICA Study Team

(2) Estimation of Potential Economic Loss due to Disasters

Based on the results of the qualitative assessment of the hazard distribution, a more detailed assessment of the disaster risk was conducted for the Harare Metropolitan area including Chitungwiza and Bulawayo in terms of population size and hazard risk magnitude. For GDP per capita, the data from World Bank was used for the year 2020. The relationship among each hazard area and population distribution is shown in the table below.

Table 3-177 Distribution of Hazard and Population in in major cities in Zimbabwe

Harare Metropolitan area	**Bulawayo City**
Flood hazard and population distribution	
	
Landslide hazard and population distribution	
	

Source: JICA Study Team

Table 3-178 Potential Economic Loss of Major Cities in Zimbabwe

Hazard	Target city	Harare Metropolitan area	Blawayo
Flood	Damaged area (km²)	5	0
	Damage area ratio (%)	1%	0%
	Population affected ('0000 persons)	0.2	0.0
	Estimated damage (million USD)	**1**	**0**
Landslide	Damaged area (km²)	11	0
	Damage area ratio (%)	1%	0%
	Population affected ('0000 persons)	2.1	0.0
	Estimated damage (million USD)	**10**	**0**

* GDP per Capita (Current USD / person) used the data from WB
the value in the year 2020 which is (1,214.5 USD / person) was used

Source: JICA Study Team

In Zimbabwe, the potential economic loss was not a large number because of the limited hazard distribution for both flood and landslides.

It is difficult to make an accurate study of the hazard analysis on a global scale, including the confirmation of the economic loss potential. In addition, the country has not developed a risk profile for GFDRR, and many hazard analyses have not been conducted.

For this reason, in the following sections, the actual disaster situation in 2019, which is the most recent disaster in the country, will be reviewed to determine the types of disasters and areas where countermeasures should be implemented. On the other hand, Cyclone Idai did not cause any significant damage in Harare and Bulawayo, so a detailed analysis, including on-site interviews, is necessary to understand the actual damage caused by disasters in both cities.

(3) Damage and Loss Disaggregated by Sector

1) Sectoral damage summarized in PDNA

In Zimbabwe, a PDNA has been prepared for the 2019 cyclone Idai and the damage figures are summarized in the table below. The amount of damage to agriculture, houses, and transportation infrastructure is significant and shown in light blue colour on the table.

Table 3-179 Damage to each sector summarized in PDNA in Zimbabwe (million USD)

Sector		2019 (Cyclones)
Industry	Agriculture	155.4
	Fishery	0.0
	Industrial, commercial, and other damage	0.0
	Sightseeing	0.0
Social assets	Houses	336.7
	Education	6.4
	Hygiene	14.8
	Other	0.0
Infrastructure	Traffic	163.8
	Electricity and communications	3.1
	Water and sewage	23.2
	Other	37.4

Source: PDNA

Since regional damage distribution analysis by a GFDRR disaster risk profile is not yet available for Zimbabwe, information related to the region and sectors was obtained from the PDNA for the 2019 cyclone Idai. Since recovery and reconstruction after the damage by Cyclone Idai in 2019 has been a challenge particularly in Zimbabwe, the situations in the most effected sectors, namely agriculture, housing, and transportation was summarized were summarized.

As for the agricultural sector, the table below shows the damage to the agricultural sector in the eastern districts that were severely damaged by Cyclone Idai, based on remote sensing. Bikita, Chikomba, Gutu, and Mutare districts were heavily affected. Irrigated areas south of Harare and agricultural lands among the mountains in the east were severely affected.

Table 3-180 Damage to the agricultural sector by district by Cyclone Idai in Zimbabwe

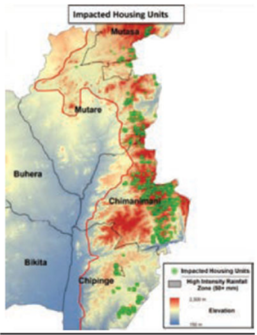
District	Arable Land Baseline	Limited to no flood damage	Possible Damage
Bikita	366,891	205,649	161,243
Buhera	115,754	53,027	62,727
Chikomba	150,391	67,241	83,150
Chimanimani	64,457	32,132	32,324
Chipinge	108,610	76,065	32,545
Chipinge Urban	20	20	
Gutu	130,074	26,892	103,182
Masvingo	213,086	162,108	50,978
Masvingo Urban	346	187	160
Mutare	132,283	52,124	80,159
Mutare Urban	1,082	503	579
Mutasa	59,464	44,050	15,413
Zaka	30,871	15,931	14,940
Total	**1,373,329**	**735,929**	**637,400**

Source: Zimbabwe Rapid Impact and Needs Assessment (RINA) for Cyclone Idai, 2019.

As for damage to houses, as shown in the table below, Cyclone Idai caused heavy damage in the Mutasa, Mutare, Chimanimani and Chipinge districts in the mountainous areas in the eastern region. It is assumed that the cyclone came from the lowlands of Mozambique maintaining its power to hit the mountainous areas of eastern Zimbabwe, causing strong wind and rain there. In the figure bellow the elevation is mentioned (lowest in Blue and higher as the colour change to yellow and red), and the location of damaged houses are mentioned in green. And it can be observed that the damaged houses are located in the mountain area.

Table 3-181 Distribution of damage to houses by Cyclone Idai by district in Zimbabwe

		Remote Sensing Data	Government Data	Remote Sensing Data	Government Data
District	Housing Baseline	Houses Damaged	Houses Damaged	Total Damage (USD)	Total Damage (USD)
Buhera	60,504	—	3,120	—	32,421,687.31
Chimanimani	35,087	6,795	6,324	71,430,970.20	66,479,684.41
Chipinga Urban	7,216	303	681	4,451,219.14	10,011,557.58
Chipinge	69,655	1,520	6,579	16,577,562.37	71,747,045.11
Mutare	50,623	1,213	386	20,831,960.92	6,631,470.86
Mutare Urban	62,125	94	474	3,255,034.35	15,225,154.91
Mutasa	45,109	805	137	14,910,030.21	2,537,483.40
Makoni	68,021	—	14		213,189.21
Total	**398,339**	**10,730**	**17,715**	**131,456,777.18**	**205,267,272.78**



Source: Zimbabwe Rapid Impact and Needs Assessment (RINA) for Cyclone Idai, 2019.

Damage to roads is also concentrated in Buhera, Chikomba, Gutu, and Mutare districts. Chikomba district is a point in the North-South Corridor, while Buhera and Gutu districts are along the road network that extends from the North-South Corridor to the periphery. In addition, Mutare district is a transit point in the Beira Corridor. These indicate that the damage to the main road network was significant.

Table 3-182 Road damage due to Cyclone Idai by district in Zimbabwe

	Road		Bridges		Total Cost (US$ 000)	
District	(km)	Cost (US$ 000)	(m)	Cost (US$ 000)	Recovery	if +20%
Bikita	20	3,220		0	3,220	3,864
Buhera	259	38,122	3,401	4,081	42,203	50,644
Chikomba	147	23,510	1,380	1,656	25,166	30,199
Chimanimani	31	7,675	1,228	1,474	9,149	10,979
Chipinge	71	17,062	1,444	1,733	18,795	22,554
Chipinge Urban	0	0		0	0	0
Gutu	228	33,751	4,831	5,797	39,548	47,458
Masvingo	6	798	3,035	3,642	4,440	5,328
Masvingo Urban	0	0		0	0	0
Mutare	96	13,390	3,157	3,789	17,179	20,615
Mutare Urban	1	244	60	73	317	380
Mutasa	6	1,485	625	750	2,235	2,682
Zaka	1	112	1,192	1,430	1,542	1,850
Grand Total	**865**	**139,369**	**20,354**	**24,425**	**163,794**	**196,553**

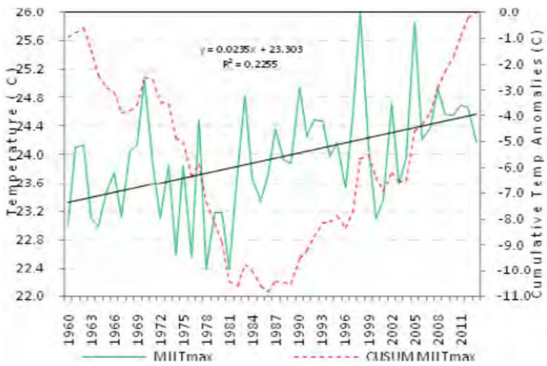
Source: Zimbabwe Rapid Impact and Needs Assessment (RINA) for Cyclone Idai, 2019

3.4.2 Climate Change

(1) Observed and Projected Climate Change

One observation that is assumed to be due to climate change in Zimbabwe is the increase in average temperature. The average annual temperature has increased by about 0.01°C per year from 1901 to 2016. By region, the northern and southern regions of the country are warmer than the central region. In addition, frosts occur from late June to late July (winter, dry season).

(a) (b)



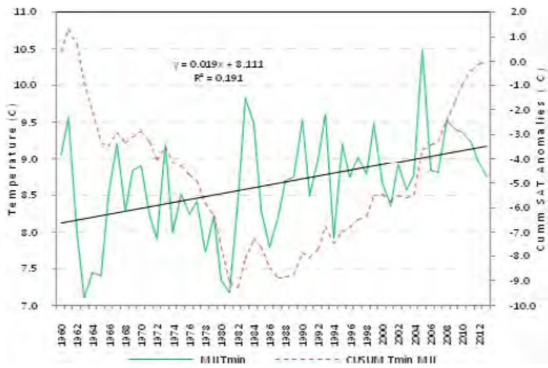
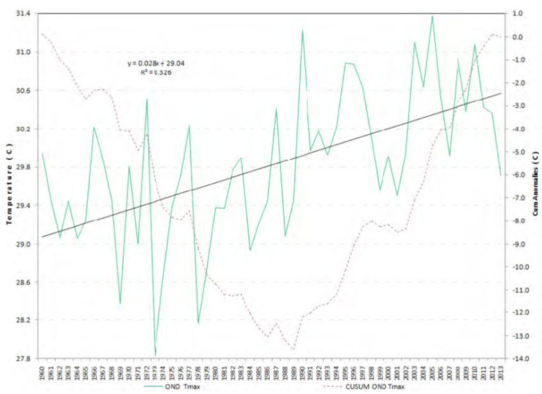


Figure 3–227 Change in maximum surface mean temperature from May to July (winter) (1960-2011)



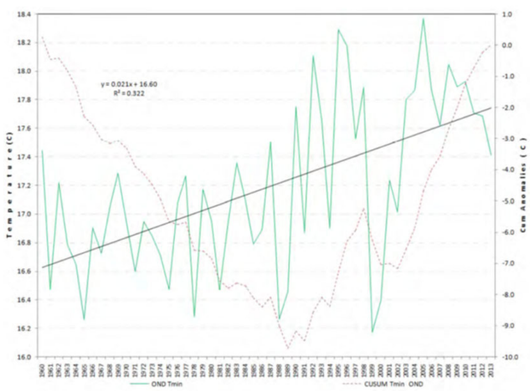


Figure 3–228 Change in maximum and minimum mean temperatures during October-December (summer), 1960-2013.

Source: National Communications 3 of Zimbabwe

In terms of rainfall, there has been no significant change in the average annual rainfall between 1901 and 2013. On the other hand, rainfall during the season of January to March, when cyclones hit the country, shows a trend of increasing (NC3).

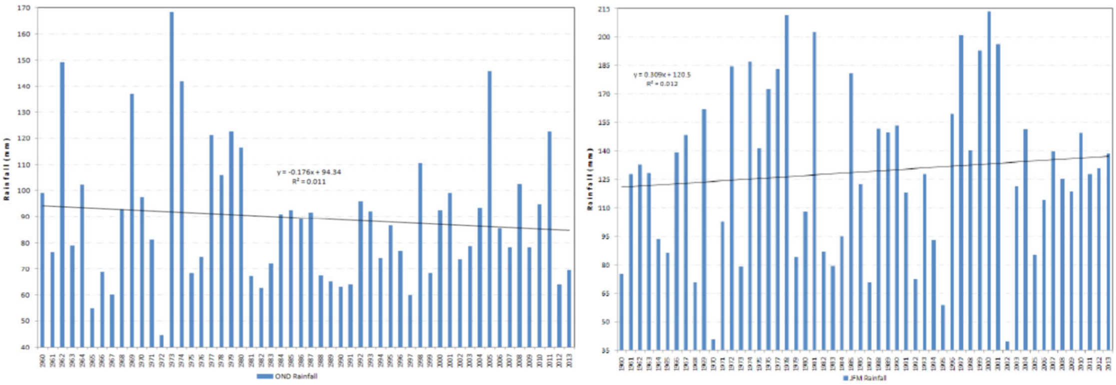


Figure 3–229 Change in rainfall from October to December (left) and January to March (right)

Source: National Communications 3 of Zimbabwe

As future projections, annual temperatures are projected to increase by 1.2°C (RCP 2.6) to 2.2°C (RCP 8.5) between 2040 and 2059, and by 1.0°C (RCP 2.6) to 5.1°C (RCP 8.5) between 2080 and 2099. The temperature increase will be especially pronounced during the summer months, from September to December. Regionally, a slightly higher warming trend is projected for the south and west.

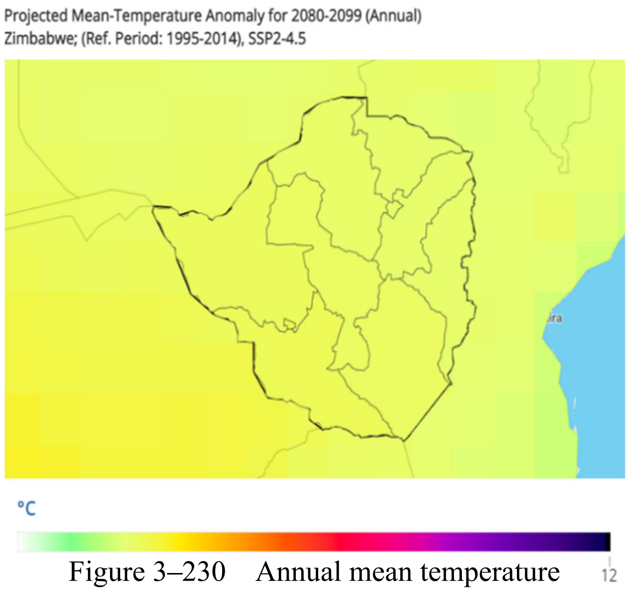


Figure 3–230 Annual mean temperature projection (2080-2099) SSP 2-4.5

Source: Climate Change Knowledge portal, WB

Annual precipitation is projected to decrease by about 1.2% (RCP 2.6) to 4.4% (RCP 8.5) between 2040 and 2059, and to increase by 2.8% (RCP 2.6 scenario) and decrease by 10.7% (RCP 8.5 scenario) between 2080 and 2099[76].

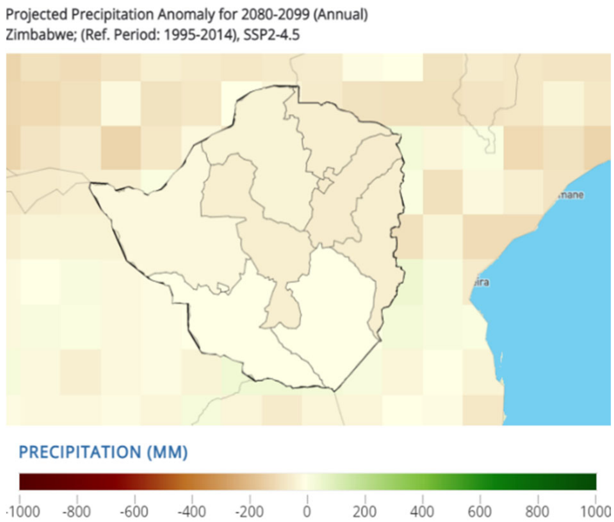


Figure 3–231 Annual precipitation forecast (2080-2099) SSP2-4.5
Source: Climate Change Knowledge portal, WB

Between 1900 and 2017, a variety of disasters, including seven droughts, 22 epidemics, 12 floods, and five storms have been occurred, and which killed about 7,000 people, affected more than 20 million people, and caused a total of US$950 million in damage. Most of the deaths and injuries (and illnesses) were caused by epidemics. As for the damage caused by floods, more than 300,000 people were affected by nine river floods during the same period, killing more than 270 people and causing financial losses of more than USD 270 million.

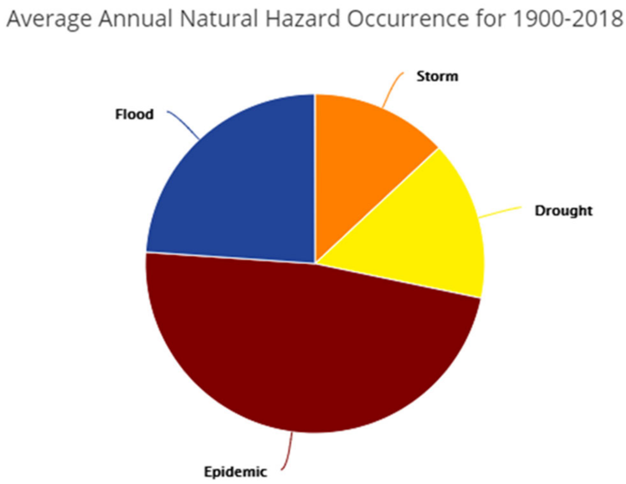


Figure 3–232 Average annual natural hazards occurrence for 1900-2018
Source: Climate Change Knowledge Portal, WB

As for future projections of climate change, the National Climate Change Response Strategy (NCCRS) published in 2014 states that temperatures will increase (2.5°C by 2050) and precipitation will decrease in the rainy season.

[76] Source: Climate Change Knowledge portal, WB

Table 3-183 Summary of climate change projections

Climate feature	Key messages	Source
Past climate variability	High variability, frequent drought years and occasional flood events	Historical rainfall records
Past climate trends	Increasing temperatures (~0.1°C/decade) No conclusive changes in precipitation	Historical temperature and rainfall records
Future climate trends	Increasing temperatures of around 2.5°C by 2050 Possible decrease in rainfall particularly during the rainy season onset (Sep-Nov)	World Climate Research Programme's Coupled Model Inter-comparison Project Phase 3 (CMIP3) Global Climate Model Multi-model Projections and Climate Systems Analysis Group (CSAG), University of Cape Town finer scale projections

Source: National Climate Change Response Strategy (NCCRS), 2014

The below impacts are projected as climate change.

Table 3-184 Impacts of climate change

Sector	Impacts
Water	There are seven rivers and water resources is abundant with a total annual water reserve of 23 billion m3 (mainly rainfall, rivers, streams, lakes, aquifers, reservoirs, and wetlands). Although there are more than 8,000 dams, about 80% of the total water are stored in 149 large dams. Climate change impacts on Zimbabwe's water resources are diverse, including reduced water resources and limited hydropower generation due to changing rainfall patterns and reduced rainfall, increased demand for water for agriculture and power generation due to rising temperatures, and increased costs for water treatment and wastewater management due to reduced rainfall, which is expected to result in flooding and drought.
Agriculture and livestock productions	Rainfed agriculture accounts for a large portion of the total agricultural production (80%) and is highly vulnerable to natural disasters such as rainfall variability, floods and droughts due to climate change. In addition, agriculture in Zimbabwe can be divided into five major regions according to rainfall and soil type. The effects of climate change are expected to have a significant impact on agriculture and production in each of these regions. Yields of maize, a major crop and staple food, are declining, causing nationwide food insecurity. The percentage of farmland suitable for maize production is projected to decline from 75% today to 55% by 2080. There is little crop production other than maize, and the country is dependent on maize production, making it highly vulnerable. Decreased precipitation is also expected to affect pastures for livestock. This also predicts that the livestock industry may face a shortage of food for livestock.
Tourism	Due to climate change, biodiversity is expected to decrease in most parts of the country, especially in the western and southern regions where many national parks are located. It is feared that this will have a major impact on the country's tourism industry, which depends on tourists coming to the country to see the wildlife and diverse natural landscapes. For example, Mana Pools, a major tourist attraction and biodiversity hotspot, is prone to flooding. Also, trout fishing in the streams and dams of the Eastern Highlands is expected to be affected.

Sector	Impacts
Health	The distribution and seasonal transmission of malaria has been found to be highly correlated with changes in temperature and rainfall. Malaria incidence is lower in drought years but higher than average in years with high rainfall. It is feared that rainfall and high temperatures will have a negative impact on the breeding of malaria-carrying mosquitoes. In addition, flooding and water-related disasters can cause serious health problems, such as outbreaks of cholera, typhoid fever, and other infectious diseases, and high temperatures can lead to the spread of meningitis.
Disaster risk management	Climate change, such as increased intensity of floods, droughts and storms, can have negative impacts on life and health, especially of the poor, and on the economic development of the nation. In particular, disaster risk management in rural areas is not functioning properly due to various factors such as lack of funds and capacity, lack of enforcement of relevant laws and regulations, infrastructure facilities that do not take into account the impacts of climate change and their aging. In addition, systems and data that provide appropriate information and knowledge on climate change are not in place, and thus appropriate responses cannot be taken.

Source: National Climate Change Response Strategy (NCCRS), 2014

(2) Policies and Strategies for Climate Change

1） National level

In 2014, the Ministry of Environment, Water and Climate issued the National Climate Change Response Strategy (NCCRS) to strengthen Zimbabwe's efforts to address climate change issues that had previously been addressed under the Environmental Management Act.

Table 3-185 Circumstances of policies, strategies and plan development

Category	Circumstances
National Communication	Initial National Communication was submitted in 1998. Second National Communication was submitted in 2012 Third National Communication was submitted in 2015
NDC	First NDC (Intended Nationally Determined Contribution) was submitted in 2015 Revised NDC was submitted in 2017
National Adaptation Programmes of Action (NAPA)	Not yet
National Adaptation Plan (NAP)	Under developing
National plan, policies	National Climate Policy (2016) National Climate Change Response Strategy (2014) National Adaptation Plan Roadmap for Zimbabwe (2019)

Source: National Climate Change Response Strategy

Table 3-186 Seven pillars of NCCRS

Pillar 1	Adaptation and Disaster Risk Management.
Pillar 2	Mitigation and low carbon development strategies (LCDS).
Pillar 3	Capacity to effect: Adaptation and mitigation, Climate change communication, Education and raising awareness, Research and development, Appropriate institutions to address climate change issues.
Pillar 4	Governance framework: Institutions, Networks, Negotiations.
Pillar 5	Finance and Investment: Partnerships, International Financing.
Pillar 6	Technology development and transfer, including infrastructure.
Pillar 7	Communication and advocacy; information management and dissemination

Source: Compiled based on National Climate Change Response Strategy (NCCRS)

The NCCRS also presents strategies in each of the sectors that will be affected by climate change. The following are examples of strategies for the agricultural sector, which will be particularly affected by climate change.

Table 3-187 Adaptation strategies in agriculture sector

Sector	Sub-sector	Strategy
Agriculture and food security	Comprehensive Strategy for Agriculture and Food Security	a) Develop frameworks for sustainable intensification and commercialization of agriculture at different scales across agro-ecologies. b) Strengthen capacity to generate new forms of empirical knowledge, technologies and agricultural support services that meet emerging development challenges arising from increased climate change and variability. c) Strengthen early warning systems on cropping season quality, rangelands conditions, droughts, floods, disease/pest outbreaks and wildlife movement in order to enhance farmer preparedness
	Farming Systems	Develop frameworks for supporting agricultural specialization according to agro-ecological regions, including mechanisms for commodity exchange, trade and marketing
	Crop productivity	a) Strengthen the capacity of farmers, extension agencies, and private agro-service providers to take advantage of current and emerging indigenous and scientific knowledge on stress tolerant crop types and varieties, including landraces that are adaptable to arising climatic scenarios. b) Develop frameworks for promoting science based crop production and post harvest technologies and management practices.
	Livestock Production	a) Strengthen the capacity to identify and promote adoption of indigenous and improved livestock breeds that are tolerant to climate related stresses. b) Establish monitoring systems for greenhouse gas emissions in agricultural systems and support mechanisms for their reduction

Source: National Climate Change Response Strategy (NCCRS)

It also submitted an Intended Nationally Determined Contribution (INDC) to the UNFCCC in 2017, specifically addressing the impacts of climate change on the agricultural sector and setting out the following medium- and long-term adaptation strategies.

Table 3-188 Long-term and near-term adaptation visions, goals and targets

A. Zimbabwe commits to promoting adapted crop and livestock development and climate smart agricultural practices through the following interventions	
	- Strengthening capacities to generate new forms of empirical knowledge, technologies (including conservation agriculture) and agricultural support services that meet climate challenges - Promoting the use of indigenous and scientific knowledge on drought tolerant crop types and varieties and indigenous livestock that are resilient to changes in temperatures and rainfall. - Developing frameworks for sustainable intensification and commercialization of agriculture at different scales across agro ecologies.
- B. Building resilience in managing climate related disaster risks such as droughts	
	- Strengthening early warning systems on climate related agricultural risks. - Developing and sustaining an integrated approach in all sectors of the economy to reduce impacts of climate extreme events. - Promoting climate indexed insurance solutions and enabling market frameworks.
- C. Strengthening management of water resource and irrigation in the face of climate change	
	- Promoting and supporting water harvesting as a climate change adaptation strategy - Developing, rehabilitate and maintain surface and groundwater resource. - Strengthening and intensify monitoring systems for hydro-meteorological parameters. - Promoting efficient water use practices in the economy - Strengthening institutional capacity, research and extension for integrated water resource management. - Strengthening biodiversity conservation management and integrity of natural ecosystems to adapt to climate change. - Strengthening water and moisture conservation initiatives
- D. Promoting practices that reduce risk of losses in crops, livestock and agricultural incomes	
	- Building capacity to conduct comprehensive vulnerability assessments and develop appropriate response models. - Strengthening the capacity of the national meteorological and hydrological services to provide climate data timely.
- E. Cross sectoral adaptation efforts	
	- Promoting capacity building through research and development, education and awareness, and training in climate change related issues. - Mainstreaming gender responsive climate policies and emphasise special efforts to support vulnerable groups (women, youth and children) in climate change adaptation efforts within all sectors of the economy. - Promoting non-timber forest products and sustainable agro-forestry practices to enhance forest-based adaptation. - Implementing management practices that enhance capacity of power generation of hydropower stations in situations of limited water availability due to reduced rainfall. - Increasing the water-holding capacity of reservoirs in anticipation of increased abstraction and increased evaporation. - Building the capacities and support communities toward a diversification of livestock productions and shifts from agriculture into other sectors, where needed.

Source:.Zimbabwe's Intended Nationally Determined Contribution (INDC), 2017

The actions, gaps, and barriers to the implementation of these adaptation measures are presented in the INDC as follows.

Table 3-189 Actions, gaps, and barriers to the adaptation implementation

Action	Gaps and Barriers
Encouraging adapted crop and livestock development and farming practices	- Inadequate institutional and technological capacity to maximize germ-plasm of adapted crops and livestock - Lack of knowledge and skills for intensive production practices - Lack of mechanization technologies for climate smart production systems - Inadequate research and extension - Lack of financial resource - Inadequate training of farmers - Fragmented implementation of climate smart strategies
Building resilience in managing climate related disaster (drought, hail, violent storms/wings, frost heat waves, erratic rainfall and floods) risks	- Inadequate institutional capacity for providing timely early warning systems - Insufficient capacity for grain storage facilities - Insufficient support services for index insurance - Incoherent institutional frameworks (policies) to coordinate disaster risk reduction - Lack of financial resource
Strengthening management of water resource and irrigation in the face of climate change	- Inadequate infrastructure and technology for irrigation as well as institutional capacity for managing water resource - Lack of knowledge, skills and technologies for improving water use efficiency in agriculture - Lack of financial resource

Source:.Zimbabwe's Intended Nationally Determined Contribution (INDC), 2017

In addition, an updated version of the NDC was submitted to the UNFCCC in 2021, in which the following four items in particular are identified as priority adaptation measures.

Table 3-190 Adaptation measures in NDC

Measure 1	**Develop, implement and scale-up climate smart agriculture solutions and strengthen the resilience of agricultural value chains and markets**
Description	Promoting the use and roll-out of gender sensitive climate-smart agriculture technologies and practices such as land and water resources conservation, sustainable mechanisation, agro-ecology, water-efficient irrigation, renewable energy and energy efficiency, climate adapted crop types/varieties and livestock types/breeds, crop/livestock diversification, agro-forestry, integrated pest and disease management, post-harvest technologies, improved livestock management, fodder production and livestock feeding strategies, silvi-pastoral systems. (i) Increasing resource-use efficiency along the agricultural value chain (ii) Supporting value addition to agricultural products (iii) Improving market access for women and youth farmers in remote areas (iv) Minimizing waste, and (v) Reducing inequalities along agricultural value chains.
Benefits	- Increasing adaptive capacity by providing the technology and tools necessary to increase efficiency of agricultural production - Sustainable use of resources, such as water and soil in the long-term - Adaptive capacity would also be improved by providing the tools to anticipate future changes in climate and adjust production accordingly - Reducing sensitivity to climate change by expanding the use of climate-resilient breeds of crops and livestock - Strengthening the resilience of agricultural value chains and resource use efficiency is expected to reduce the sensitivity of water, energy, waste, and biodiversity sector to climate change and variability
Measure 2	**Enhance early warning and climate-related disaster risk reduction systems (including information management systems)**
Description	(i) Enhance early warning systems, including through better information management systems (ii) Provide the systems and knowledge to manage disaster risks at national and community-level, and (ii) Support the coordination of responses to climate hazards and to climate impacts across sectors and geographies.
benefits	- Increasing their adaptive capacity through improving knowledge of future events and improving systems to prevent, prepare for, and/or manage their consequences - Reduce exposure of key vulnerable groups located in hazard-prone areas by allowing them to relocate when hazards are foreseen
Measure 3	**Ensure climate-resilient infrastructure and design**
Description	(i) Provide the means and incentives for new infrastructure to be planned, designed, built and operated while accounting for future climate change, including extreme-weather events (ii) Facilitate retro-fitting of previously built infrastructure to ensure it is resilient to future climate events. This measure applies to infrastructure such as buildings, roads, bridges, telecommunications infrastructure, water infrastructures like dams, sewages, drains, water supply pipes, pumps (iii) Use energy generating technologies (wind, photovoltaic solar) that are not reliant on climate-sensitive hydrological resources
Benefits	Reduce the climate sensitivities of all sectors that are reliant on infrastructure

Measure 4	Develop and promote resilient water resources management
Description	(i) Support the use of best available hydro-climatic information to improve water resource management (water resource assessment), (ii) Explore options to increase water supply from surface and underground (water demand management and water use), considering gender differences in water supply and access, and (iii) Support the management of extreme events (integrated flood management, drought management)
Benefits	Increase their adaptive capacity by providing the tools and knowledge to better manage water resources and to reduce their sensitivity by increasing the availability of water

Source: Zimbabwe Revised Nationally Determined Contribution 2021

The NAP (National Adaptation Plan) is under review with a target completion date of December 31, 2021.[77]

2） Regional level

Information on climate change adaptation impact assessments and adaptation measures in rural areas have not been found.

(3) Supports from Other Donors

A number of international organizations and donors have been providing various types of support for climate change-related policy making and project formation. The following is a list of donor support for agriculture, food, and livestock.

Table 3-191 Support from donors (as of 2021)

Donor	Sector	Name of project
UNDP、GEF	Community	Building Climate Resilient Rural Communities in Zimbabwe (2012-present)
UNDP DFID	Responding to hazards and strengthening resilience to disasters	Resilience Building Fund (2015-2019)
UNDP and GEF	Wildlife sanctuaries, community support in response to climate change	Strengthening Biodiversity and Ecosystems Management and Climate-Smart Landscapes in the Mid to Lower Zambezi Region of Zimbabwe (2018-2024)
DFID	Responding to hazards and strengthening resilience to disasters	Zimbabwe Resilience Building Fund Programme (ZRBF) (2015-2021)

Source: JICA study team

77 Not published as of early January 2022.

3.4.3 National and Urban Development

(1) National Axis and Strategic Cities

In the Southern Africa region, the main distribution routes via Zimbabwe are the north-south corridor that goes north from South Africa to landlocked countries such as Zimbabwe and Zambia, and the east-west corridor (Beira corridor) that connects Mozambique to landlocked countries. In Zimbabwe, good soil spreads over a wide area, mineral resources spread widely from the northeast to the southwest where Harare is located. Important tourism resources are located at the border. Connecting them, the transport axes form a good network (see the figure below). The Zimbabwe government has implemented infrastructure and social facilities (economic infrastructure including roads) in the national economic recovery plan "Zimbabwe Agenda for Sustainable Socio-Economic Transformation, Zim Asset 2013-2018" (hereinafter "ZIM ASSET") formulated in October 2013. Development is positioned as one of the four major fields, and improvement of the road environment is listed as an important item. More specifically, it is considered important to improve and expand arterial roads and accessibility to transportation facilities along ports, airports, and development corridors.

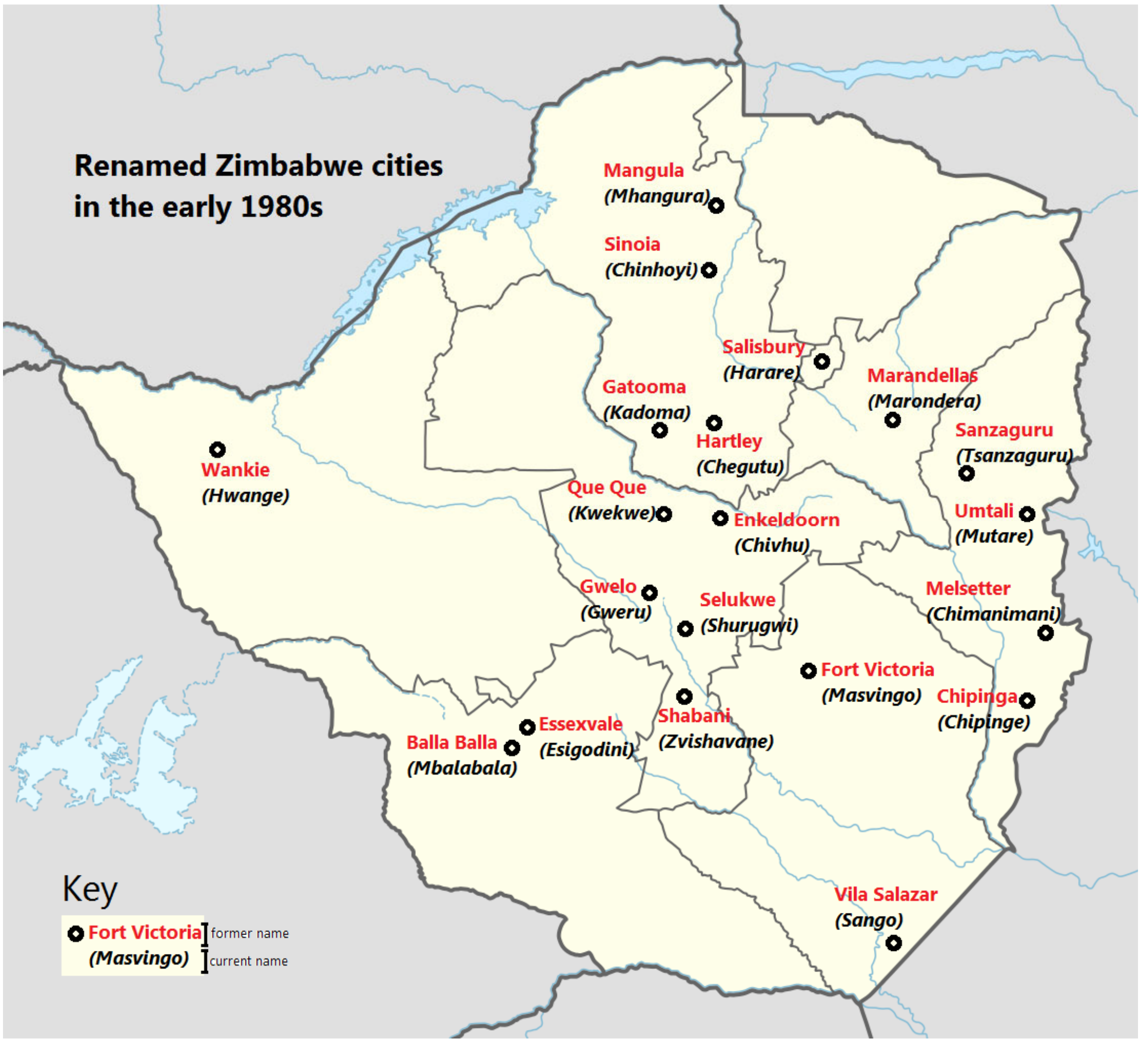


Figure 3–233 Location of Major Cities

Source: Renamed cities in Zimbabwe in the 1980s, Maps on the Web[78]

[78] https://mapsontheweb.zoom-maps.com/post/139716743701/renamed-cities-in-zimbabwe-in-the-1980s-via-reddit

Figure 3–234 Corridors in Zimbabwe

Source: Transit Facilitation Programme[79]

(2) Cross-border infrastructure

The improvement of north-south corridor, which has been deteriorated after construction 50 years ago, had been desired as a countermeasure against increased traffic demand. Its southern section (between Harare and Beitbridge at the South African border) was implemented as a Public Private Partnership (PPP) project by an Austrian company in 2017. Also in the northern section, a project as a Chinese loan is requested for the Chirundu section on the Harare-Zambia border, and Japan's grant for 13.6 km from the suburbs of Makuti to Hell's Gate has been provided.

(3) Location of Important Industries

Zimbabwe was once a nation with a balanced economy of agriculture, mining and industry. Efficient agriculture run by large white farmers accounts for half of foreign currency income. The unit area yield of wheat from the 1980s to the 1990s was the highest in the world. The figure below shows the land classification and agricultural land utilization in Zimbabwe at that time. However, as the compulsory land expropriation policy for white farmers started, those farmers

[79] https://tttfp.org/corridors/north-south-corridor-2/

with management know-how disappeared, and the yield of agricultural products decreased sharply. The resulting shortage of foreign currency hindered the import of industrial parts caused decline of industrial production, and led to economic stagnation

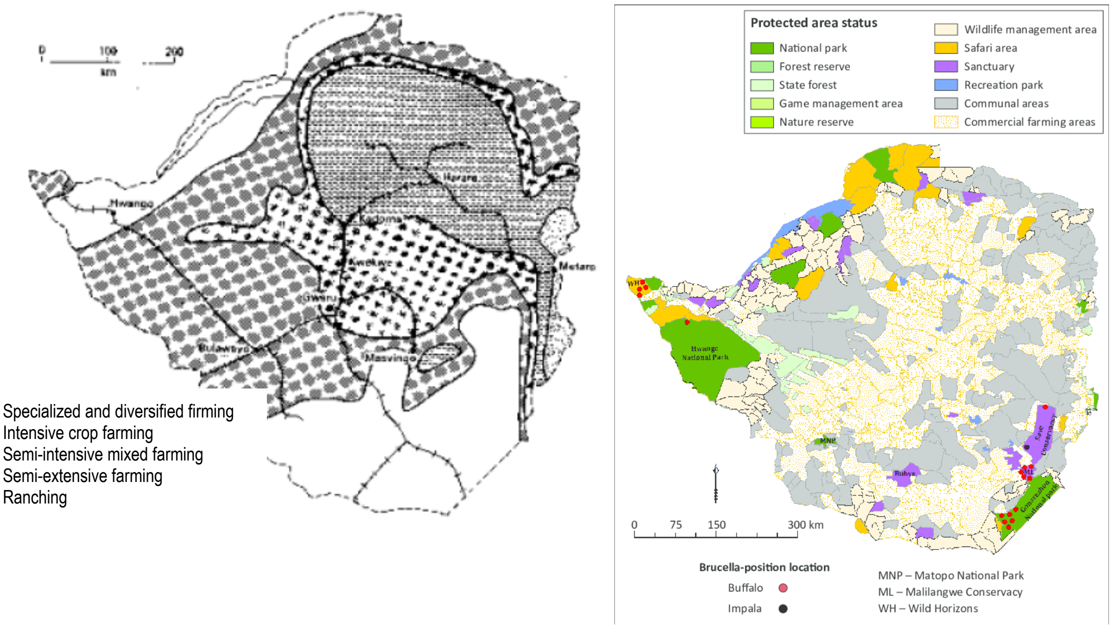


Figure 3–235 Soil Classification (left) and Agricultural Land Use (right)
Source: Lands and Peoples of Central Africa, Longman 1983

As for the mining industry, coal, chromium ore, asbestos, gold, nickel, copper, iron ore, vanadium, lithium, tin, and platinum are produced, and is an important foreign currency earning sources along with agriculture and tourism. Platinum, in particular, boasts one of the largest reserves in the world. The diamond mine also has one of the highest yields in the world that marked 12 million carats in 2014. The figure below shows the distribution of major mineral resources.

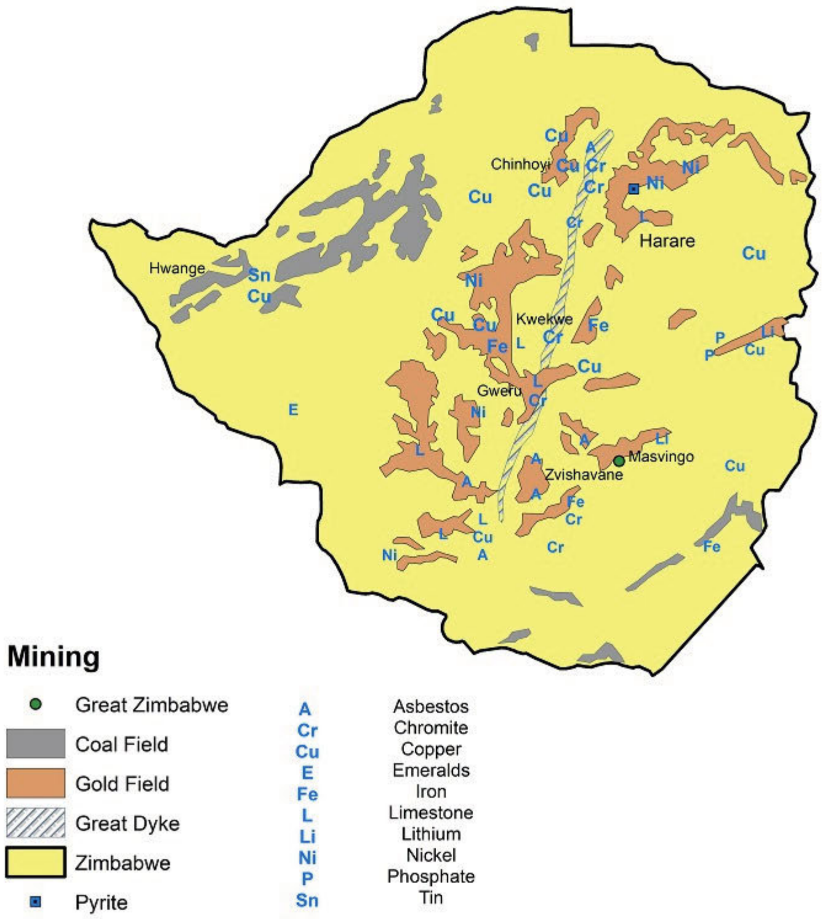


Figure 3–236 Distribution of Major Mining Resources

Source: Research Gate

Regarding the manufacturing industry, industries such as steel industry, food processing, tobacco manufacturing, chemical manufacturing, textile, transportation equipment manufacturing, paper manufacturing, and wood are prosperous. Some products, such as coal, gold, chromium, nickel, have been traditionally practiced.

It is a country with abundant resources for tourism, and has important natural landscape resources such as Victoria Falls, which is considered to be one of the three major waterfalls in the world. In addition, internationally renowned national parks and nature reserves, which are designated as national parks, are widely scattered on the border areas to the neighbouring countries. Among them, Hwange National Park, and Cariba National Park are very prominent. (See the figure below)

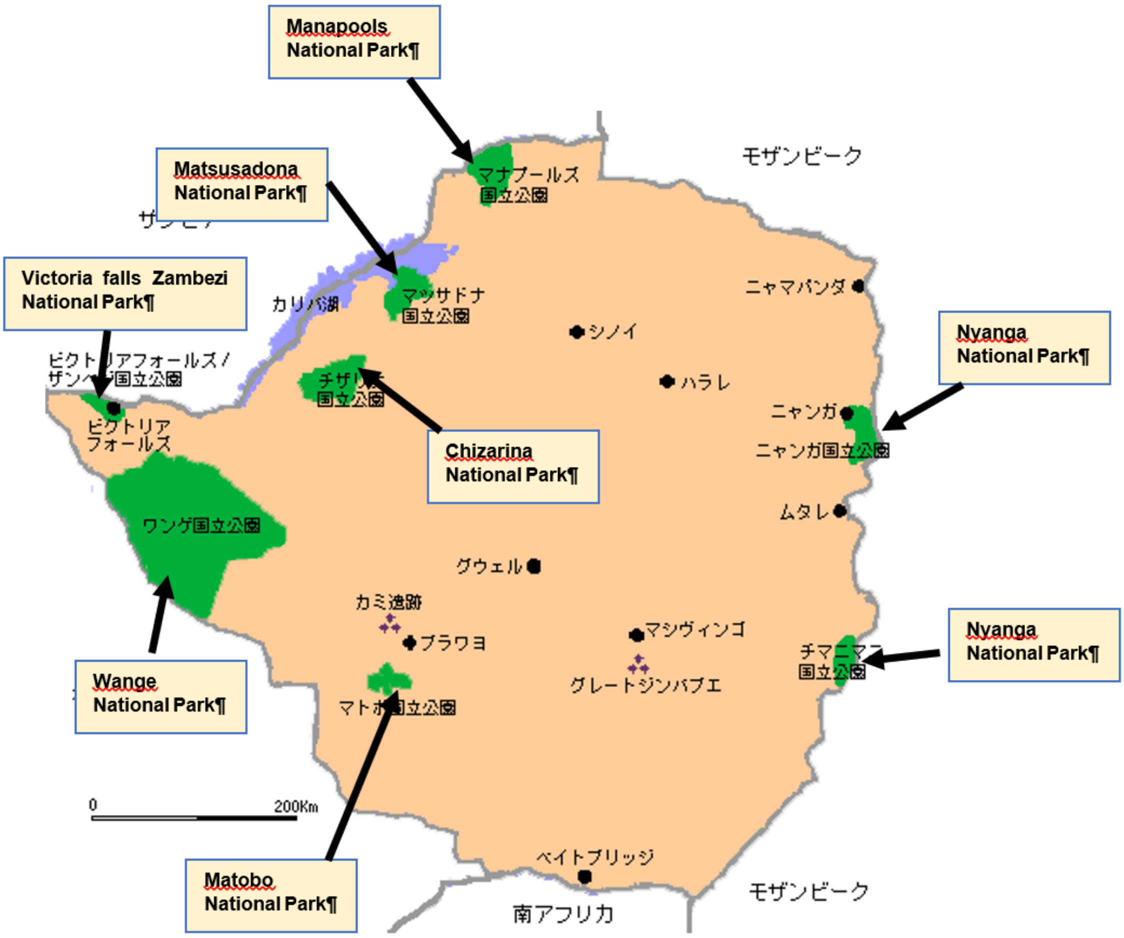


Figure 3–237　Distribution of National Parks

Source: Research Gate

(4)　Key cities in Terms of Urban Development

In Zimbabwe, the disaster type of a highest risk is sediment disasters in mountainous areas. In addition to Harare, the capital, and Bulawayo, the second largest city, Mutare and Chimanimani along the Mozambican border are more susceptible to sediment disasters and cyclones than other areas, and these areas were also affected by Cyclone Idai.

In addition, since Zimbabwe is a landlocked country, it is important to secure logistics routes. Nyamapanda and Mutare along the border with Mozambique, Beitbridge on the border with South Africa, and Victoria Falls connecting to Zambia are also important transportation nodes.

3.4.4 Disaster Management Plan and Implementation Structure

(1) Legal framework and planning for disaster management

In Zimbabwe, the Civil Protection Act, enacted in 1989 and amended in 2001, covers aspects of disaster management, including responses to refugees, epidemics, and socio-environmental events as part of “disasters” as defined by the law. As for planning, planning committees under the Civil Protection Act have been set up in provinces and districts to formulate civil protection plans. At the provincial and district levels, too, the agencies concerned are to work together to prepare plans for response measures to be implemented. The plans are to organize, in particular, the dissemination of disaster information, evacuation procedures, and coordination with related organizations, which are something similar to an emergency response plan. On the other hand, for Zimbabwe, we have not found any medium- to long-term plans focusing on disaster risk reduction and disaster prevention infrastructure development.

(2) Implementation Structure of Disaster Risk Reduction and Management

In accordance with the Civil Protection Act, the Department of Civil Protection of the Ministry of Local Government and Public Works has been established to take overall responsibility for disaster management and coordination among related agencies. The Department of Civil Protection is also responsible for the collection and dissemination of information related to disaster management, as well as the training and capacity building of disaster management officials at the national, provincial and district levels. The Department of Civil Protection itself has its own staff in the provinces and districts to ensure coordination between the central government and the provinces.

In the event of a disaster, the National Civil Protection Committee, as stipulated in the Civil Protection Act, will be established to take necessary measures. In addition, in the emergency response system, responses will be divided into the three levels of national, provincial, and district levels, which will be carried out in coordination. Zimbabwe's emergency disaster management system is shown in the figure below. Depending on the nature of the disaster, there should be coordination with the military, police, local governments, relevant ministries, INGOs, international donors, etc. For a broader regional support, the government will also call on SADC, AU and AfDB for support.

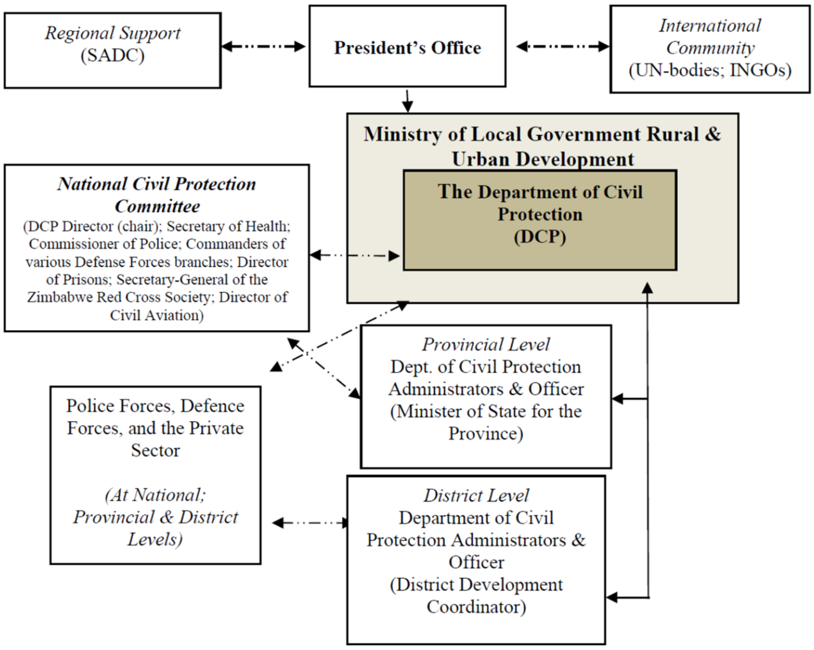


Figure 3–238 Disaster Response System in Zimbabwe

Source: Prepared by JICA Study Team.

There is no mention in the Civil Protection Law, etc., of a coordination system for the promotion of integrated measures covering both "soft" and "hard" aspects for disaster risk reduction, such as the development of disaster prevention infrastructure. Therefore, actions for disaster risk reduction, especially through "hard" measures, seem to be basically dependent on the efforts of individual ministries and agencies concerned. It is considered that there are many issues to be addressed in understanding disaster risks and considering countermeasures from a medium- to long-term perspective.

3.4.5 Trends in Donor Support

(1) Overview of Donor Support

According to the Ministry of Foreign Affairs of Japan's International Cooperation Bureau's Official Development Assistance (ODA) Country Data Collection, totals for 2000-2017, donor aid to Zimbabwe is dominated by Global Fund to Fight AIDS, Tuberculosis and Malaria (GFATM) and European Union (EU) institutions such as the European Commission and the European Investment Bank. By major donors, the U.S. and the U.K. provide the most aid.

Table 3-192 Top five donors' economic cooperation (in millions of dollars)

Economic cooperation by international organizations		**Economic cooperation from major donors**	
GFATM	1074.94	US	2,309.1
EU Institutions	980.4	UK	1,723.5
WFP	209.36	Sweden	427.2
GAVI	95.26	Germany	396.0
UNDP	62.52	Australia	209.8

Source: Compiled by the research team from the Official Development Assistance Country Data Collection (2000-2017), International Cooperation Bureau, Ministry of Foreign Affairs of Japan

According to the main areas of support by donor shown in the COUNTRY BRIEF UPDATE 2014-2016 of the African Development Bank, by sector, a large part of support goes to the health sector.

Table 3-193 Main areas of support by donors

	Capacity building and institutional support	Education	Health	Water and sanitation	Energy	Agriculture	Economic reform	Food	Other Infrastructure	Displaced persons	Judicial reform
ACBF	√						√				
AfDB	√			√	√		√		√		
Australian Aid (AUSAID)	√	√	√	√		√	√		√		
China		√	√	√		√	√		√		
CIDA			√	√				√		√	
Denmark		√				√		√	√		√
European Commission	√	√	√	√		√	√	√		√	
Finland							√				
France			√			√		√			
Germany		√	√	√				√	√		
Ireland			√					√			
Japan		√	√	√				√		√	
Norway		√	√			√			√		
SIDA		√	√	√		√		√	√	√	
Spain			√			√		√			
Switzerland			√	√		√		√			
The Netherlands	√	√	√	√		√		√	√	√	
UK Department for International Development (DFID)	√	√	√		√	√	√	√	√	√	
UNDP	√						√				
USAID	√	√	√	√		√		√			
World Bank	√						√				

Source: AfDB COUNTRY BRIEF UPDATE 2014-2016

(2) Trends in Aid from World Bank (WB)

The WB has suspended direct lending to Zimbabwe since 2000 due to non-payment of arrears, but continues to provide assistance to Zimbabwe through trust funds such as the multi-donor Zimbabwe Reconstruction Fund (ZIMREF), the Global Financing Facility (GFF), the State and Peacebuilding Fund (SPF), and Cooperation in International Waters. In addition, agencies such as the Financial Sector Reform and Strengthening Initiative (FIRST), Global Environment Facility (GEF), Energy Sector Management Assistance Program (ESMAP), and the Global Facility for Disaster Reduction and Recovery (GFDRR) are also supporting sectoral activities.

On the other hand, the Cyclone Idai Recovery Project received an exceptional $72 million from the International Development Association (IDA). The project includes: (i) provision of immediate and integrated livelihoods and health care to victims as emergency support for cyclone recovery; (ii) support for restoration of critical community infrastructure to enable medium-term post-cyclone recovery and resilience building, such as water and sanitation facilities, irrigation networks, community schools, and community roads; and support for risk reduction such as slope protection and environmental restoration, and (iii) project management and provision of technical assistance.

In addition, the Zimbabwe Reconstruction and Recovery Project ($3 million) is working with the Department of Civil Protection (DCP) to strengthen the institutional, systems, and policy-related aspects of government-led disaster risk management in Zimbabwe. In addition, the Climate Change TA ($1.5 million) supports efforts to strengthen the government's capacity to integrate climate change into forestry, agriculture, and water and energy investment planning. This indicates that while direct loans have been suspended due to Zimbabwe's financial situation, support is being provided for post-disaster recovery projects and related capacity building projects.

The Interim Strategy Note 2013-2015 identifies three priority areas for the WB Group to support: private sector development and job creation; strengthening core systems for public sector management and service delivery; and reducing vulnerability, increasing resilience, and strengthening human development. As for disaster risk reduction efforts, the report only states that the government will consider supporting the development of a national strategy for disaster risk management.

Table 3-194 List of relevant projects in the field of disaster response / DRR

Project Name	Project Objective	Financier	Approval Year
SPF - Support to Zimbabwe Recovery and Resilience	To support the Government of Zimbabwe to i) improve Governmental coordination capacity to respond to cyclone Idai, and ii) to scale- up and institutionalize DRM capacity.	Zimbabwe Reconstruction Fund (Zimref)	2020
Zimbabwe Idai Recovery Project	To address the early and medium-term resilient disaster recovery needs of cyclone-affected people	IDA Grant	2019

Source: WB Website Projects & Operations

(3) Trends in Aid from the African Development Bank (AfDB)

Requested by a group of donors supporting Zimbabwe, the AfDB established in 2010, and have been managing, a multi-donor trust fund (MTDF/ZimFund) with the aim of promoting Zimbabwe's socio-economic transformation, increasing its resilience, and accelerating its re-engagement with the international community. It provides, in particular, assistance for the rehabilitation of basic infrastructure in the energy and water sectors to provide comprehensive services, capacity building and technical assistance to strengthen organizational governance etc.

The COUNTRY BRIEF UPDATE 2014-2016 identifies three priority areas: "Economic Diversification - Basic Infrastructure Rehabilitation—Boosting Capacity for Delivery of Critical Services," "Governance and Institutional Capacity Strengthening," and "Private Sector Development." Although climate change is mentioned as one of the issues to be addressed, there is no mention of disaster risk reduction, etc., and the AfDB does not indicate its support policy for that.

On the other hand, assistance for disaster management is being provided, and has included capacity building for disaster management financing and humanitarian assistance for flood damage. In addition, the Post-Cyclone Idai and Kenneth Emergency Recovery and Rehabilitation Program (PCIREP) has restored transportation, power, water and sanitation, and agricultural service levels to the affected population in the most affected districts of Chimanimani District, Manicaland Province, and has also provided support to the Zimbabwean government's disaster management (including early warning weather systems) and management capacity.

Table 3-195 List of relevant projects in the field of disaster response / DRR

Project Name	Project Objective	Financier	Approval Year
Africa Disaster Risk Financing (ADRiFi) Capacity-building Project	To (i) strengthen the country's capacity to understand climate-related risks, to estimate their costs for the country and to design measures to adapt to extreme events at the national and sub-national levels; and (ii) promote financing instruments to deal with climate-related disasters, including insurance.	African Development Fund	2020
Humanitarian Emergency Assistance to the 2005 Drought Victims	To help alleviate the suffering of drought victims in Zimbabwe.	Special Relief Funds	2005

Source: AfDB Website Projects & Operations

3.4.6 Selection of Key Cities

Based on a comprehensive review of the general situations of disaster risks, climate change, land development and urban development in Zimbabwe, and trends in donor support, it was decided that Harare would be the key city in this study, and that the study would focus on issues related to disaster risk reduction at the city level and the possibilities for support projects. As for inter-city infrastructure, it was decided to focus on the Central Corridor. The study will focus particularly on these key cities and inter-city infrastructure, but the study of potential support projects will not be limited to these, but will be conducted flexibly as appropriate based on sectoral conditions, local needs, and issues related to regional disaster risk reduction.

3.4.7 Information Collection and Analysis for Cooperation in the areas of Disaster Risk Reduction in each sector

(1) Transportation

As a landlocked country, the most important feature of Zimbabwe's transportation infrastructure is that it has developed a transportation network of roads and railroads to connect with international ports, mainly through international corridors, since the import and export of goods are done through international ports in neighboring Mozambique and South Africa. Zimbabwe's road network forms a hub of the road transportation in the southern African region, since it also connects Zambia and Malawi, which are also landlocked countries, with South Africa. The country's road and rail networks are centered in Harare, the capital, and Bulawayo, the second largest city.

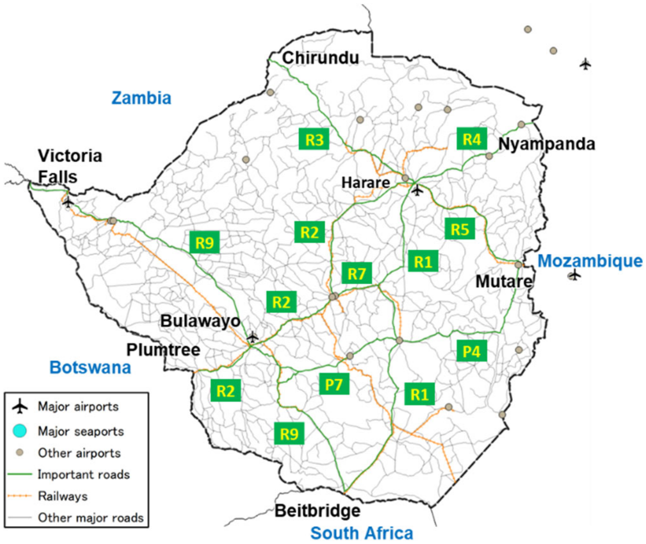


Figure 3–239　Major transportation infrastructure in Zimbabwe

Source: JICA Study Team

1) Overview of Relevant Organizations and Legal systems

Table 3-196 shows the main relevant institutions such as the ministries and agencies that have jurisdiction over the transportation sector in Zimbabwe, and the organizations that manage or operate each subsector.

Table 3-196　Key Institutions in the Transportation Sector in Zimbabwe

Subsector	Key Institutions
-	Ministry of Transport and Infrastructural Development, MoTID
Road	Department of Roads, DOR (under MoTID)
	Zimbabwe National Road Administration, ZINARA
Railroad	The National Railways of Zimbabwe, NRZ
Airport	Civil Aviation Authority of Zimbabwe, CAAZ
	Airports Company of Zimbabwe, ACZ

Source: JICA Study Team

a) Road

In 2001, the Zimbabwe National Road Administration (ZINARA) and Road Fund were established to operate and manage the country's road-related budget. ZINARA manages the Road Fund and allocates the road budget to the following administrative agencies and organizations related to roads.

- Department of Roads, Ministry of Transport and Infrastructure Development: management of Trunk Roads
- Rural District Council and Urban Council: management of urban roads
- District Development Fund: management of rural roads

According to WB/GFDRR data, “Zimbabwe Rapid Impact and Needs Assessment, 2019” (Rina), there are 30 Urban Councils and 60 Rural District Councils across the country. Urban roads are managed by these. The total road length in Zimbabwe is about 98,000 km, and it consists of the Regional Trunk Road Network (RTTN), primary roads, secondary roads, tertiary roads, and urban roads. The current status of these roads is shown in Table 3-197. The national road network is also shown in Table 3-198.

Table 3-197 Current Status of Roads in Zimbabwe (2016/2017 Survey)

Road Class	Definition	Length (Km)	% of total RTRN
RTRN	Roads linking countries within the Southern African region	3,182km	3
Primary	Roads not part of the RTRN but link RTRN with urban centres or between urban centres	8,053km	8
Secondary	Roads connecting RTRN, primary, tertiary and urban roads, industrial and mining centres, tourist attractions and minor border posts to each other	14,084km	14
Tertiary	Roads providing access to schools, health centres, dip tanks and other service facilities within a rural district council area or connects and provides access to secondary, primary and RTRN within and outside a rural district council area	56,368km	57
Urban	(a) Any roads within an urban council area, other than secondary, primary or regional road; (b) Any road located on urban land in a rural district council, other than tertiary, secondary, primary or RTRN	10,065km	10
Others	Roads not falling into above-mentioned classifications	6,298km	6
	Total	98,051km	

Source: Roads Conditions and Inventory Report - Results of the National Roads Condition & Inventory Survey Project; MoTID, ZINARA, and ZILGA

Figure 3–240 National road network in Zimbabwe

Source: Infrastructure and Growth in Zimbabwe - An Action Plan for Sustained Strong Economic Growth, AfDB, 2011.

According to the WB/GFDRR data, “Zimbabwe Rapid Impact and Needs Assessment, 2019” (Rina), only 18% of Zimbabwe's roads are paved, while 48% are gravel-paved, 28% are unpaved, 3% are gravel + unpaved, and 2% are not surveyed. The evaluation of the road surface condition by visual inspection was as follows: 8% "Very good", 17% "Good", 39% "Fair", 18% "Poor", and

12% "Very Poor". Conditions on unpaved roads are even worse, with 37% of the above ratings being "poor" or "very poor". The standard thickness of gravel pavement is 100 mm or 200 mm, but 37% of gravel roads have a thickness less than 50 mm and 17% have a thickness between 50 and 100 mm, which means that they are not properly constructed or maintained. There are 1,398 bridges, 5,323 box culverts, 443 railroad bridges, and 37 pedestrian bridges in the country. Of the 1,398 bridges, the largest number, 1,354 (97%), are for river crossings, followed by 34 (2%) for railroad crossings, and the other 10 (1%) for road crossings. There are 522 bridges in good condition (37%), 476 bridges in fair condition (34%), and 59 bridges in poor condition (4%), while 161 bridges (12%) are damaged (the other 522 bridges (37%) have not been surveyed).

The roads that traverse Zimbabwe from east to west between Prunthree and Mutare, through Bulawayo and Harare (RTRN Roads R2 and R5) are roads that have been built in accordance with international standards. They were completed in May 2015 with a loan of US$206 million from the Development Bank of Southern Africa, and their improvement works were carried out by Infralink, a joint venture (JV) between ZINARA and Group Five International (South Africa).

There is no such concept as emergency transportation roads for disaster response, and redundancy of road network is not considered in most cases. Hence, when a disaster occurs and roads are not usable, it is difficult to reach the destination, and the impact on emergency support and recovery work immediately after the disaster is significant. In response to the damage caused by Cyclone Idai, the Zimbabwe government has developed a road development and maintenance policy to strengthen roads. Road engineers in Zimbabwe are planning and designing roads from the perspective of both resilience and redundancy, aiming for a road system that can be quickly restored after a disaster, and a road network with alternative routes even if some parts are closed to traffic.

b) Railroad

The total length of Zimbabwe's national railroad network is approximately 1,760 km (using a narrow-gauge track width of 1,067 mm, similar to that of regular JR lines in Japan), and the development, maintenance and operation of the railroad infrastructure and train services are carried out by the state-owned National Railways of Zimbabwe (NRZ). The NRZ is the administrative body that manages and supervises the country's railroad sector, but it also manages the infrastructure and operates the train services.

Zimbabwe's railroad network acts as a hub and gateway in the Southern Africa Development Community (SADC) region (see Figure 3–241). Zimbabwe's national rail network is shown in Figure 3–242. It is connected to the Port of Beira through the Mutare/Machipanda border, and to the Port of Maputo through the Sango/Chicualacuala border in the neighbouring country of

Mozambique. It is connected to the railroads of South Africa at Beitbridge, of Botswana at Plumtree, and of Zambia at Victoria Falls. As in other African countries, Zimbabwe's railroads are the primary means of transporting agricultural products and natural resources. Bulawayo, Gweru and Harare are major hubs in the country's railroad network.

Figure 3–241 Railroad network in Southern Africa
Source: Infrastructure and Growth in Zimbabwe - An Action Plan for Sustained Strong Economic Growth, AfDB, 2011.

Figure 3–242 Railroad network in Zimbabwe

Source: Infrastructure and Growth in Zimbabwe - An Action Plan for Sustained Strong Economic Growth, AfDB, 2011.

The entire railroad system, including rolling stocks, locomotives, tracks, and signal systems, is aging and in need of huge reinvestment. Even disregarding inadequate maintenance due to the country's severe economic recession, due to shortage of parts and use of various equipment that are past their useful life, only a few sections of the railroad are in good working condition, which is causing a decline in the overall level of service in the railroad sector. Steam locomotives were reintroduced in 2004 to use coal, which has a more stable supply compared to diesel fuel, for which the country is dependent on imports, and electricity, which is subject to frequent power outages. With the country's serious debt situation, it will be difficult to solve these issues without foreign aid. The volume of cargo handling has declined from about 18 million tons/year in 1998 to about 4 million tons/year in 2015.

The 313 km section between Dabuka near Gweru and the capital Harare was electrified but is currently out of service due to frequent breakdowns caused by theft of cables (copper). In 2001, NRZ launched intercity passenger services, including commuter train services (connecting suburban and urban areas) in the capital Harare and Bulawayo, the country's second largest city. The main intercity passenger service routes are those from Harare to Bulawayo, Victoria Falls to Chiredzi, and Harare to Mutare, with daily train services on each route. Passenger transportation has grown significantly since the launch of commuter train services in Harare and Bulawayo in 2002. Many of them are passengers from Harare. However, as a result of using locomotives to operate commuter trains for passenger service, freight traffic was hampered.

Passenger traffic peaked in 2007 at about 17.4 million passengers per year but declined to about 2 million in 2009. The reasons for this are unreliable passenger service and strong competition with buses and shared cabs in terms of fares and frequency of service. Bus fares are about 50% higher than regular rail fares, and bus services have more delays, breakdowns, and excessively high ridership, but they are faster and more frequent than trains. The commuter train service is also the cause of the NRZ's financial difficulties. The reasons for this are that the uniformly set fares are so low that the fare revenue can only cover a small portion of the operating costs, the prevalence of illegal rides without paying fares, and the inefficient use of materials and equipment. This deterioration in the financial situation of NRZ’s has resulted in deteriorating operational services, and the aging of the railroad infrastructure has led to train accidents, including derailments.

c) Airport

Established in 1998 under the Civil Aviation Act, the Civil Aviation Authority of Zimbabwe (CAAZ) is the government organization responsible for civil aviation services, including the regulation, management and supervision of all aspects of civil aviation, the management of civil aviation infrastructure including major airports, and air traffic management services. There are more than 200 airfields and airports in the country, but CAAZ manages 8 civil airports as shown in Table 3-198.

Table 3-198 Civilian airports in Zimbabwe operated by CAAZ

Airport	Location	Runway	Capacity (per annum)
Robert Gabriel Mugabe International Airport	Harare	L= 4,725 m, W= 46 m	2.5 million
Joshua Mqabuko Nkomo International Airport	Bulawayo	L= 2,588 m, W= 45 m L= 1,347 m, W= 30 m	2.5 million
Victoria Falls International Airport	Victoria Falls	L= 4,000 m, W= 60 m	1.5 million
Kariba Airport	Near Kariba Dam	L= 1,650 m, W= 30 m	-
Masvingo Airport	Masvingo	L= 1,726 m, W= 18 m	-
Hwange National Park Airport	80 km from Hwange	L= 4,600 m, W= 30 m	250 passengers per peak hour
Buffalo Range Airport	Between Triangle and Chiredzi	L= 1,578 m, W= 30 m	-
Charles Prince Airport	Harare	L= 1,200 m, W= 17 m L= 925 m, W= 18 m	-

Source:.Zimbabwe Infrastructure Report 2019, AfDB

The three main international airports are the Robert Gabriel Mugabe International Airport in Harare (Harare Airport), the country's main hub, the Victoria Falls International Airport (Victoria Falls Airport), and the Joshua Mqabuko Nkomo International Airport in Bulawayo. These are planned to have the capacity to handle 6.5 million people per year. In the 2000s, Harare Airport was upgraded to handle up to 2.5 million passengers per year.

However, due to the economic recession in the country, the airport facilities have not been improved, upgraded, or regularly maintained properly. The greatest concern is the aging air traffic control and air safety system, which urgently needs to be upgraded. Related to air traffic monitoring, there is the issue of the capacity of radio communication between aircraft and the ground. The current radio communication system does not cover the entire airspace of Zimbabwe and its operation is inefficient and not properly managed. Such a monitoring system would also hinder search and rescue operations. Weather radar facilities are inadequate, and broadband communication systems are not in place at many airports. Currently, the CAAZ is implementing measures for the aviation radio communication system, but these measures are still insufficient.

The downturn of the country's economy and its tourism industry over the past decade has resulted in a sharp decline in the number of international and domestic aircraft arrivals and departures. As for international flights, the number of flights decreased from 31,000 in 1999 to 16,000 in 2009, and the situation is even worse for domestic flights due to the decline in tourism and economic recession.

2） Overview of Related Plans and Development Status

In 2018, the MoTID developed the National Transport Master Plan with the assistance of AfDB. This Master Plan reflected the then latest National Transport Policy, the Zimbabwe Medium Term Plan (MTP) 2011-2015 and the Zimbabwe Agenda for Socio-Economic Transformation (Zim Asset) 2013-2018. However, the National Transport Master Plan could not be collected in this study. On the other hand, another AfDB document (Zimbabwe Infrastructure Report 2019, AfDB) states that the total budget required for the road, rail and aviation sectors is USD 28.6 billion, of which US$27.3 billion is required for the renovation and improvement of existing infrastructure.

a) Road

The action plan for Zimbabwe's road sector as indicated by the AfDB document (Zimbabwe Infrastructure Report 2019, AfDB) mentions the following. The biggest challenge is to raise funds.

- Rehabilitation of the entire national road network between 2019-2030
- Expansion and improvement of roads in key locations and regions
- Strengthen financial and administrative capacity for regular maintenance
- Reform of the road sector to ensure implementation of the SADC agreement on transportation, etc.
- Reforms for road traffic safety

The construction of new roads is planned for the improvement of pipelines, one of the key infrastructures in the country, and when completed, the following major road axes are expected to ensure road infrastructure redundancy.

- Mutare - Harare - Gweru - Bulawayo
- Beitbridge - Harare - Chirundu

According to the above AfDB data, the following roads are planned to be constructed by the MoTID Road Department in the next 10 years (total amount: USD 542 million). PPP is also considered for propelling this project.

- Matebeleland South Provincial Roads: Gwanda-Maphisa, Maphisa-Mpoengs, Gwanda-Guyu-Manama-Tuli;
- Matebeleland North: Dete-Binga Road and Binga-Karoi Road;
- Midlands: Mberengwa-West Nicholson, Gokwe-Siyabuwa, Kwekwe-Nkayi, Mberengwa-Mataga, Jeka Bridge, Kwekwe-Gokwe and Kawonga Shelvert;
- Mashonaland East: Hwedza-Sadza, Mushandirapamwe-Hwedza, Beatrice-Mubaira, Zaire-Chingondo;

- Mashonaland Central: Guruve-Kanyemba, Mt Darwin-Mukumbura;
- Mashonaland West: Golden Valley-Sanyati, Skyline-Mubaira-Chegutu, Alaska-Copper Queen, Kirkman Road;
- Masvingo: Kapota-Zimuto, Chilonga Bridge, Gutu-Buhera, Mhandamahwe-Chivi-Tokwe, Rutenga-Zvishavane, Chartsworth-Gutu, Rutenga-Boli-Chicualacuala;
- Manicaland: Ngundu-Tanganda, Nyamangura Bridge, Murambinda-Birchnough, Nyanga-Ruwangwe, Odzi-Marange-Zviripiri;
- Matebeleland North: Bulawayo-Nkayi, Bulawayo-Tsholotsho, Ingwingwisi bridge.

The Beitbridge-Harare-Chirundu route (North-South Corridor), which has been repeatedly damaged by natural disasters year after year, is undergoing an improvement project with international assistance, which is expected to be completed by 2022. The JICA's "The Project for the Road Improvement of the Northern Part of the North-South Corridor" is part of the project, and the work in the Makuti-Chirundu section has been completed as Phase 1, and the next phase is currently under preparation.

b) Railroad

According to an AfDB document (Zimbabwe Infrastructure Report 2019, AfDB), the railroad infrastructure has been aging over the past decades; in addition to the problems such as aging track, ballast shortages, unstable ground and slopes, and shortages of signal and communication equipment components, there is a shortage of rail vehicles, which prevents the system to meet the demand for rail transportation is also a major problem. The budget required for the renovation of the railroad infrastructure is USD 400 million. In addition, USD 145 million is needed to refurbish and replace vehicles. Another issue that this document points out is the reform of the NRZ, which is in a position to manage and supervise the railroad sector but also operates it. One of the proposed reforms is to establish a state-owned company (RICZ) to own, develop, and maintain the railroad infrastructure, and a private company (ZRSC) to operate passenger and freight trains under a concession agreement.

The above AfDB document is a relatively recent document, but it does not describe any specific plans for renovation of railroad infrastructure. On the other hand, another AfDB document prepared about a decade ago (Infrastructure and Growth in Zimbabwe - An Action Plan for Sustained Strong Economic Growth, AfDB, 2011) proposed seven new routes (Figure 3–243). The total length of these seven lines is 1,340 km. Of these, the most promising is the 260 km section from the Lion's Den to Chirundu to make a connection to Kafue, Zambia. If this is realized, another rail transportation route to Zambia will be secured in addition to Victoria Falls. Detailed economic and financial analysis is necessary for the commercialization of these seven routes.

Even in a simple estimation assuming a single non-electrified line, it is expected to require USD 2.5-6.0 billion depending on topographical conditions.

Figure 3–243 Planned new rail lines in Zimbabwe's rail network

Source: Infrastructure and Growth in Zimbabwe - An Action Plan for Sustained Strong Economic Growth, AfDB, 2011.

c) Airport

As previously mentioned, CAAZ operates civil airports and civil aviation facilities while regulating and supervising the entire civil aviation sector in Zimbabwe. As in the case of railroads, it is desirable to divide the aviation sector into administrative and operational parts, and as a result of the 2018 amendment to the Act, airports and airfields that were previously owned or leased by CAAZ will be transferred to the Airports Company of Zimbabwe (ACZ).

The AfDB document (Zimbabwe Infrastructure Report 2019, AfDB) mentions five airport renovation projects.

- J.M. Unkomo Airport: Terminal Building Renovation (US$31 million from PSIP) [Approved in 2013].
- J.M. Unkomo Airport: installation of a sewage treatment facility at the airport (US$1.33 million) [approved in 2018].
- Victoria Falls Airport: airport development with Chinese funding (US$150 million) [approved in 2016].
- Harare Airport: upgrades to increase the annual passenger handling capacity from 2.5 million to 6 million, by expanding the international terminal, and improving the radar system, runway lighting, and communication facilities (US$153 million from China) [approved July 2018].
- Harare Airport: Renovation of Sewage Treatment Facility (US$1.82 million from PSIP)

CAAZ is trying to get out of a long downturn in the airline business. The short-term strategy aims to develop businesses to overcome the economic recession that Zimbabwe is facing. Long-term strategies include the development of new products, restrictions on business diversification, and the outsourcing of airport operations to the private sector (concessions).

Zimbabwe is in the process of implementing a revival plan for its aviation sector, and airports are slowly changing. As mentioned above, Harare Airport is under renovation through a loan of US$153 million. Once this renovation is completed, we can expect synergies in the global value chain, accelerating the current economic growth and transformation in the trade and tourism industries. To this end, it is considered that there must be closer and stronger cooperation between the civil aviation authorities and trade and tourism related authorities. We believe that the airport will become an air traffic hub because it will be the largest airport in the surrounding area, capable of handling more than 6 million passengers per year.

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Zimbabwe has experienced a variety of disasters, out of which the biggest problems are cyclones, floods and droughts. Zimbabwe's roads are vulnerable to damage from heavy rains, and the scale of the damage is on the rise. The reason for this is the aging of the road infrastructure, most of which is more than 30 years old. Most of the damage caused by natural disasters is the loss of some sections of road, erosion of shoulders and lanes, damage to pavement layers, damage or clogging of surface drainage facilities, and road disruption due to sediment disasters. Road structures have also been severely damaged, with bridges, culverts, and other ancillary facilities such as guardrails, fences, road signs, street lights, and signal lights washed away or damaged.

Figure 3–244 shows the risks of sediment disasters and floods in Zimbabwe. There is a high risk of sediment disasters in eastern and northern Zimbabwe, especially in the mountainous areas near the border with Mozambique. As for flooding, there are no areas at risk of large-scale floods, although there is a high risk of flooding along some sections of the Save River, which flows from north to south in the eastern part of the country and across Mozambique into the Indian Ocean.

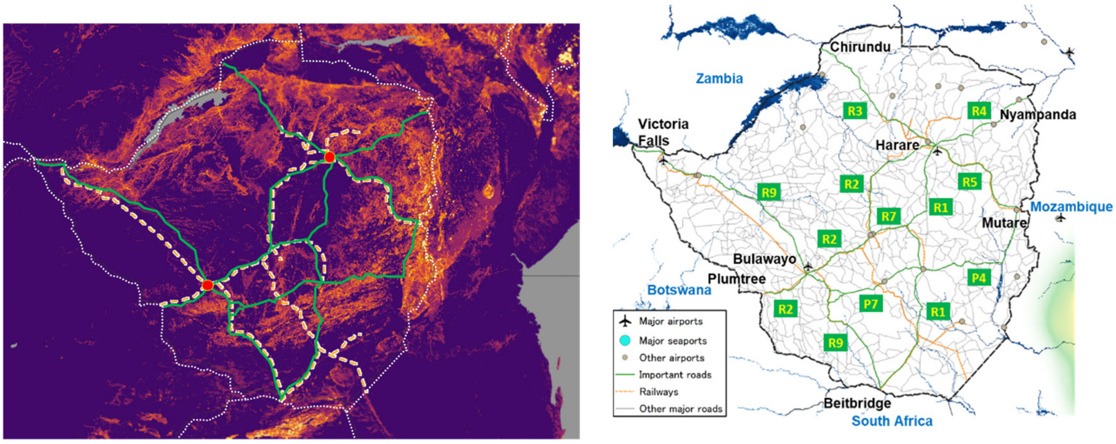


Figure 3–244 Sediment disaster (left) and flood (right) risks in Zimbabwe

Source: JICA Study Team

In order to identify critical transportation infrastructures with a high risk of damage, it is necessary to collect detailed information through interviews. Based on the above discussion, Table 3-199 summarizes the important transportation infrastructures for disaster risk reduction that can be considered at present. However, as for the rehabilitation of RTRN Road R3, the "The Project for the Road Improvement of the Northern Part of the North-South Corridor" is now being undertaken by JICA including the improvement of the road alignment (Phase 1 completed). Once the next phase is completed, damage by sediment disasters is expected to be mitigated.

Table 3-199 Critical transportation infrastructure for DRR in Zimbabwe

Subsector	Critical infrastructure for disaster risk reduction	High-risk disaster
Road	RTRN Roads R3 (North-South Corridor), R4 (Durban Corridor), R5 (Beira Corridor), and R9	Sediment disasters
Railroad	Section between Mutare and Machipanda	Sediment disasters

Source: JICA Study Team

4) Consideration of Disaster Risk Reduction Measures

a) Harare Ring Road Construction Project

Harare, the capital of Zimbabwe, is the country's largest transportation hub where international corridors such as the North-South Corridor and the Beira Corridor intersect. In particular, large trucks traveling between Zambia, Malawi, and the Port of Durban in South Africa pass through Harare. However, there is no ring road in Harare, so these heavy vehicles should pass through the city center. There have also been reports of flooding due to heavy rains in Harare, and there is a risk that the international corridor through Harare will be paralyzed in the event of a disaster in the city center that would make it difficult to pass through. In addition, even during normal times, there is congestion in the city center due to the concentration of traffic, and traffic safety issues due to large vehicles passing through.

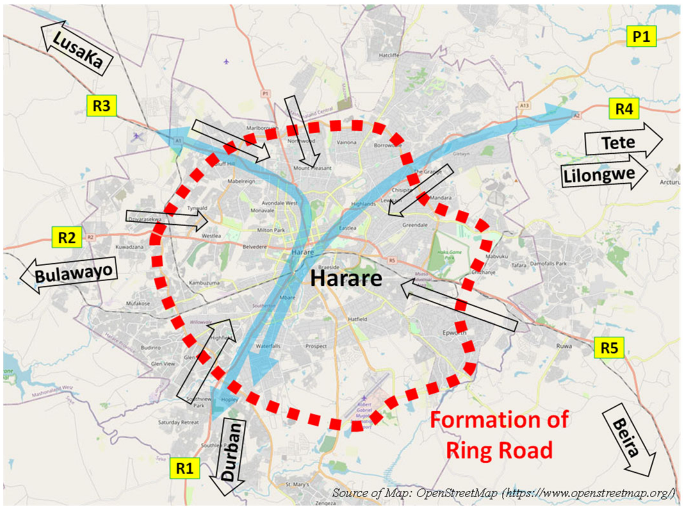


Figure 3–245 Proposed Ring Road in Harare, Zimbabwe
Source: JICA Study Team (map data: OpenStreetMap)

For these reasons, construction of a ring road or a North-South Corridor Bypass for the Harare urban area is proposed. These roads are expected to serve as a traffic countermeasure in central

Harare in normal time, and ensure the road traffic on those international corridors, which secures international cargo transportation not only for Zimbabwe but also for Zambia and Malawi. However, because the information about records of damages caused by disasters, frequency of the road closure of international corridors, traffic volume, etc. could not been investigated in this study, detailed study including investigation on the current situation and local needs including the above information is required.

b) RTRN Road R5 Improvement Project

RTRN Road R5 forms the Beira Corridor, which connects the Port of Beira, the closest international port to Zimbabwe, with the capital Harare. However, as the border with Mozambique is a mountain range, RTRN Road R5 near Mutare passes through mountainous areas, posing a risk of sediment disaster. However, since there is no alternative route, if the road is closed due to a disaster, etc., people have to make a detour using RTRN Road R2 or use another international port.

Slope protection works and alignment improvement can be considered for sections where there is a risk of sediment disaster. In addition, since RTRN Road R5 passes through Mutare City, which has a population of 200,000, it is expected that many large vehicles will pass through the city center. Thus, the Mutare Bypass may be constructed depending on the situation.

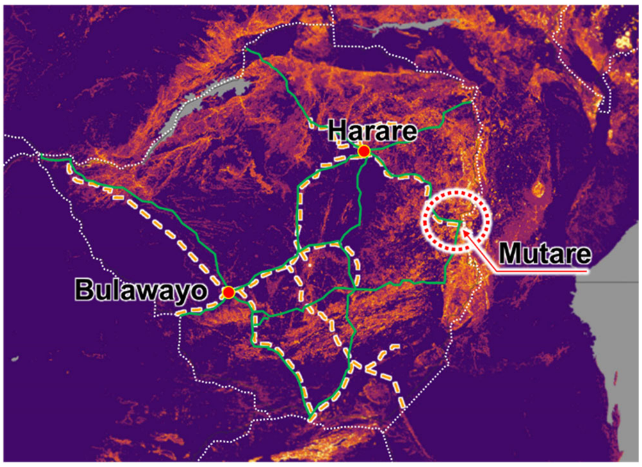


Figure 3–246 Proposed RTRN Road R5 Improvement Project in Mutare, Zimbabwe

Source: JICA Study Team

However, the actual situation is unclear due to lack of information about damages on the road section caused by disaster, since a site visit and an interview have not been conducted for Zimbabwe in this study.

(2) Power

1) Overview of Relevant Organizations and Legal systems

In terms of electricity supply in Zimbabwe, the Ministry of Energy and Power Development oversees legislation and policy, and ZERA, under its supervision, oversees grid and off-grid policies. For the on-grid, ZPC and ZETDC under ZERA and ZESA Holdings develop and operate power generation, transmission and distribution. Rural electrification, which is not grid-connected, will be carried out by the Rural Electrification Department under ZERA.

There are five major power plants, but due to inadequate facilities, supply is actually concentrated in one coal-fired plant and one hydropower plant. Demand peaked in 2006 at 2,100 MW, but has recently dropped to 1,600 MW due to political and economic turmoil. Actual supply capacity is 30-260 MW short of demand (2015).

The main grid in the country is a two-line transmission, either radial or loop system.

Currently, international interconnection lines with Mozambique, Zambia, and Botswana are already in place, and SAPP's international interconnection lines are either multiplexed or looped with Mozambique and South Africa.

The SAPP headquarters is located in Zimbabwe, where the SAPP MP (pool plan), the SADC MP (Regional Development Master Plan), and the MPs of each country are coexisting, and the SADC priority plan has been reflected in the SAPP priority plan.

The entire country is facing power shortages due to aging and inadequate maintenance of equipment (Zimbabwe Infrastructure Report - 2019). 40 MMUSD was spent in 2011 to rebuild the country, but it failed. The shortage of electricity is being imported but it is not economically sustainable. The T&D (transmission and distribution) infrastructure as well as the power generation facilities are aging. More than 75% of substations are equipped with old transformers, resulting in the loss of continuous reserve capacity, increasing the risk of blackouts and preventing new connections.

In addition, inadequate reactive power compensators reduce system capacity, affecting system reliability and voltage compliance; T&D losses reached 18.9 percent in 2016.

On a related note, the need to generate 150 MW of power for Namibia is one burden. 12 IPP projects exist, but they represent only 2% of the total generation capacity. Currently, Kariba hydro and Hwange thermal are the main power producers, while the remaining three thermal plants are only generating 1/3 of their rated capacity. This is due to aging and high costs.

The reason behind the lack of maintenance in the power sector is the deteriorating financial situation. The main reason for this is the too low selling price of electricity. The average price of electricity for final consumers in Zimbabwe has remained unchanged since 2011 at 9.86 USc/kWh, and the price has continued to fall in real terms when inflation is taken into account.

In addition, ZETDC is in arrears on its power import payments to South Africa, making it difficult for it to enter into new, long-term power purchase agreements at lower prices.

2） Overview of Related Plans and Development Status

The government is in the process of formulating a long-term plan (National Integrated Energy ReSource Plan), and there is a system development plan enacted in 2015.

There is also an international interconnection and power supply development plan by the Southern Africa Power Pool (SAPP), and priority PJs have been designated. The current status of these projects needs to be confirmed.

In the medium term, the plan is to increase power generation capacity to 5 GW (hydro, gas and coal); Kariba South hydropower is under expansion to 920=>1050 MW (Zimbabwe Infrastructure Report - 2019). New projects include 1.6 GW hydropower, 1.4 GW coal, 600 MW coal, and 300 MW hydropower, which SAPP has asked to be prioritized for development. The potential of the Zambezi River is expected to be exploited by SAPP, with the idea of exporting hydropower to South Africa in the future.

In Zimbabwe, 100 megawatts of electricity is expected to be added to the national grid from renewable energy projects by the end of this year, and another 50 megawatts from thermal power generation.

The National Renewable Energy Policy (NREP) has also been formulated under the overall framework of the 2012 National Energy Policy. This policy will not only increase the share of renewable energy in the overall energy mix and address the issue of climate change induced disasters, but also promote cost-effective deployment of sustainable energy sources, social upliftment through community participation, gender equality, and job creation, among various other government laws and policies, are emphasized.

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Cyclone Idai had a significant impact on power transmission and distribution infrastructure, causing massive power outages. The estimated damage caused by Cyclone Idai in Zimbabwe alone was US$3.1 million (Zimbabwe Rapid Impact and Needs Assessment, 2019). Manicaland and Masvingo provinces were severely affected; according to an assessment conducted by

ZETDC, 33.6 km of MV network, 88.9 km of 33 kV network, 106.2 km of 11 kV network, and 40 secondary substations were damaged, with overhead lines and substations washed away. The distribution network was also severely damaged. The distribution network was also severely damaged; poles were uprooted and fell, transformers attached to poles fell to the ground, and transformers and satellite substations on the ground were flooded.

The African Development Bank (AfDB) is funding the Post Cyclone Idai and Kenneth Emergency Recovery and Rehabilitation Program (PCIREP). The main objective of the program is to restore service levels of transport, power, water and sanitation, and agriculture to the affected population in the most affected districts of Chimanimani in Manicaland Province, and to strengthen the disaster preparedness (including early warning weather systems) and management capacity of the Government of Zimbabwe. In addition, the construction strategy incorporates principles of climate-resilient planning and design. Improved reliability through the construction of climate-resilient transmission and distribution infrastructure will ensure that critical services such as hospitals, clinics, schools, and wastewater treatment plants will have a reliable and stable supply of electricity in the event of a disaster. A continuous supply of electricity could improve the living standards of local residents. The project to rehabilitate and strengthen power transmission lines will replace the wooden poles used in the past with steel poles that can withstand different types of disasters.

<hazard map>

In many cases, the main grid is located to avoid areas with high risk of landslides, but the grid connecting the central and eastern regions has to cross such risk areas. The Zambezi River hydropower plant, which is the backbone of the power supply, will also have to be constructed in a risk area, and appropriate civil engineering design is required.

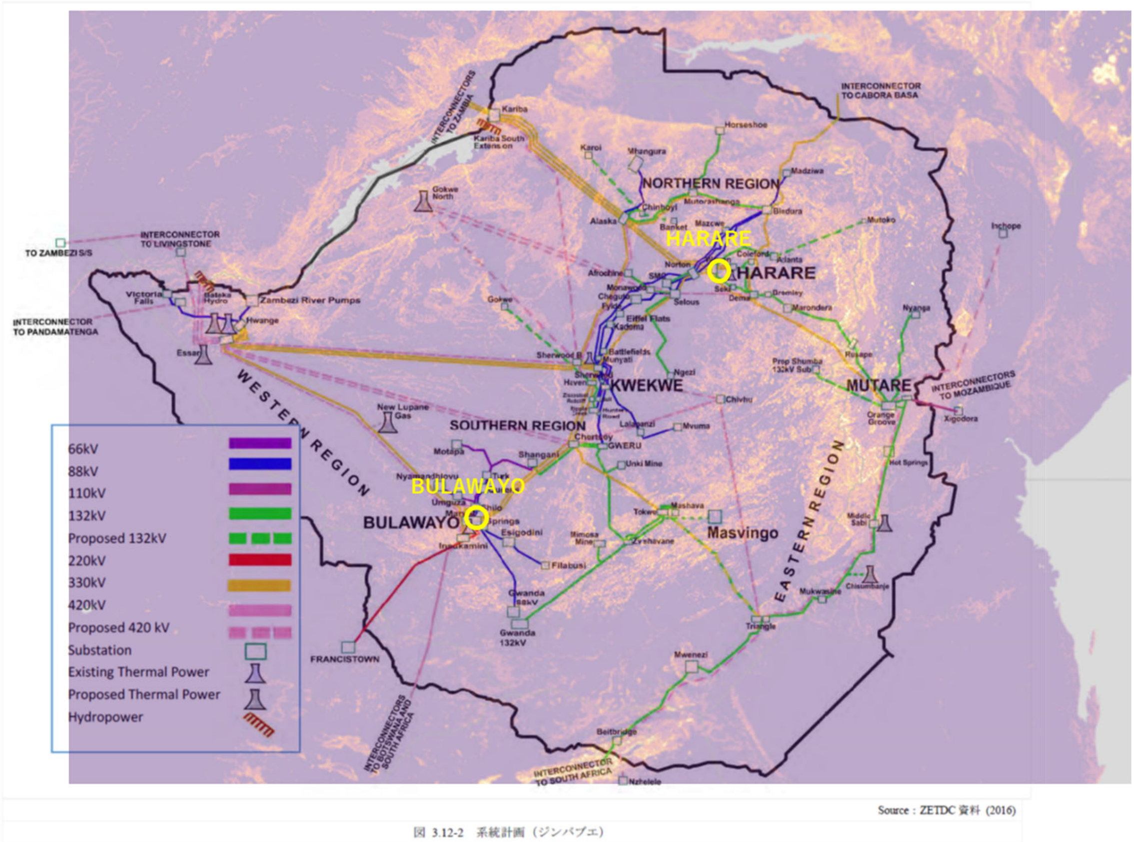


Figure 3–247 Zimbabwe Power Facilities Map and Landslide Risk

Source: Prepared by JICA Study Team based on Africa Region Southern Africa Power Pool Information Collection and Verification Study (2017,JICA)

In addition, there is less risk of flooding or cyclones in both the backbone system and power supply. However, hydropower plants along the Zambezi River are close to risk areas and should be appropriately diked, bulged, and drained.

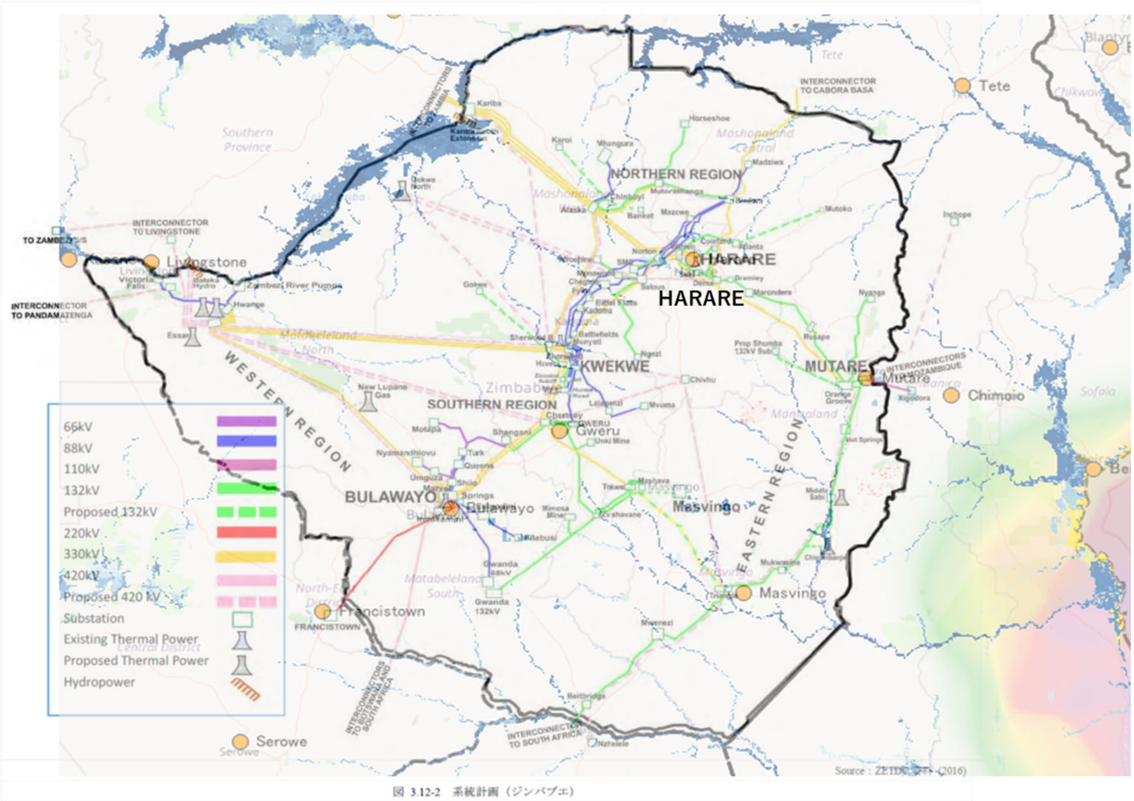


Figure 3–248 Zimbabwe Power Facilities Map and Cyclone/Flood Risk
Source: Prepared by the study team based on Africa Region Southern Africa Power Pool Information Collection and Verification Study (2017,JICA)

4) Consideration of Disaster Risk Reduction Measures

It is explained in the first half of this report that the key points for disaster risk analysis and disaster reduction in Zimbabwe are Harare and Bulawayo, where important political and economic facilities are concentrated. Similarly, for disaster reduction measures in the power sector, focusing on areas where the public sector and major industries are concentrated will result in better measures in terms of cost effectiveness. Harare and Bulawayo, the capital, are particularly mountainous and are among the most vulnerable areas in Zimbabwe to landslides. Landslides can lead to the collapse of power generation facilities and transmission and distribution networks, which in turn can lead to the suspension of various public and private activities due to power outages.

The concept of disaster reduction in the power sector is to enhance the resilience of important facilities and areas to disasters in order to maintain and sustain public services and industrial activities. For example, in the public sector, it is possible to create and operate facilities that can continue to supply energy to water treatment facilities, hospitals, and communication facilities in

the event of a disaster.
In addition, as indicated in Section 3.1.2, the 2021 NDC Update aims to "ensure climate resilient infrastructure and design" by, among other things, achieving the following:

- Provide the means and incentives to plan, design, build and operate new infrastructure that takes into account future climate change, including extreme weather events
- Promoting the retrofitting of existing infrastructure to ensure its resilience to future climate change
- Supplying energy using technologies that are less sensitive to climate change (wind power, solar power)

In addition, as mentioned above, due to aging and inadequate maintenance of electricity facilities throughout the country, Zimbabwe's actual supply capacity is 30-260 MW short of demand (2015), and new connections are becoming difficult. The country is also unable to receive additional supply from SAPP due to tariff arrears. On the other hand, there is a policy to introduce renewable energy to improve sustainability and economic efficiency.

In order to address these issues, we propose to pick up important facilities and areas in the public and private sectors, and introduce hybrid power generation equipment (solar power generation + storage batteries + engine generators) to them, which will be used as in-house power generation equipment including renewable energy. Improving the stability of electricity supply is important for improving the functions of government and industry, as well as for maintaining these functions in the event of a disaster. This proposal will also lead to the realization of a stable power supply while introducing renewable energy regardless of grid constraints. The first items to be implemented are as follows, and it is desirable to add capacity building and other items as appropriate.

- Survey of important public sectors that require stable power supply
- Survey of industrial sectors and industrial parks that require stable power supply
- Understanding the extent to which grid constraints are a problem for the introduction of renewable energy
- Investigating the possibility of augmenting the power supply and improving the operating rate by adding hybrid systems to existing diesel power generation facilities
- Technical and economic studies in cooperation with Japanese heavy industry manufacturers

(3) Water and Sanitation

1) Overview of Relevant Organizations and Legal systems

The institutions involved in water supply and sanitation in Zimbabwe as follows.

- Department of Environment, Ministry of Environment, Water and Climate
- Responsible for governance and policy making for environment and sewage.
- Department of Water, Ministry of Environment, Water and Climate
- Responsible for governance and policy for water supply and sanitation.
- Zimbabwe National Water Authority (ZINWA)
- Implementation body for water and sanitation services and water resources management.
- Harare Water
- Implementation body of water and sewage services in Harare City.

The laws relating to water supply and sanitation in Zimbabwe are as following.

- National Water Policy (NWP) 2012
- Water Act, Law, Environmental Management Act, Zimbabwe National Water Authority Act

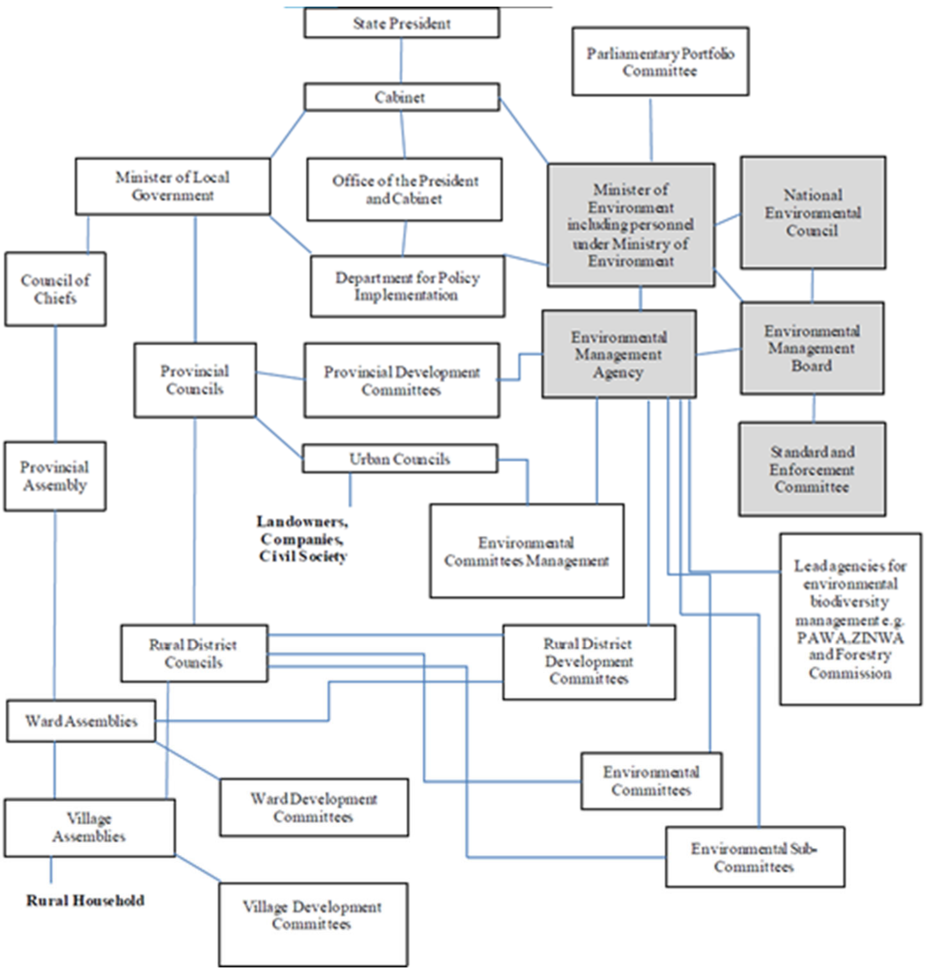


Figure 3–249 Organization of Ministry of Environment, Water and Climate

Source: National Environmental policy and Strategies June 2009

2) Overview of Related Plans and Development Status

There is an urgent need to improve the proportion of the population with access to water and sanitation services in Zimbabwe. The proportion of households with access to improved sources of drinking water is 97.3% in urban areas, 67.9% in rural areas and 77.1% nationally. The proportion of households with stable access to safe water is even more limited, at 27.3% in urban areas, 2.5% in rural areas and 10.2% nationally. The proportion of households with access to improved sanitation is 98.4% in urban areas, 55.2% in rural areas and 68.8% nationally, while 31.3% of households in rural areas are forced to have OD. (UNICEF, 2019)

Zimbabwe has the following national plans in place for water and sanitation.

- Zimbabwe Interim Poverty Reduction Strategy Paper: I-PRSP 2016
- Zimbabwe Agenda for Sustainable Socio-EconomicTransformation: Zim Asset 2013-2018

- Results Based Strategic Plan (2017-2020, Harare City)
- Results Based Strategic Plan (2017-2020)

Harare City has set specific numerical targets to be achieved.

- Increase access to drinking water from the current 40% to 75% by December 2020
- Increase water production from the current 400 ML/day to 580 ML/day by December 2017
- Reduce NRW from the current 61% to 48% by December 2017

However, financial difficulties have made it hard to maintain healthy water and sanitation services. As of 2019, the Morton Jaffray Water Treatment Plant, Harare's largest water treatment plant, has been forced to limit its operations due to a shortage of chemicals. Unreliable electricity supply is also affecting the capacity of water and wastewater facilities. In Harare, daily power cuts can last up to 18 hours. (JICA, 2018)

Chitungwiza City, which is adjacent to Harare City, purchases its water supply from Harare City, but due to leaks in the distribution pipes, the two cities have different perceptions of the amount of water used, which has led to a shortfall in the fees paid by Chitungwiza City to Harare City, causing problems with unpaid fees.

Inadequate water supply due to financial difficulties is also a serious problem in rural areas, where many wells are out of service due to lack of spare parts.

All sewage in Chitungwiza is supposed to be treated at the Zengeza Sewage Treatment Plant. However, due to damage to the water pumping facilities and pipelines, the inflow is limited to a small part of the city area and wastewater overflows onto the roads around the damaged areas, causing a deterioration in sanitation. Domestic and industrial effluents from the Harare metropolitan area are causing serious water pollution in Lake Chivero and Lake Manyame, which are the main water sources in the area.

As JICA's past studies showed, damage to these pumping stations and pipelines is caused by the discharge of sand, which is used as a detergent in households, and various types of rubbish. In order to prevent this, it is necessary to awareness to the citizen.

JICA handed over the treatment facilities to the Zengeza Sewage Treatment Plant in Chitungwiza in 2000, but at the same time the financial situation in Zimbabwe deteriorated seriously, and the plant stopped operating without sufficient maintenance. Since then, although the support was temporarily suspended, a data collection surveys was carried out, and from 2020, advisors have been dispatched to support the formulation of an action plan to improve the finances of the sewage works.

- Project for Improvement of Sewage Treatment Facilities in Chitungwiza (JICA, 2000)
- Data collection survey for improvement of water supply, sewage and solid waste management in Chitungwiza (JICA, 2011)
- Project for the improvement of water supply, sewage and solid waste management in Chitungwiza (JICA, 2013)
- Data collection survey on water supply and sewage sector in Harare city area (JICA, 2018)
- Financial management advisory for sewerage service (JICA, 2021)
- The following project support has been provided by international donors.
- The Urgent Water Supply and Sanitation Rehabilitation Project (UWSSRP/ZimFund/AfDB)
- Zimbabwe Idai Recovery Project (ZIRP) (WB, UNICEF, Oxfam and other donors, ongoing from 2019)
- Zimbabwe WASH programme (UNICEF)

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Cyclone Idai affected some 270,000 people, mainly in Chimanimani and Chipinge districts of Manicaland Province, and UNICEF, with EU funding, provided assistance in the water supply and sewerage sector, including emergency water supply support. Flooding following the cyclone severely damaged or dried up 130 wells in Masvingo District and 135 wells in Manicaland District. (IOM, July 2020 survey)

No damage to water supply and sewerage systems due to natural disasters was reported in the Harare metropolitan area.

In both urban and rural areas, the severe financial situation has resulted in the inability to ensure stable operation of facilities and the abandonment of facilities that cannot be repaired quickly in the event of failure. In the case of natural disasters, the challenge is to minimize the downtime of water and sewage facilities by speeding up repairs through securing spare parts and procurement routes through financial improvements.

4） Consideration of Disaster Risk Reduction Measures

Zimbabwe is at a difficult stage in its disaster management mainstreaming efforts because of the urgent need to improve access to water and sanitation services and to improve services within limited financial and human assets.

JICA plans to conclude its cooperation on water and sanitation issues with the on-going support for the preparation of the action plan on financial management for the sustainable operation of water supply and sewerage services in Chitungwiza.

(4) Telecommunications

1) Overview of Relevant Organizations and Legal systems

The telecommunications sector in Zimbabwe operates under the Postal and Telecommunications Act of 2000 and its amendments. The objectives are as follows.

- Ensuring the provision of domestic and international telecommunications services
- Maintaining fair pricing for telecommunications services
- Promote the development of demand-driven communication services
- Maintaining and promoting fair competition in the market

The ministry responsible for consumer communications was the Ministry of Information and Communication Technology, which was renamed MoICTPCS (Ministry of ICT, Postal and Courier Services) in 2013. The ministry is finalizing the SMART Zimbabwe 2030 Master Plan to promote the digitization of government, economy and society in Zimbabwe.

On the other hand, it is the Office of the President and Cabinet (OPC) that controls the use of ICT within the government. Government Internet Service Providers (GISPs) are mandated to be the sole provider of Internet services to all government ministries and semi-governmental entities and are required to report to the OPC.

This situation is complicated by the fact that OPC and MoICTPCS seem to have overlapping mandates regarding the management of government data, interoperability with the enterprise architecture, and coordination of the different MDA ICT units, and there is not enough coordination between them.

The Postal & Telecommunications Regulatory Authority of Zimbabwe (POTRAZ) was established under the Postal and Telecommunications Act of 2000 as the regulatory authority for the telecommunications sector. POTRAZ is an independent authority from MoICTPCS and licensing authority under a law enacted in 2000. While POTRAZ mainly regulates the telecommunications sector, BAZ (Broadcasting Authority of Zimbabwe) regulates the broadcast media sector. In April 2018, the government approved a plan to merge POTRAZ and BAZ to improve regulation of integrated ICT and media services, although the timing of the merger has not been disclosed.

- In addition to the Postal and Telecommunications Act of 2000, other related legislation and regulations include the following
- Broadcasting Services Act of 2001
- Broadcasting Services Act of 2001

- Competition Act of 2001
- Interconnection S.I 28 of 2001, International Termination Rates S.I 263 of 2008
- Internet Services S.I 262 of 2001, Penalties S.I 162 of 2008
- Postal S.I 238 of 2001, SI 11A of 2001 Licensing and Certification, Statutory Instrument 87 of 2015
- VSAT Regulations and Sim Registration SI 95 of 2014

2） Overview of Related Plans and Development Status

In Zimbabwe, the digital divide between urban and rural areas has been decreasing in recent years due to the rapid diffusion and use of ICTs. Zimbabwe's master plan for the telecommunications sector is the Zimbabwe National Policy for Information and Communication Technology (ICT), developed in 2016. Here, the need to improve service availability and quality and to develop new services is emphasized by developing infrastructure, eliminating monopolies, privatizing, and introducing PPPs. In recent years, an ICT master plan in line with the country's Vision 2030 has been under development but has not been released yet and was not available for this study.

In Zimbabwe, broadband Internet access continues to grow, with about 25% of all residents having access to the Internet in 2019, but only 1% of the population having a broadband connection over 256 kbit/s.

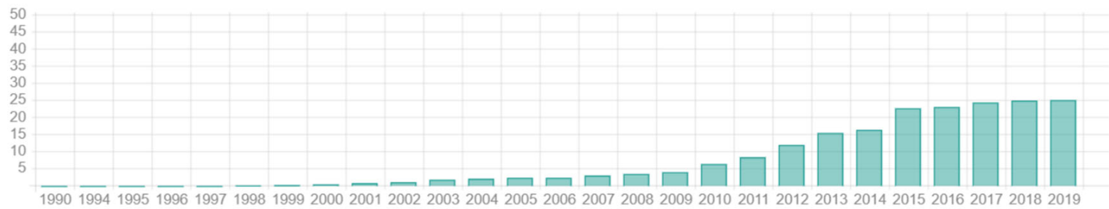


Figure 3–250 Percentage of population with access to the Internet (1990-2019)[80]

Source: WorldData

[80] https://www.worlddata.info/africa/zimbabwe/telecommunication.ph

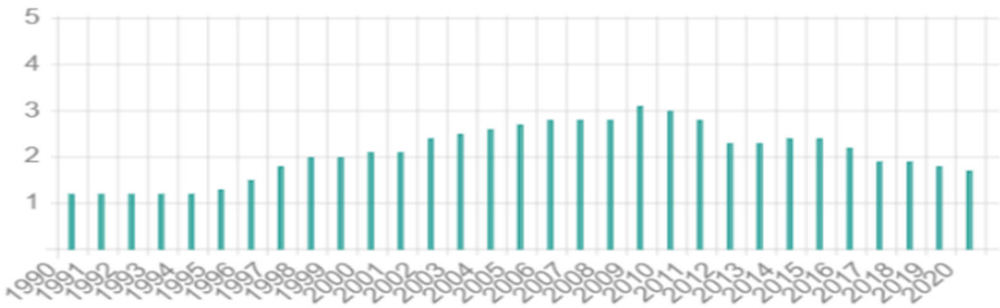


Figure 3–251 Fixed-line Subscriber Population Ratio

Source: WorldData

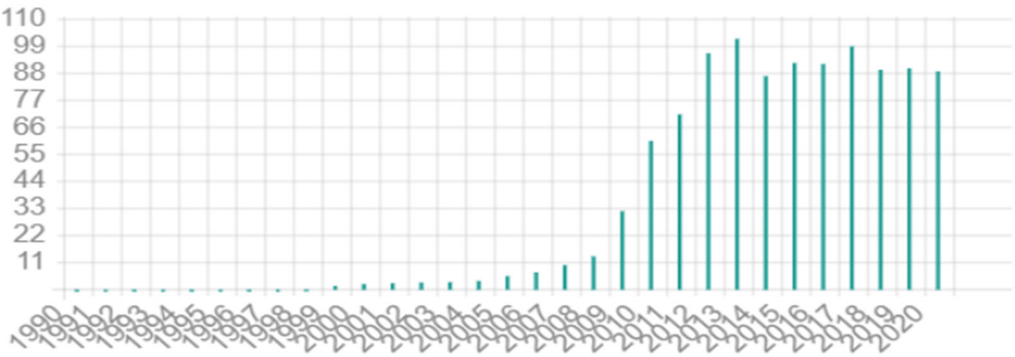


Figure 3–252 Mobile subscriber population ratio

Source: WorldData

Table 3-200 Key indicators for Zimbabwe (ITU estimates, 2017)

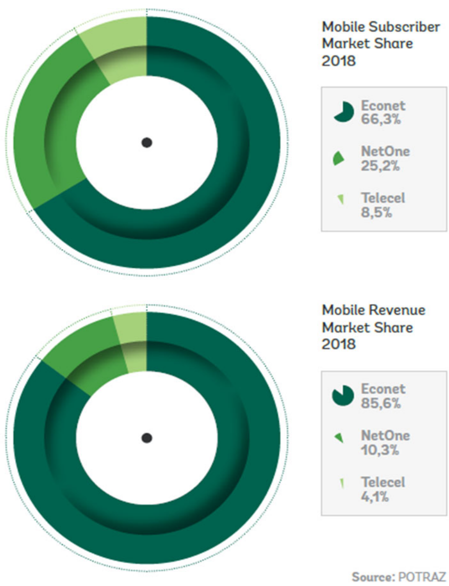
Indicator	**Zimbabwe**	**Africa average**	**World average**
Fixed-telephone sub. per 100 inhab.	1.6	0.9	13.0
Mobile-cellular sub. per 100 inhab.	83.5	74.4	103.6
Active mobile-broadband sub. per 100 inhab.	41.3	24.8	61.9
3G coverage (% of population)	78.2	62.7	87.9
LTE/WiMAX coverage (% of population)	34.7	28.4	76.3
Individuals using the Internet (%)	27.1	22.1	48.6
Households with a computer (%)	13.9	8.9	47.1
households with a computer (%)	24.0	19.4	54.7
International bandwidth per Internet user (kbit/s)	10.7	11.2	76.6
Fixed-broadband sub. per 100 inhab.	1.1	0.6	13.6

Source: ITU

Zimbabwe's telecoms market size in 2018 was about US$1.56 billion (source: POTRAZ), with the majority of the revenue (about 74%) coming from mobile services. Even though the total number of mobile connections has stagnated since 2013, the number of unique mobile subscribers is still increasing since 2008.

Zimbabwe's fixed-line telephone service is still operated by TelOne, a semi-private monopoly operator. According to POTRAZ, the number of fixed line subscribers also declined from 2017 to 2018, with 274,408 fixed lines provided and operated in the second quarter of 2019. TelOne is focusing on fixed voice and broadband, but its financial situation is difficult due to the relative decline in service prices under inflation.

In terms of mobile services, the subscriber population is sluggish at just under 90%, with private company Econet Wireless Zimbabwe holding the top share of over 70%, followed by state-owned mobile operator Net One and Telecel Zimbabwe in third place. Regulatory authority POTRAZ seeks to strike a balance between the operator's request to raise prices to ensure the financial situation and the obligation to guarantee affordable service price to consumers.As of 2018, the number of base stations in Zimbabwe is 4,828 for 2G (GSM), 2,696 for 3G (W-CDMA), and 951 for 4G (LTE). 2G(GSM) is still the largest. POTRAZ estimates that population coverage is 93.4% for 2G, 83.9% for 3G, and 34.9% for LTE (as of the end of 2018).



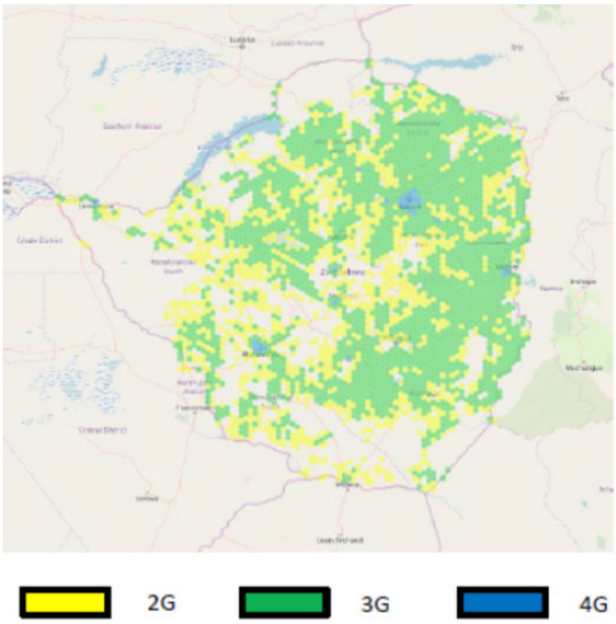


Figure 3–254 Mobile Subscriber&Revenue Market Share
Source:POTRAZ

Figure 3–253 Mobile Network Coverage
Source: HIP Consult

Despite the fact that Zimbabwe is a landlocked country and is connected to submarine cables through neighbouring countries, its international connectivity infrastructure is relatively well developed. Since 2010, several private and governmental operators have deployed international optic fiber links that connect to multiple submarine optic fiber cables through neighbouring countries. It reduced the cost of Internet access dramatically cheaper. The specific connection routes are as follows.

- TelOne's optic fiber backbone is connected to EASSy (Eastern Africa Submarine System) through Mozambique and to multiple submarine cables through South Africa and Botswana
- Liquid Telecom's optic fiber backbone is connected to EASSy, SEACOM and WACS (West African Cable System) via South Africa, Zambia, and Botswana
- PowerTel's optic fiber backbone is connected to the international fiber network via the Botswana and South Africa borders, and to SEACOM via Mozambique.
- Dandemutande's optic fiber backbone is connected to SEACOM via Mozambique
- Africom's optic fiber backbone is connected to SEACOM via Mozambique

With multiple fiber-optic links now available, sufficient redundancy can be ensured, and the bandwidth of international circuits have been greatly expanded. Total available international bandwidth is increasing rapidly, with total Internet bandwidth reaching 124,995 Mbps in the third quarter of 2019, according to POTRAZ. Thanks for expansion of bandwidth, the price of international communication has dropped significantly, from about US$5,000 per month to about US$100 per month per Mbps for an STM1 line to London. In November 2017, the Zimbabwean government has launched the country's first Internet Exchange Point (IXP), the Zimbabwe Internet eXchange, with the aim of reducing the cost of internet connectivity. A second private, non-profit IXP, the Harare Internet eXchange Point, was also established, and the domestic networks were interconnected through these IXPs.

In Zimbabwe, telecommunication infrastructure was rapidly developed to meet the growing demand for Internet services. ISPs (Internet Service Prividers) has provided various service menu to match the spread of the Internet. The major ISPs, include Liquid Telecom, EcoNet, Africom, Aptics, Aqcuiva, Dandemutande, Pecus, Powertel, Teleontract, and TelOne. The domestic internet backbone has a download speed of 9.6Mbps and an upload speed of 7.39Mbps as of September 2018. The development of an infrastructure centered on mobile services has enabled the development and use of many ICT services, which consumers use as a means to facilitate communication and transactions between individuals, between individuals and businesses, and between businesses and corporations. Specifically, money transfer through cell phones and various social networking applications such as WhatsApp, Facebook, Twitter, YouTube, Skype, etc. are being used. Governments have also begun to use ICT to provide a variety of e-government services to their citizens, and all ministries now have official websites. Efforts and investments are being made in the areas of ICT backbone infrastructure development, ICT in education, research and development, establishment of regional information centers, ICT governance, and training of legislators and government officials in the use of ICT.

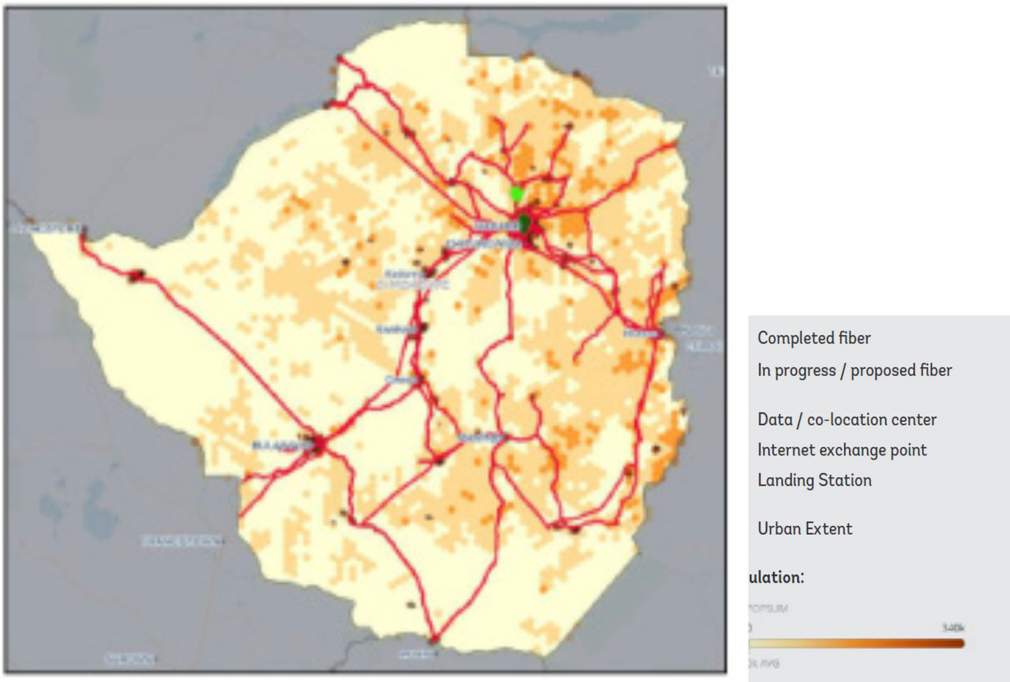


Figure 3–255 Location Map of Optic Fiber Links and IXPs in Zimbabwe
Source: POTRAZ

Notable among Zimbabwe's telecom operators is Liquid Telecoms, a subsidiary of Econet. The company changed its name to Liquid Intelligent Technologies and successfully raised US$840 million from the market to pay off its debt and continue its operations. Today, SEACOM is Africa's leading optic fiber network, operating a network of more than 70,000km from Cape Town to Cairo, and is also connected to Muanda in Angola. At the end of 2020, Africa Data Centres (ADC), another subsidiary company of Liquid Intelligent Technologies, attracted the attention of the International Development Finance Corporation, a US agency that supports investment in developing countries, and received an investment of 300 million USD. ADC is operating five data centers (including Johannesburg, Cape Town, and Nairobi) in four countries in African (South Africa, Kenya, Rwanda, and Nigeria) and is working to establish new data centers in Ghana, Morocco, and Egypt.[81]

[81]https://www.theafricareport.com/78586/econets-zimbabwean-ceo-strive-masiyiwa-to-invest-in-data-centres-on-the-continent/

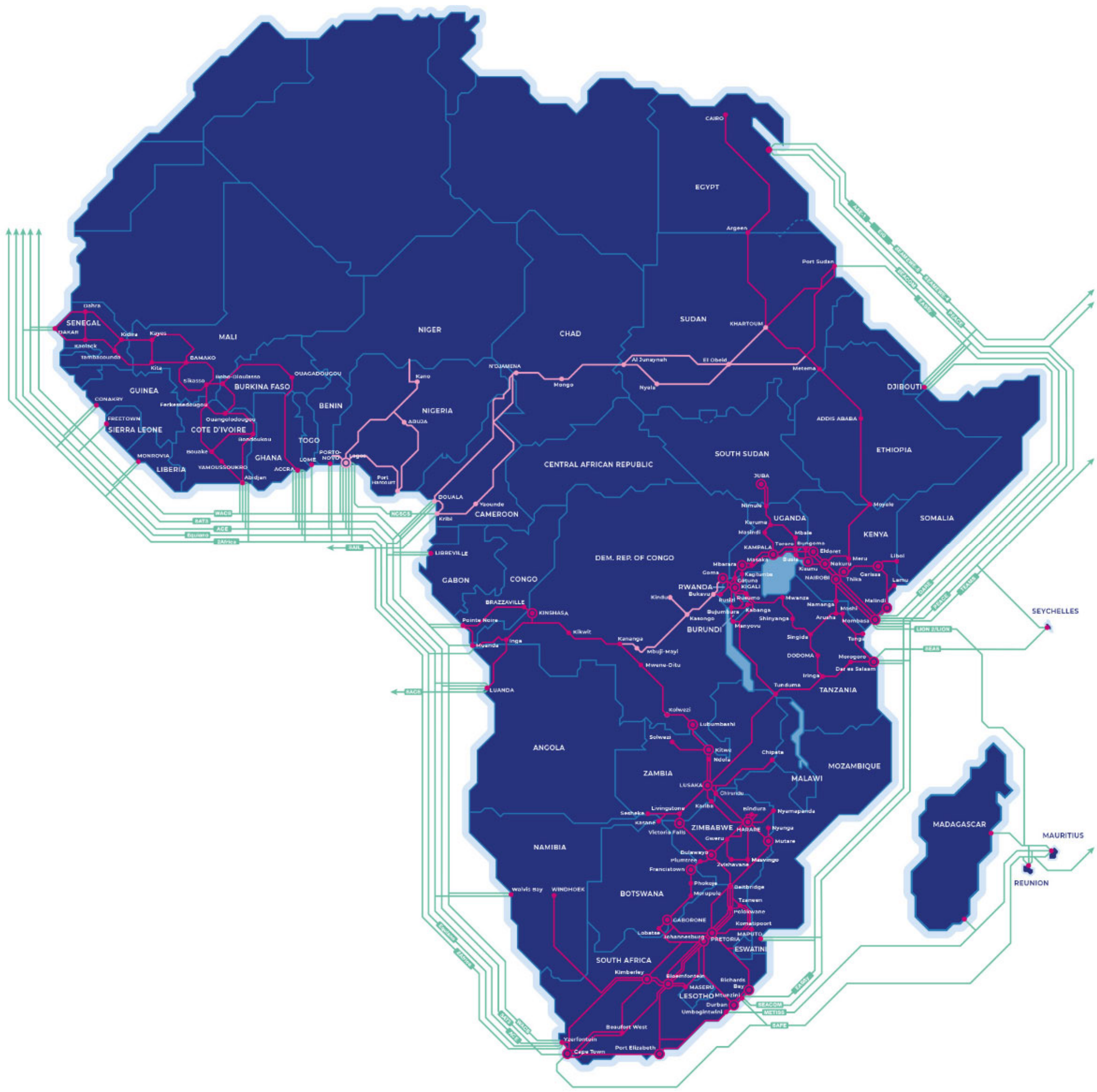


Figure 3–256 Optic fiber network operated by Liquid Intelligent Technologies

Source: Liquid Intelligent Technologies[82]

According to WB's analysis report, the following are some of the challenges that are preventing the expansion of telecommunication infrastructure and ICT market in Zimbabwe[83]

- Macroeconomic conditions. Challenges in macroeconomic management over several decades have led to structural difficulties including high inflation, limited access to foreign

[82] https://www-liquid-tech.translate.goog/about-us/our_network?_x_tr_sl=en&_x_tr_tl=ja&_x_tr_hl=ja&_x_tr_pto=sc
[83]Digital-Economy-for-Zimbabwe-Country-Diagnostic-Report, 2019

exchange, and electricity load shedding.

- Institutional arrangements. Overlapping mandates within the Government in the ICT area are resulting in duplication and uncoordinated actions.
- Limited competition. Econet and Liquid Telecom with a strong market position, access to capital, and competent management are competing against an unusually large number of Government-owned telecommunications operators, which have overlapping mandates, compete directly with each other in various market segments, and have limited access to capital. Limited competition in the mobile sector has contributed to high prices and low rural access.
- Market failure in rural areas. Zimbabwe is still a long way from achieving widespread use of broadband because of major infrastructure challenges and market failure, particularly in rural areas. High capital and operational costs, low disposable income, and the lack of a reliable grid electricity supply render services commercially unviable and induce a lack of interest from operators and ISPs in deploying infrastructure in rural areas. Accordingly, network operators have focused on the most profitable geographical areas, primarily major urban areas and intercity routes, to the disadvantage of the population that lives outside those areas. Significant further investments will be needed to provide universal and affordable access to broadband, especially in rural areas.
- Regulation of retail tariffs. POTRAZ's regulation of retail mobile voice and data tariffs is contrary to the principles of a competitive retail market, distorts the market, and is complicated to administer in a high inflation environment. The regulation is likely to translate into reduced investments and roll-out of infrastructure.
- Electrification rate in rural areas. The low electrification rate in rural areas limits demand for broadband. Only 19 percent of the rural population has access to electricity, which is a major constraint on the use of broadband. Current battery technology does not allow for the sustained use of broadband without access to a reliable power supply.
- Limited infrastructure sharing. Effective infrastructure sharing and wholesale open access could bring broadband to rural areas more quickly by limiting duplication of infrastructure and redirecting resources to under-served communities. Optimally, infrastructure sharing should be market based and commercially agreed between the operators, but it can be mandated in certain situations. However, infrastructure sharing should not eliminate infrastructure-based competition, which has been critical for the development of the ICT sector in recent decades.
- High costs, limited skills and lack of relevant internet content. The cost to acquire a broadband-enabled device, digital illiteracy, and lack of local content are other major barriers to the use of broadband in Zimbabwe. There is an urgent need to develop policy and

regulation that will increase the affordability of smart devices and develop awareness of the internet as well as the skills to access and use it. This is critical to achieve a significant reduction in digital inequality. Availability of locally relevant content could drive demand for internet services.

- Low investment. The difficult macroenvironment has made it difficult to attract further investment for development of digital infrastructure. The low investment in digital infrastructure has resulted in limited potential for enhanced growth; hence Zimbabwe remains largely underdeveloped in comparison to other Southern Africa countries. Attracting further investment is critical for growth of the sector and to keep up with the fast changing digital technologies such as 4G and 5G.

According to the report, the SWOT analysis (SWOT matrix) of the telecom sector in Zimbabwe is as follows

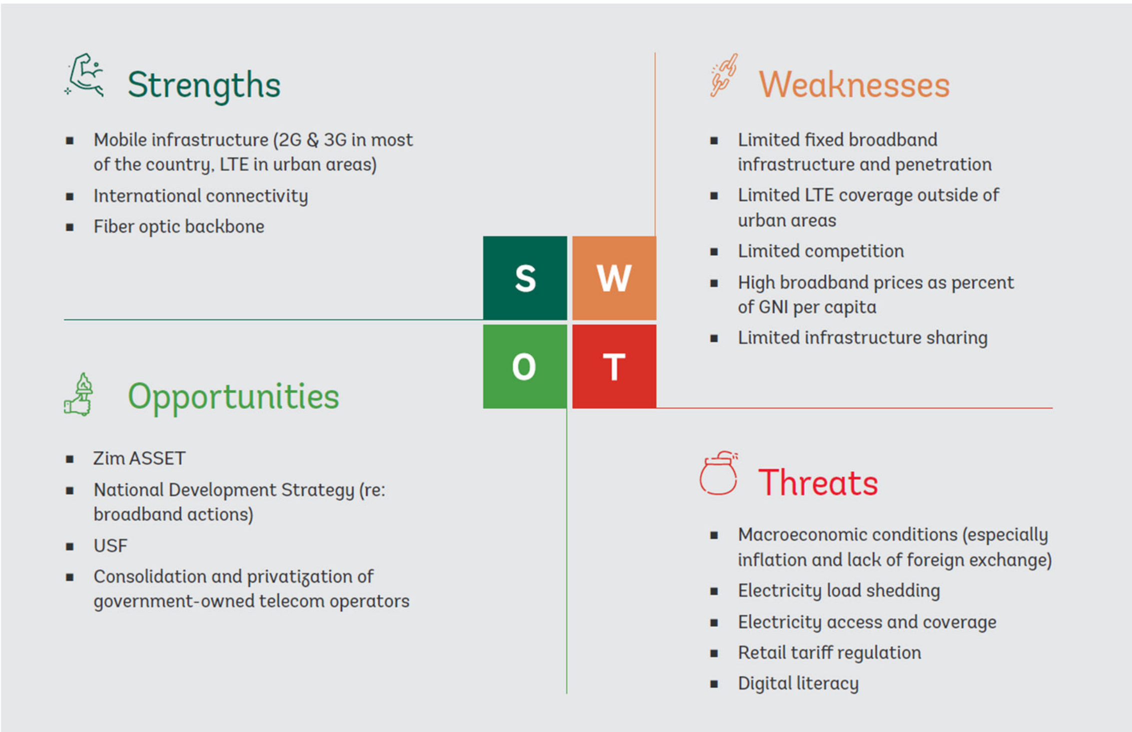


Figure 3–257 DIGITAL INFRASTRUCTURE SWOT MATRIX

Source: WB

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

In Zimbabwe, the Zimbabwe National Policy for Information and Communications Technology (ICT) 2016 envisages disaster vulnerable areas in terms of telecommunications sector. A map of

Zimbabwe's telecommunication backbone lines and a hazard map of flooding are expected continues below. As far as comparing these two maps, it is estimated that the area through which the telecommunication backbone passes is expected to be relatively resilient to flooding. However, this survey is a desktop survey only, and on-site interviews are required for confirmation.

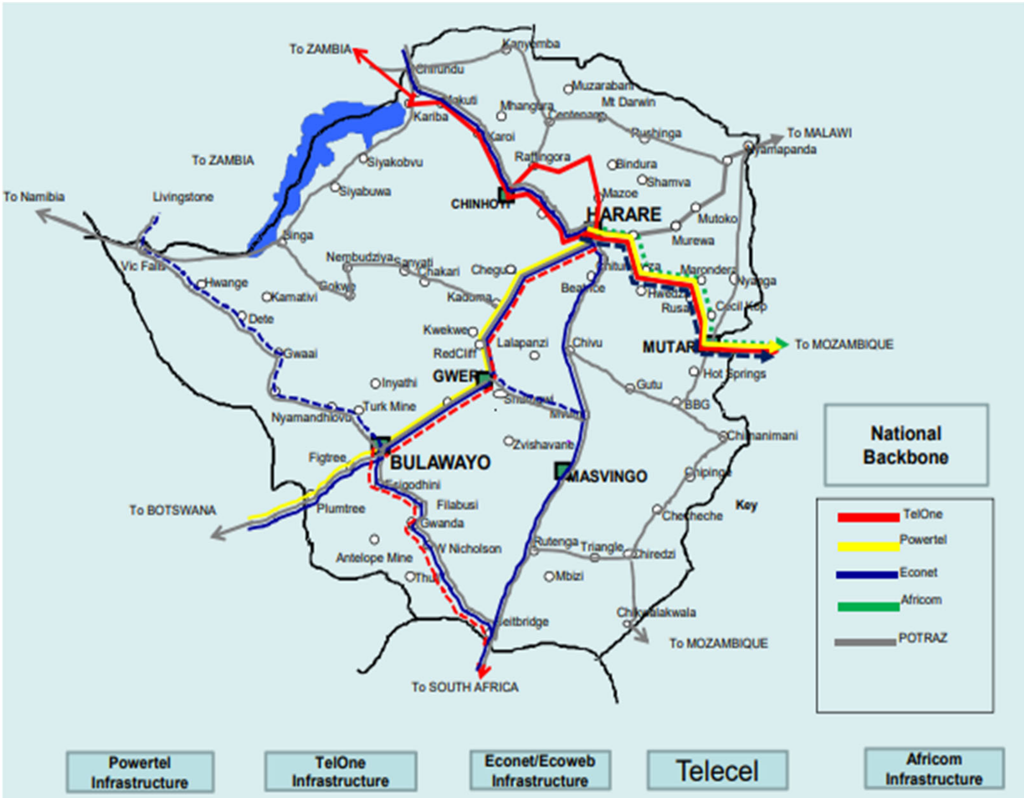


Figure 3–258 Telecommunication backbone in Zimbabwe

Source: POTRAZ

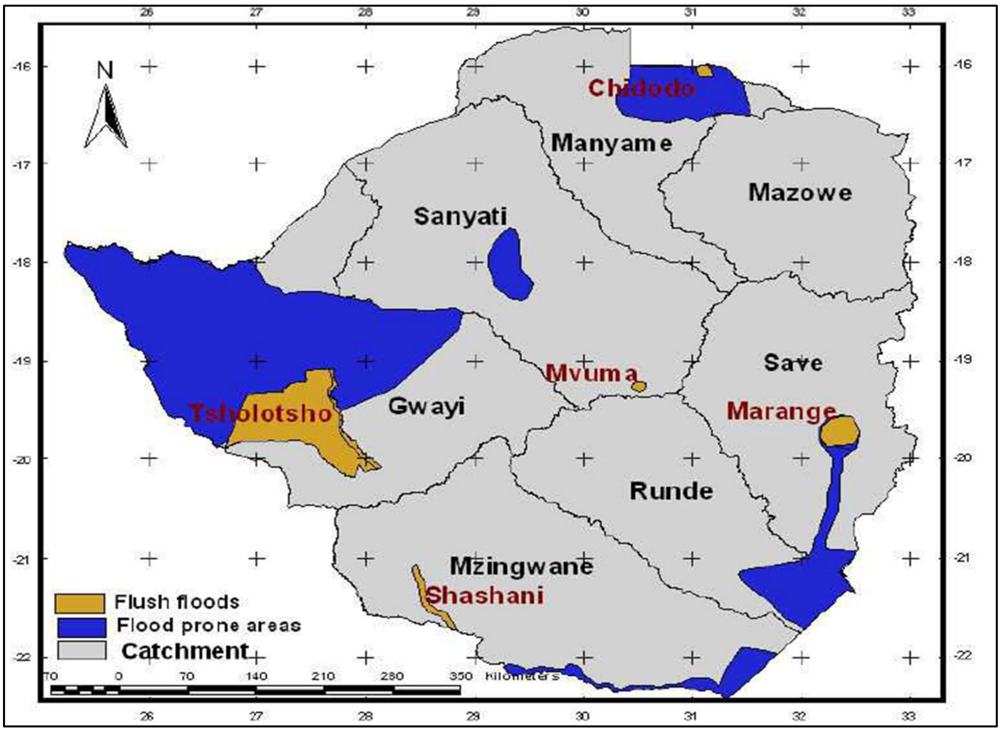


Figure 3–259　Hazard map for flooding in Zimbabwe

Source: POTRAZ

4） Consideration of Disaster Risk Reduction Measures

As mentioned in the analysis of the transportation sector, it is expected that road structures will be severely damaged in the event of flooding, so it is considered necessary to take measures against landslides, especially in the optical cable network near the bridges. However, we were not able to identify specific high-risk areas because we were unable to conduct a field survey.

In addition, since prerequisite for stable telecommunication networks is the existence of power supply networks, strengthening the disaster resilience of power networks is directly related to strengthening the disaster resilience of telecommunication networks. In this regard, reinforcing the power network of the International Internet Exchange (IDX), especially in the capital city of Harare, will be effective in terms of disaster prevention in the telecommunications sector.

In addition, the government of Zimbabwe is introducing Community Information Centers in rural areas to ease the digital divide between rural and urban areas. This is a computerized facility with an Internet connection and has been established in many rural areas of the country. For example, if satellite telecommunication would be prepared in those Community Information Center as backup communication channels, those centers can be used as a disaster hub station even when the general terrestrial public wireless network is blocked during a disaster.

Figure 3–260 Community Information Centre for internet access.3
Source: Ateg Resources 2021

(5) Agriculture

In Zimbabwe, the agricultural sector accounts for 66.2 % (2019) of the working population, with agriculture, forestry and fisheries accounting for 8.3% (2019) of total GDP and 26.7% (2018) of exports[84]. In the past, small-scale farming and large-scale farming by European developed in a well-balanced manner. Agriculture was so well developed that it was called "the granary of Africa”. However, the First Track Land Reform (FTLR) implemented by the Zimbabwean government in the 2000s seized the large-scale farms owned by European and reallocated their land to landless people working on cooperative farms. As a result, the area under irrigation was reduced from approx. 200,000 ha to approx. 120,000 ha due to the famer’s lack of irrigation technology and theft, deterioration, and vandalism of irrigation infrastructure[85].

1） Overview of Relevant Organizations and Legal systems

a) Ministry of Lands, Agriculture, Water, Climate and Rural Resettlement

It provides technique, extension, advisory, regulation, and management services related to

[84] Employment in agriculture (% of total employment): WB, World Bank Indicator, Agriculture, forestry, and fishing, value added (% of GDP): Calculation based on World Bank Indicator, Agriculture as % of total exports: World Trade Organization, Trade Profile 2020
[85] Nhundu, K.; Mushunje, Abbyssinia, Nalysis of Irrigation Development Post Fast Trackland Reform Programme. A Case Study of Goromonzidistrict, Mashonaland East Province, Zimbabwe, 2017
https://agris.fao.org/agris-search/search.do?recordID=US2022248600

agriculture with a vision of a prosperous, inclusive, diverse, sustainable, and competitive agricultural sector by 2030. The Ministry prioritizes efforts to eradicate hunger, combat malnutrition, and strengthen food and nutrition security, as well as to recover from the negative impacts of climate change and other disasters

The ministry prioritises resilience to the negative impacts of climate change and other disasters as well as engage in poverty eradication, fighting against malnutrition, and enhancement of food and nutrition security. The ministry has the following departments.

Table 3-201 Department of Ministry of Lands, Agriculture, Water, Climate and Rural Resettlement

Department	Role
Department of Agricultural Advisory Services	- To provide technical, extension and advisory services - To develop and maintain databases on crop, soil, and livestock technologies for improvement, training, and service provision - To disseminate agricultural and market-related information - To conduct crop and livestock assessments for food security, early warning of pests and diseases, including the use of Geographic Information Systems (GIS). - To collate agricultural production information - To promote extension and adoption of new crop and livestock production technologies
Department of Agricultural Education Directorate	- To develop and review curricula and syllabi of agricultural universities and farmer training institutions in line with developments in the agricultural sector and government policies and standards - To administer agricultural education and farmer training programs - To promote youth entrepreneurship programs and innovation in the agricultural sector
Department of Agricultural Engineering, Mechanization and Soil conservation	- To plan and develop agricultural mechanization systems meeting farmers' needs - To conduct pre-shipment and pre-delivery inspections of agricultural equipment - To ensure timely distribution of agricultural machinery and equipment and inputs for agricultural mechanization based agricultural mechanization programs - To process water use permit, inspect mine waste, fix small dams and pipelines and reclaim ditch - To design of farm structures and post-harvest grain storage structures

Department	Role
Department of Agricultural Research, Innovation and Development	- To develop new crop varieties adapted to agro-ecological zones - To provide seeds certified for the market - To conduct research to develop appropriate field and horticultural crop production technologies for use by farmers - To provide knowledge and information aimed at increasing agricultural productivity in an environmentally sustainable manner. - To develop and share crop handling, processing, and value-adding technologies. - To provide advisory services on crop management
Department of Fisheries and Aquatic Resources	- To formulate and implement fisheries research and development programme, formulate and enforce laws, rules and regulating governing the management of fisheries
Department of Strategic Policy Planning and Business Development	- To do long-term planning for investment and development of the agricultural sector and integrate the plan into the national development plan. - To coordinate the formulation of development policies and strategies for the agricultural sector and subsectors. - To coordinate the development of feasibility studies, identification, evaluation, design and assessment of all agricultural programs and joint ventures implemented by Ministry of Lands, Agriculture, Water, Climate and Rural Resettlement, its ministries and quasi-government - To conduct strategic analysis of the agricultural sector, monitor and evaluate all agricultural projects and programs, and maintain the Agricultural Information Management System (AIMS) and Knowledge Support System (KSS) - To promote investment and business development in agriculture, and maintain marketing and trading of agricultural products, and a Marketing Information System (MIS) - To conduct advice and guidance on agricultural policy to farmers' associations, marketing committees, and other agricultural institutions
Surveyor-General Department	- To maintain national geodetic network and standardize surveying instruments, electronic distance meters (EDMs), and tapes - To maintenance of the Zimbabwe International Boundary - To do magnetic survey - To do coordinate system transformation - To do consultancy services
Department of Land Management and Administration	- Land Management and Operation - Land Acquisition and Transfer - Land Management and Valuation - Resettlement - Land Information Management
Department of Water Resources Planning & Irrigation Development	- To Provide irrigation engineering services (planning, scheme identification, design, construction, operation and management of existing irrigation schemes)

b) Grain Marketing Board (GMB)

GMB has responsibility to accord local maize producers their fair share of the local and export markets and also to provide them with a guaranteed outlet for their excess maize produced. GMB's mission is to ensure national food security through the efficient and sustainable management of the Strategic Grain Reserve. GMB is require to maintain the minimum strategic grain reserve of 500,000 tons in physical stocks. In the 2021/22 marketing year, Zimbabwe will, for the first time in three years, manage to maintain 500,000 tons[86].

2） Overview of Related Plans and Development Status

a) Related Plans

(i) Comprehensive Agricultural Policy Framework (2012-2032)

The Framework gives the situation analysis of the agricultural sector, highlights the vision, goals, objectives and detailed policy statements and strategies for the development of the Zimbabwean agricultural sector during the period 2012 – 2032. The Government plans to increase crop productivity and production through the following strategies: (i) set up an agriculture fund to subsidize inputs; (ii) promote, in collaboration with seed companies and international and national research organizations, research into the development of high yielding and drought tolerant crop varieties; (iii) promote research into integrated crop management practices; (iv) promote sustainable agricultural production including conservation agriculture techniques; (v) promote greater adoption and use of improved hybrid seed varieties for different crops; (vi) promote the construction of cost-effective storage technologies by all classes of farmers and increasing crop diversification; (vii) improve animal health and welfare; (viii) develop new irrigation infrastructures and resourcing agricultural research.

(ii) Zimbabwe's Agricultural Investment Plan 2013-2017 (ZAIP)

The objective of ZAIP is to facilitate sustainable increase in production, productivity and competitiveness of Zimbabwean agriculture through building capacity of farmers and institutions, improving the quantity and quality of public, private and development partner investment and policy alignment.

ZAIP set four Intermediate Result Areas as follows: i) Increasing production and productivity

[86] SUDA, Grain and Feed Annual

through improved management and sustainable use of land, water, forestry and wildlife resources; ii) Increased participation of farmers in domestic and export markets through development of an efficient agricultural marketing system and an enabling environment for competitive agricultural production, investment (Domestic and FDI) and Trade; iii) Ensuring food and nutrition security by facilitating a cohesive multi-sectoral agricultural response; and iv) Improving Agricultural Research, Technology Dissemination and Adoption.

b) Development status

(i) Japan’s Assistance Policy

To use effectively Zimbabwe's vast land and fertile soil suitable for cultivation of cash crops and other crops, and promote economic development, Japan will provide assistance for human resource development to contribute to strengthening industry, agricultural and rural development, and infrastructure development to encourage further agricultural development. Japan's major assistance in the agricultural sector related to this project in recent years are summarized below.

Table 3-202 Japan’s Assistance

Project	Summary	Duration
Project for Irrigation Development for Nyakomba Irrigation Scheme (Grant Aid)	The project constructed and rehabilitated irrigation facilities in the Nyakomba Irrigation Scheme, which was developed by Japan's assistance, affected by the hurricane in 2000 and 2006.	2015 - 2019
Food Assistance （WFP） (Grant Aid)	Japan provide food through the WFP to improve the food situation in the country and contribute to solving development issues.	-

(ii) Assistance by related donors and private sectors

Assistance by related donors and private sectors in the agricultural sector related to this project in recent years are summarized below.

Table 3-203 Assistance by related donors

Project/Donor	Summary	Duration / Cost
Smallholder Irrigation Revitalization Programme/ IFAD	The objective of this programme is to revitalize existing smallholder irrigation systems and agricultural land in the semi-arid areas of four provinces (Manicaland, Masvingo, Matabeleland South, and Midlands) in Zimbabwe. The programme will cover approx. 46% of the country's estimated total irrigated area of approx. 13,000 ha. It will increase productivity and climate resilient crop production under rain-fed and irrigated conditions through crop diversification and expansion of improved varieties, climate-smart agriculture, and enhanced market access.	2016 - 2023 US$ 53.34 million

3) Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Assistance by related donors and private sectors in the agricultural sector related to this project in recent years are summarized below.

Table 3-204 Damage and loss to the agricultural sector (flood)

Year	Area	Outline
Feb. 2014	**Masvingo province,** Matabeleland North province	-Unknown about agricultural sector
January, 2013	Matebeleland North province, Matebeleland South province, Masvingo province, Manicaland province	- The canals were damaged in Nyanyadzi (Ward 8) and Tonhora (Ward 20) irriation schemes (Manicaland province)

Source: JICA Study Team

Table 3-205 Damage and loss to the agricultural sector (Cyclone)

Year	Area	Outline
Mar. 2019 Cyclone Idai	**Manicaland province,** **Masvingo province,** Mashonaland province	- Total damaged area: 1.4 million ha - Affected irrigation systems: 2,295.5 ha (Chimanimani district and Chipinge distrct in Manicaland province) - Total cost of damage: US$ 196 million - Total cost of loss: US$ 147.9 million for crops and US$ 0.4 million for livestock - Total recovery and reconstruction cost: US$ 59 million

Source: JICA Study Team

The flood risk map in Zimbabwe is as below.

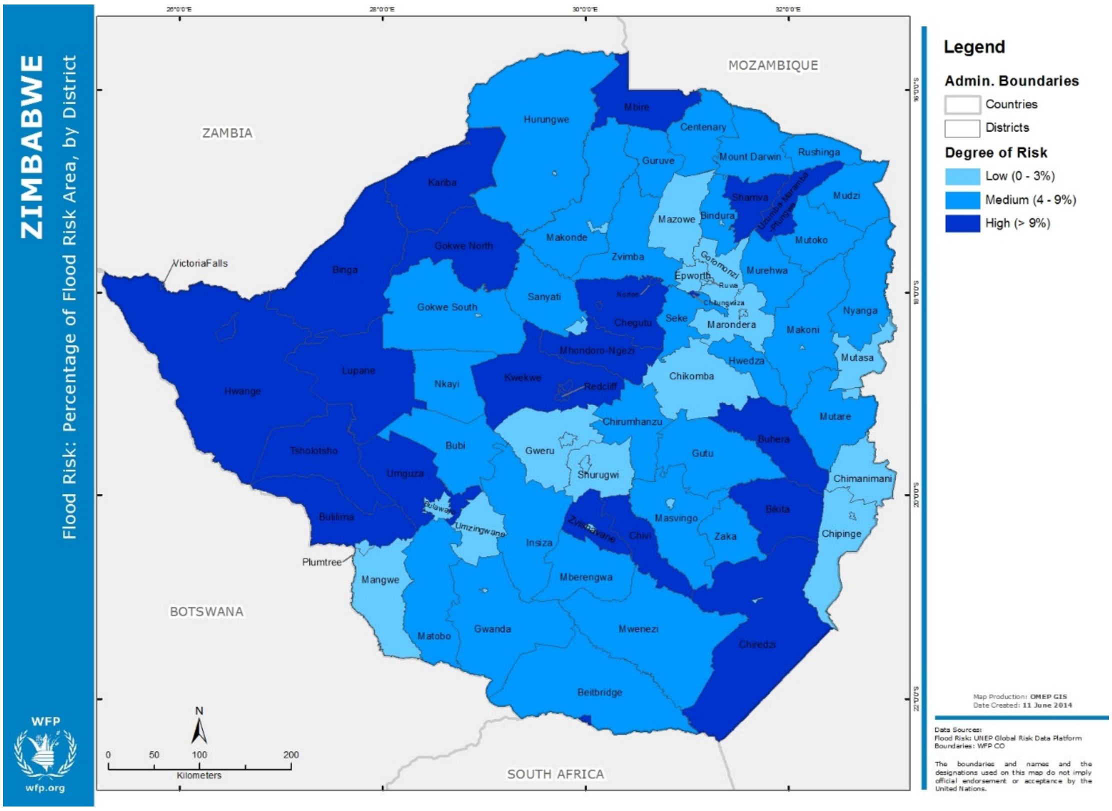


Figure 3-261 Flood Risk Map in Zimbabwe

Source: WFP

Based on recent flood and cyclone-idai damage and flood risk maps, the provinces of West Mashonaland, Central Mashonaland, Masvingo, and North Matebeleland are vulnerable to flooding.

Zimbabwe has been imported approx. 1 million tons of maize each year since 2018/19, because production of the staple food, maize, has not been able to meet demand. The figure below shows the ratio of maize production by province in Zimbabwe. Western Mashonaland province and Central Mashonaland province are particularly high production areas.

Zimbabwe Corn Production (2012-2017)

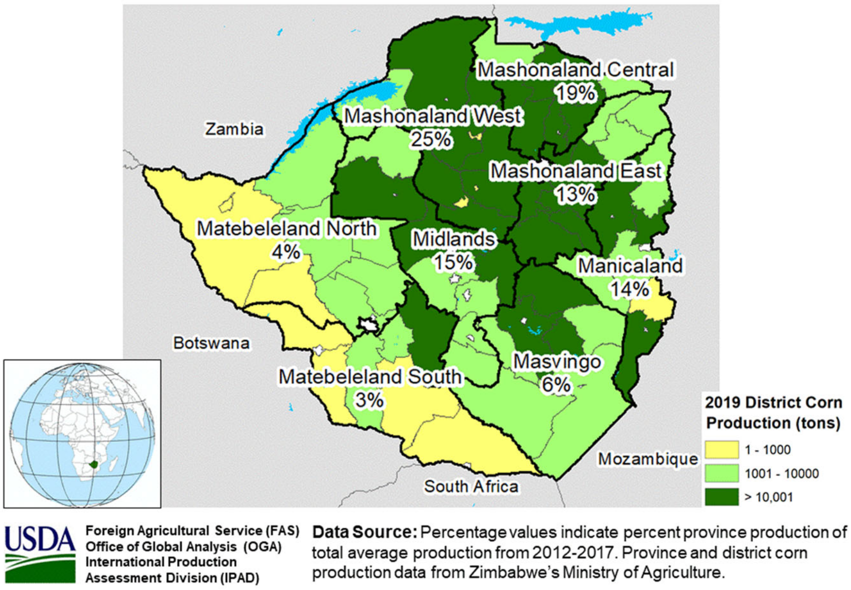


Figure 3-262 Maize production Map

Source: USDA

The figure below shows the irrigation development map in Zimbabwe. The irrigation development is in progress especially in Manicaland province, Mashonaland West province, Mashonaland Central province and Masvingo.

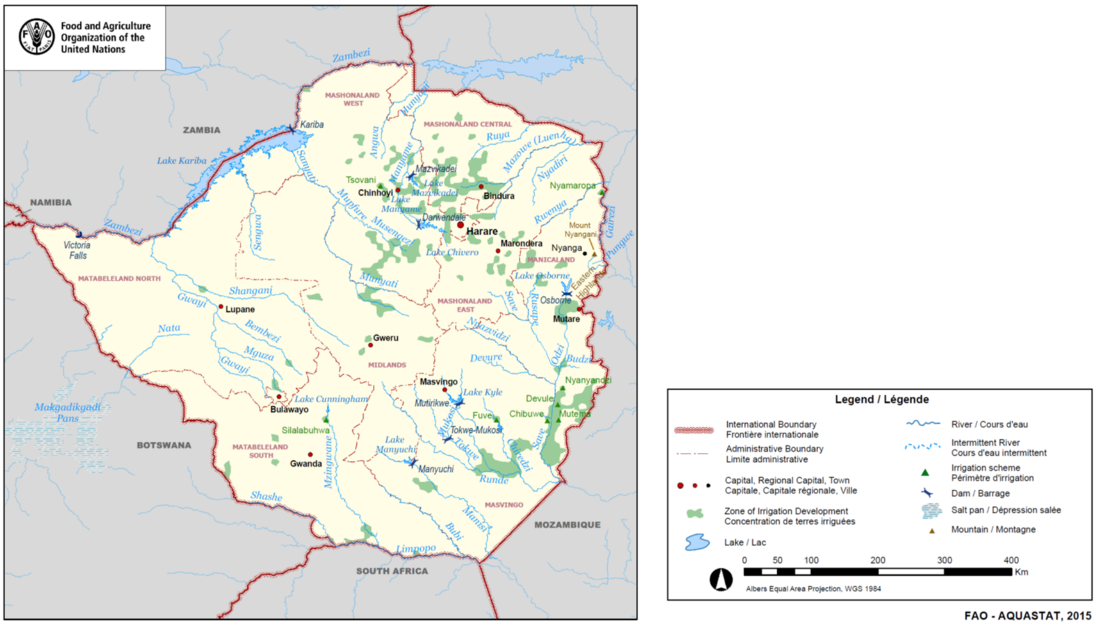


Figure 3-263 Irrigation development Map

Source：FAO

Given that Zimbabwe has been affected by drought and flooding many times and has received food assistance, it is important to mitigate damage to agricultural land and irrigation infrastructure for maize, staple food in Zimbabwe. In addition, measures are needed to protect irrigation development areas since irrigation development are an important issue in Zimbabwe, which has been affected by prolonged and severe droughts. Therefore, assistance to Mashonaland West, Mashonaland Central and Masvingo provinces will be considered.

4) Consideration of Disaster Risk Reduction Measures

In general, the most effective way to protect agricultural lands from flooding is to improve river levees against external flooding and to rehabilitate and improve irrigation and drainage systems against internal flooding, as well as to properly manage irrigation facilities before flooding occurs. The details of area and activities should be decided after confirming the following points: (i) Need for assistance, (ii) Cause of flood damage and (iii) priority area, through a surveys of the current status of irrigation and drainage systems, and interviews with stakeholders since only the desk research has been conducted due to the Covid-19.

(6) River management and coastal management

1） Overview of Relevant Organizations and Legal systems

The agency responsible for river management in Zimbabwe is the Ministry of Lands, Agriculture, Fisheries, Water Resources and Rural Resettlement (MoLAFWRR) and its subsidiary, the Zimbabwe Water Authority (ZINWA). In addition, the Environmental Management Agency (EMA) under the Ministry of Environment, Water and Climate (MoEWC) is responsible for the management of the development of riverine areas and their conservation, including conducting studies on integrated river basin management.

Table 3-206 List of agencies involved in river management in Zimbabwe

Abbreviation	**English name**	**Japanese name**	**Overview**
MoLA FWRR	Ministry of Lands, Agriculture, Fisheries, Water, and Rural Resettlement	Ministry of Land, Agriculture, Fisheries, Water Resources and Rural Resettlement	The former Ministry of Water Resources and Development was re organized and it is responsible for river and basin management.
ZINWA	Zimbabwe National Water Authority	Zimbabwe National Water Authority	A semi-governmental organization established under the National Water Authority Act of 1998 that is responsible for water resources development and planning related to water resources distribution
-	Catchment Council	Catchment Councils	Responsible for the preparation of river basin development plans, water allocation, and the monitoring of basin management activities87
MoEWC	Ministry of Environment, Water and Climate	Ministry of Environment, Water and Climate	Responsible for policies, monitoring, and overseeing related agencies for the management of the environment and natural resources88
EMA	Environmental Management Agency	Environmental Management Agency	An agency under the Ministry of Environment, Water and Climate, established under the Environmental Management Act of 2002 to ensure sustainable management of natural resources and formulation of environmental plans for environmental management and protection.

Source: JICA Study Team

[87] Republic of Zimbabwe Project Finding Study Report
[88] Report on Basic Information Collection and the Verification Study on the Water Supply and Sewage Sector in the Harare Metropolitan Area, Zimbabwe

The Zimbabwe Water Authority is under the Department of Water, which was part of the former Ministry of Water Resources and Development. In addition, catchment councils for each of the seven river basins in Zimbabwe are preparing development plans and monitoring management activities in each basin with technical support from ZIMWA.

Due to the recent establishment of the Ministry of Land, Agriculture, Fisheries, Water Resources and Rural Resettlement, it is difficult to obtain a detailed organizational chart from the desktop survey, so the organizational chart of the former Ministry of Water Resources and Development is shown below.

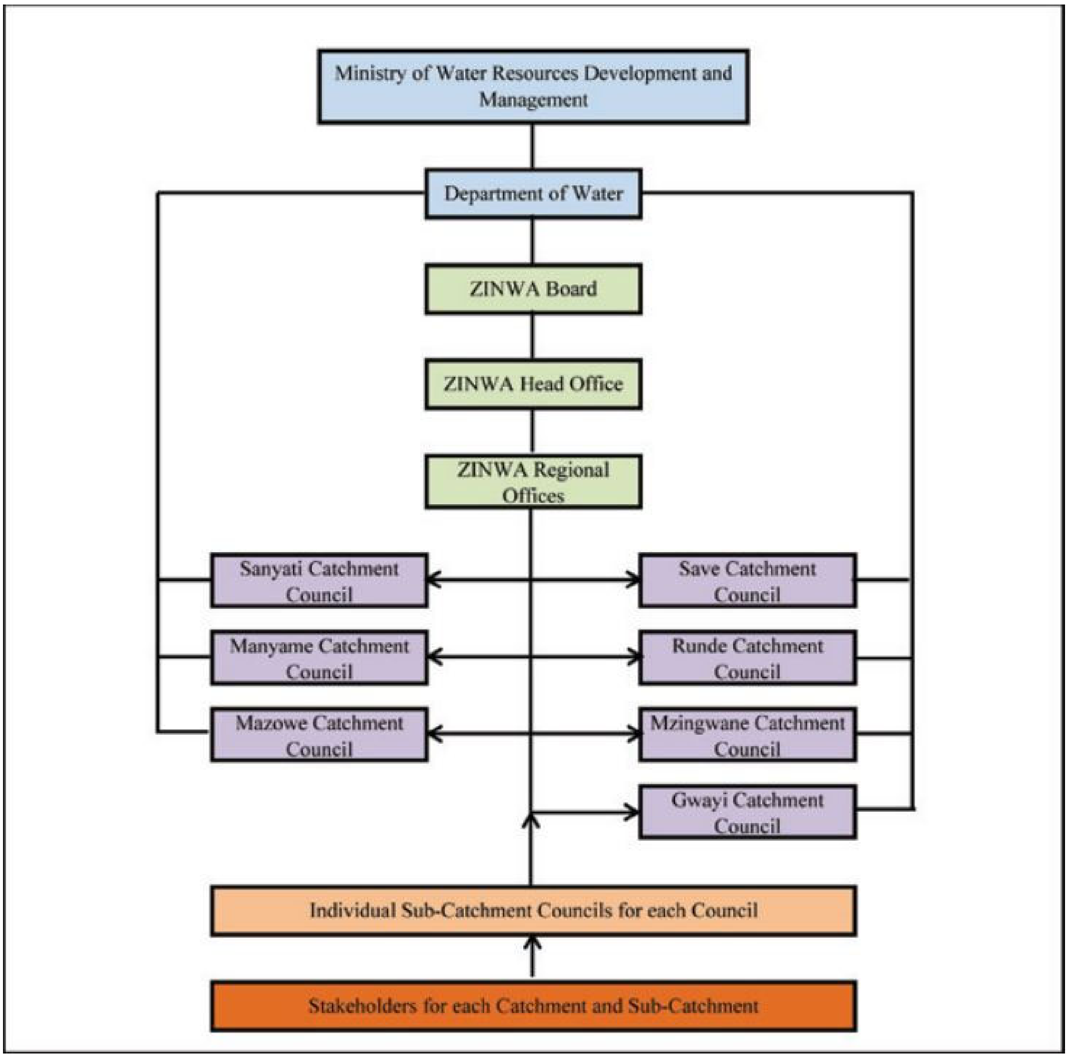


Figure 3–263 Organizational chart of the Ministry of Water Resources and Development of Zimbabwe

Source: Ateg resources

2） Overview of Related Plans and Development Status

a) Plans for river management

The National Water Policy 2012 is a comprehensive plan for the water sector developed in 2012 and covers river management. The policy sets out the following eight objectives, but no objectives for flood management have been established under river management.

- Equal access to water resources
- The efficient use of water among competing uses
- Ensuring sustainable public health services
- Environmental conservation
- Conservation of water resources, including ensuring the safety of dams and groundwater
- Ensure appropriate organizational structure of the water sector
- Economic development of the country
- Administration of the water act

In the National Water Policy, the importance of implementing comprehensive river management for each river basin is stated under "integrated water resources management." This includes management that considers the entire water cycle of the basin, decentralization of water resources management, participation of stakeholders in policy making, and treating water resources as social capital. However, there is no mention of flood management.

b) Status of support by donors

Study on comprehensive river management for the Gwebi river basin

In Zimbabwe, the Environmental Management Agency (EMA) is leading a study on comprehensive river management with the support of the Infrastructure Development Bank of Zimbabwe (IDBZ). The study defines comprehensive river management as the effective land use and development of river basins through environmental conservation, development and management of water resources, and resource utilization.

Studies have been conducted on the seven items listed below. The sixth item is to conduct hydraulic analysis on the Gwebi side based on 10, 20, 50, and 100-year probability scales.

- Organize information on socioeconomic activities in the basin (location and usage information, etc.)
- Update land use maps in the basin
- Identify conservation areas and prohibited development areas in the basin and understand its

current use

- Ensure consistency of river basin management plans with national and local economic development plans
- Collection of geomorphological information on the Gwebi river basin and study of river basin conservation measures
- Hydrological analysis of the Gwebi river basin and analysis of the impact of future development plans
- Consultation with stakeholders

In Zimbabwe, there are no plans in place for flood control and river management, and donor support for flood control and river management is limited. Therefore, it is considered important to include a disaster preparedness perspective in the comprehensive river basin management plan described in Zimbabwe's water policy.

In the above study, a small catchment area of the Gwebi River near Harare is examined. Based on hydraulic analysis, the relationship between inundation risk and future development plans is analyzed to determine disaster countermeasures.

Since the study was started in 2020, it is expected that its results will be used to assist in developing basin management plans in other river basins based on hazard analysis.

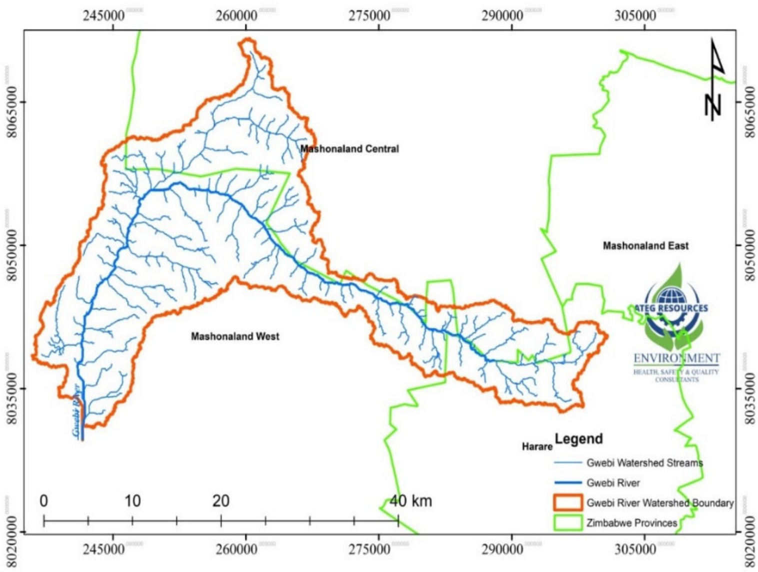


Figure 3–264 Basin map of the Gwebi River

Source: Ateg resources

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

a) Topographic and climatic conditions in Zimbabwe

Zimbabwe is a landlocked country surrounded by four countries. It has a mountainous region with Mount Nyangani as the highest point, which is in the east near the Mozambique border. The lowest point is 162 m above sea level, at the confluence of the Save and Lunde rivers in the south. Zimbabwe has a tropical climate, and the rainy season generally lasts from November to March. Average monthly rainfall maps available on the internet for the two stations of Harare and Bulawayo are shown below. From this, we can see the following.

- Looking at the average monthly rainfall, rainfall is concentrated in the period from November to March.
- The average annual total rainfall is about 800 mm in the capital city of Harare and 550 mm in Bulawayo. Since the average annual total rainfall in Tokyo is about 1,600 ㎜, it is clear that rainfall is relatively low.

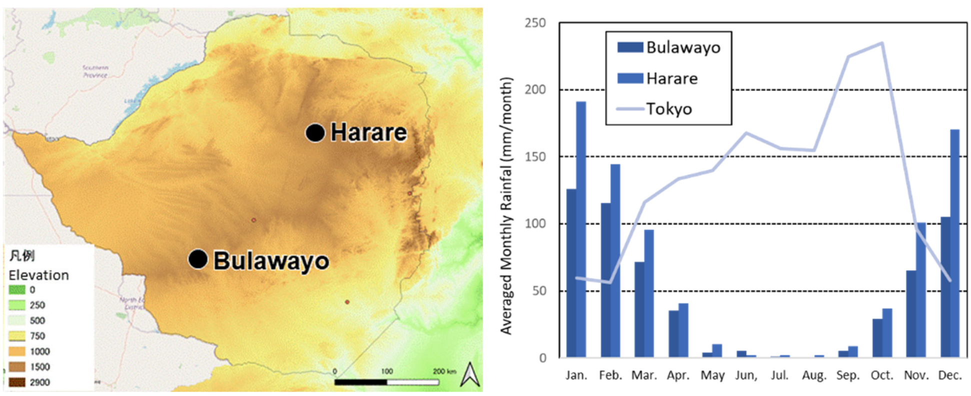


Figure 3–265 Average rainfall in Zimbabwe

Source: Japan Meteorological Agency website

b) Overview of Rivers in Zimbabwe

As the central part of Zimbabwe has a high elevation, many rivers flow from those regions toward the national borders. The major rivers in Zimbabwe are the Save and Lunde rivers in the east, the Hunyani River that flows from the northern capital of Harare to the north, and the Gwayi River that flows from Bulawayo, the second largest city in terms of population, to the Zambezi River in the north.

Figure 3–266 Location map of major rivers in Zimbabwe

Source: Prepared based on the JICA report on the collection and verification of basic information on the water supply sector in Harare metropolitan area, Zimbabwe.

Zimbabwe has also established management units for each of the seven river basins, and the locations of the units are shown in the figure below. Catchment councils have been set up for each of the basin management units to prepare management plans and to supervise sub-catchment councils, in addition to approving, regulating and monitoring water use.

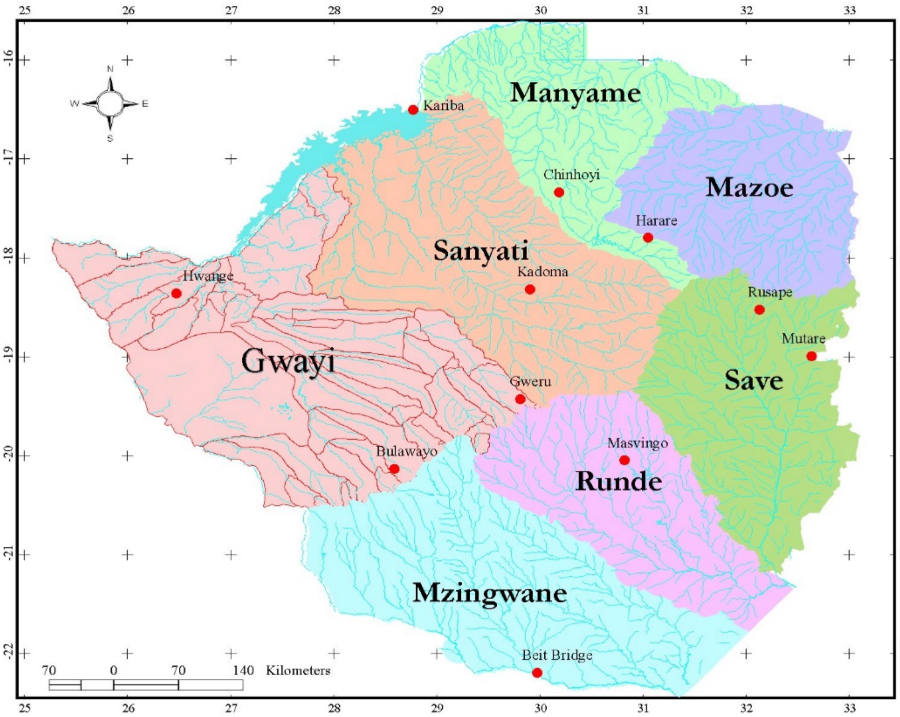


Figure 3–267　Location map of the seven river basin management units in Zimbabwe
Source: Data and Research Department, ZINWA (Zimbabwe National Water Authority)

c) Flood damage in the past

According to the report, "Spaces of vulnerability and areas prone to natural disaster and crisis in six SADC countries" published by the International Organization for Migration (IOM), the table below summarizes the EM-DAT information on Zimbabwe's flood history from 2000 to 2015. In particular, flooding has been more frequent in Mashonaland Central Province, which is located north of the capital Harare（mentioned in red in the table below）, and cyclone damage has occurred in Manicaland Province (mentioned in blue in the table below).

Table 3-207 Flood history in Zimbabwe, 2000-2015

Year	Classification	District of occurrence (province)
2000	Riverine flood	Manicaland, Masvingo, Matabeleland South, Midlands
2001	Flood	Mashonaland Central, Matabeleland
2003	Riverine flood	Mashonaland Central, Mashonaland West
2003	Tropical cyclone	Manicaland, Masvingo, Matabeleland South
2007	Riverine flood	Mashonaland Central; Masvingo
2007	Tropical cyclone	Manicaland
2010	Riverine flood	Mashonaland Central
2011	Riverine flood	Mashonaland Central, Mashonaland West
2013	Riverine flood	Matabeleland South, Matabeleland North, Midlands, Masvingo, Mashonaland Central, Manicaland
2014	Flash flood Riverine flood	Mashonaland Central, Masvingo, Matabeleland North, Midlands, Mashonaland West, Bulawayo, Harare, Matabeleland South
2015	Convective storm	Mashonaland Central, Mashonaland East, Mashonaland West, Midlands, Harare

Source: Report on "Spaces of vulnerability and areas prone to natural disaster and crisis in six SADC countries"

d) Status of hazard map development

In Zimbabwe, the United Nations Development Programme (UNDP) has analysed the distribution of disaster risks in its report on the Human Development Goals (2017), and has conducted a simple risk assessment. In addition, the Department of Civil Protection (DCP), which is the ministry in charge of disaster management in Zimbabwe, has only conducted a simple GIS hazard analysis with the support of UNDP, and no flood hazard maps are available in Zimbabwe.

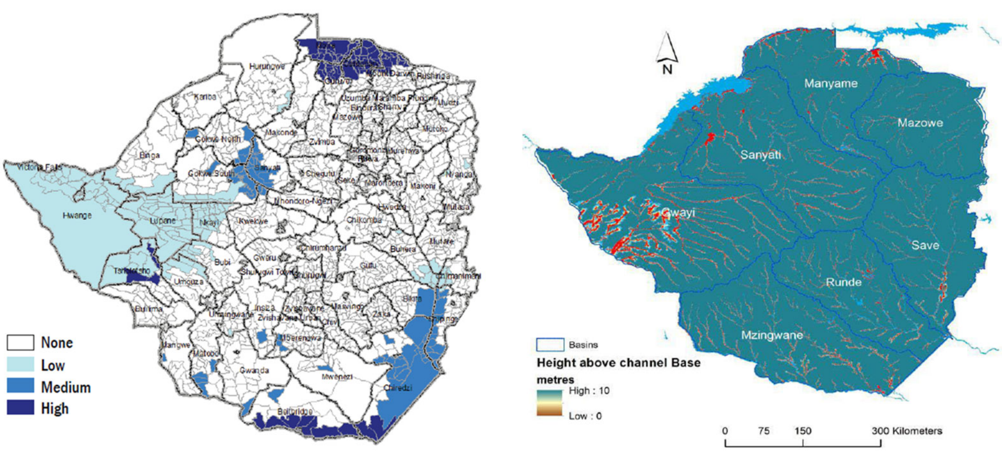


Figure 3–268 Results of analysis of existing flood hazard risks in Zimbabwe.
Source: Zimabwe Human Development Report 2017, UNDP (left); PPT presentation prepared by the Office of Civil Defense (right).

e) Flood risk based on an overlay map of estimated inundation with population distribution

Using the data collected as described in "2.1.2 Methodology for assessing disaster risk," an overlay map of population distribution and inundation areas based on 100-year flood probabilities was prepared for all of Zimbabwe.

According to the results of the hazard analysis described above, the flood risk is high near Bulawayo, the second largest city, the border with Zambia in the north of the capital Harare, the border with South Africa in the south, and the confluence of the Save and Lunde rivers in the southeast. On the other hand, the 100-year flood probabilities based on the global model assumes a low disaster risk, and detailed analysis is still needed to determine the exact hazard distribution. The research team's GIS analysis showed that the population distribution and the flood inundation area cover the lower part of the Save River. On the other hand, during the landfall of Cyclone Idai in 2019, damage to housing was widespread in the border areas of Mozambique. It is assumed that damage from sediment disasters and small-scale river flooding also occurred in the same areas, and it is essential to investigate the damage caused by the cyclone in greater detail.

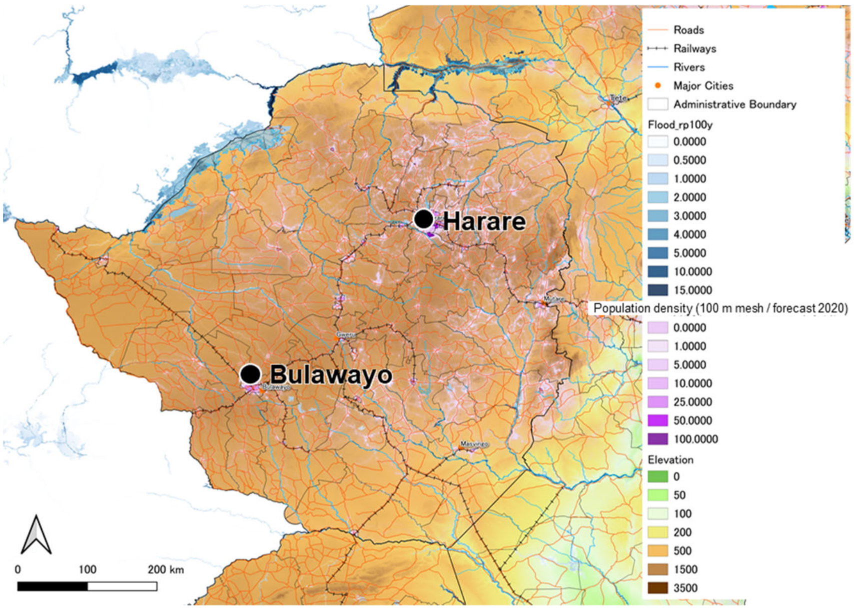


Figure 3–269 Overlay of flood risk and population distribution in Zimbabwe
Source: WorldPop, NASA SRTM Terrain Data, (Flood Risk) JRC Data Catalogue, Aqueduct Floods Hazard Maps

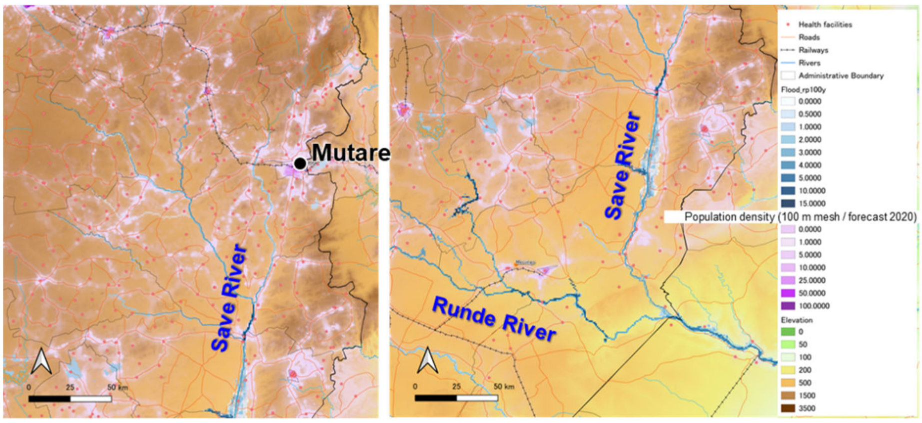


Figure 3–270 Overlay of flood risk and population distribution in the Save and Lunde river basins

Source: WorldPop, NASA SRTM Terrain Data, (Flood Risk) JRC Data Catalogue, Aqueduct Floods Hazard Maps

4) Consideration of Disaster Risk Reduction Measures

Based on the above results, the following points are assumed to be possible measures in Zimbabwe. On the other hand, since this study did not include field surveys and interviews with the Government of Zimbabwe, it is necessary to gain greater information including from field surveys in order to consider specific measures.

- Support for the development of hazard maps based on hydraulic analysis in major river basins in Zimbabwe

In particular, since Zimbabwe does not have a comprehensive set of measures for river management, it is assumed that a legal framework for river management, including an accurate understanding of hazards, needs to be established first. When considering disaster countermeasures, it is effective to identify necessary measures based on actual damage to various infrastructures.

3.5 Mauritius

3.5.1 Disaster Risk Profile

(1) Qualitative Evaluation of Hazard Distribution

1) Situation of Hazard Distribution in Mauritius

The hazard data described in "2.1.2 How to identify overview of disaster risk" was visualized in GIS to identify the profile of hazard as shown in the figure below.

- The impact of cyclones is significant throughout the region, and almost the entire coastal area is likely to experience Storm Surge damage.
- Landslide potential is high in the steep southwestern, central and eastern mountainous areas.
- Since flood hazard cannot be confirmed by global model analysis, it was confirmed using previous reports. The area along the Grand River basin from Port Louis and the eastern Mahebourg area, as well as the northern part of the country, are greatly prone to flooding.

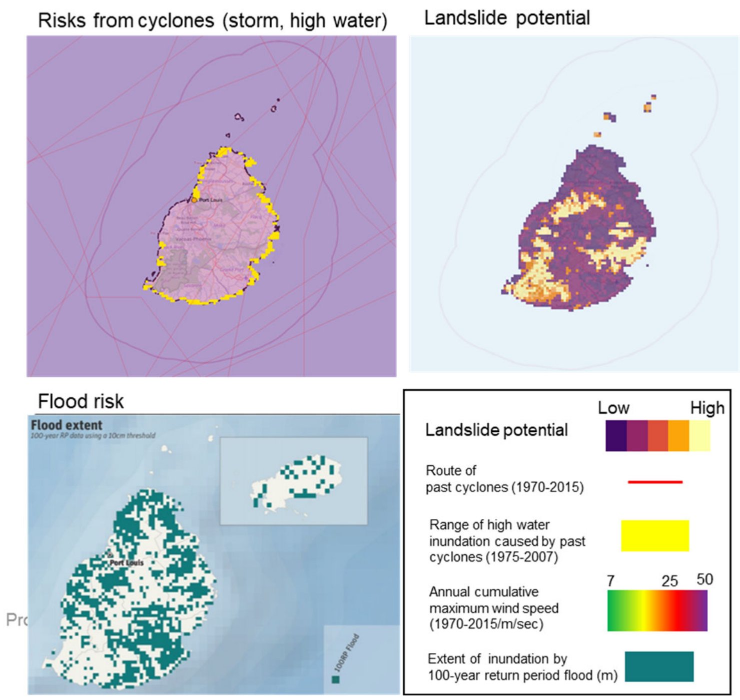


Figure 3–271 Hazard distribution in Mauritius
Source: Each data source is listed in Chapter 2, Open Street Map (background map)

2） Situation of Hazard Distribution in Major Cities of Mauritius

Situation of hazard distribution in each major city was identified according to the criteria shown in "2.1.2 Basic Idea and Methodology to Identify Disaster Risk Profile ". The population of major cities was confirmed based on UN-Habitat and World Population Review, and the major cities with large population sizes were sorted out.

Table 3-208 Hazard Status in Major Cities in Mauritius

City name	Population size (thousand person)	Hazard Status			
		Flood	Cyclone	Storm Surge	Landslide
Port Louis	155	✓✓	✓✓✓	✓✓✓	✓✓✓
Plaines Wilhems district[89]	386	✓✓✓	✓✓✓	–	✓
Rodrigues Island	43	✓✓	✓✓✓	✓✓✓	✓✓✓

Source: JICA Study Team

a) Port Louis and Plaines Wilhems district

In Mauritius, the capital city Port Louis and the Plaines Wilhems district including four major cities in Mauritius and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "✓✓" in Port Louis and "✓✓✓" in Plaines Wilhems district based on the analysis conducted by GFDRR (Figure bellow (1)). Storm surge hazard was evaluated as "✓✓✓" in Port Louis since the inundation area is distributed broadly (Figure bellow (4)). Hazard of the strong wind was evaluated as "✓✓✓" in both Port Louis and Plaines Wilhems district since the Annual accumulative wind speed is over 25m/sec (colour in red to purple) broadly in the city (Figure bellow (3)). Landslide hazard was evaluated as "✓✓✓" in Port Louis since area with high landslide potential score over the medium level exists broadly, and evaluated as "✓✓" in Plaines Wilhems district since area with high landslide potential score over the medium level exists but relatively steep area is limited compared to Port Louis. (Figure bellow (2)).

[89] The population of the Plaines Wilhems district is the sum of four major cities (Beau Bassin-Rose Hill、Vacoas-Phoenix、Curepipe、Quatre Bornes), since Port Louis is the largest in city level it is assumed as the city with largest population.

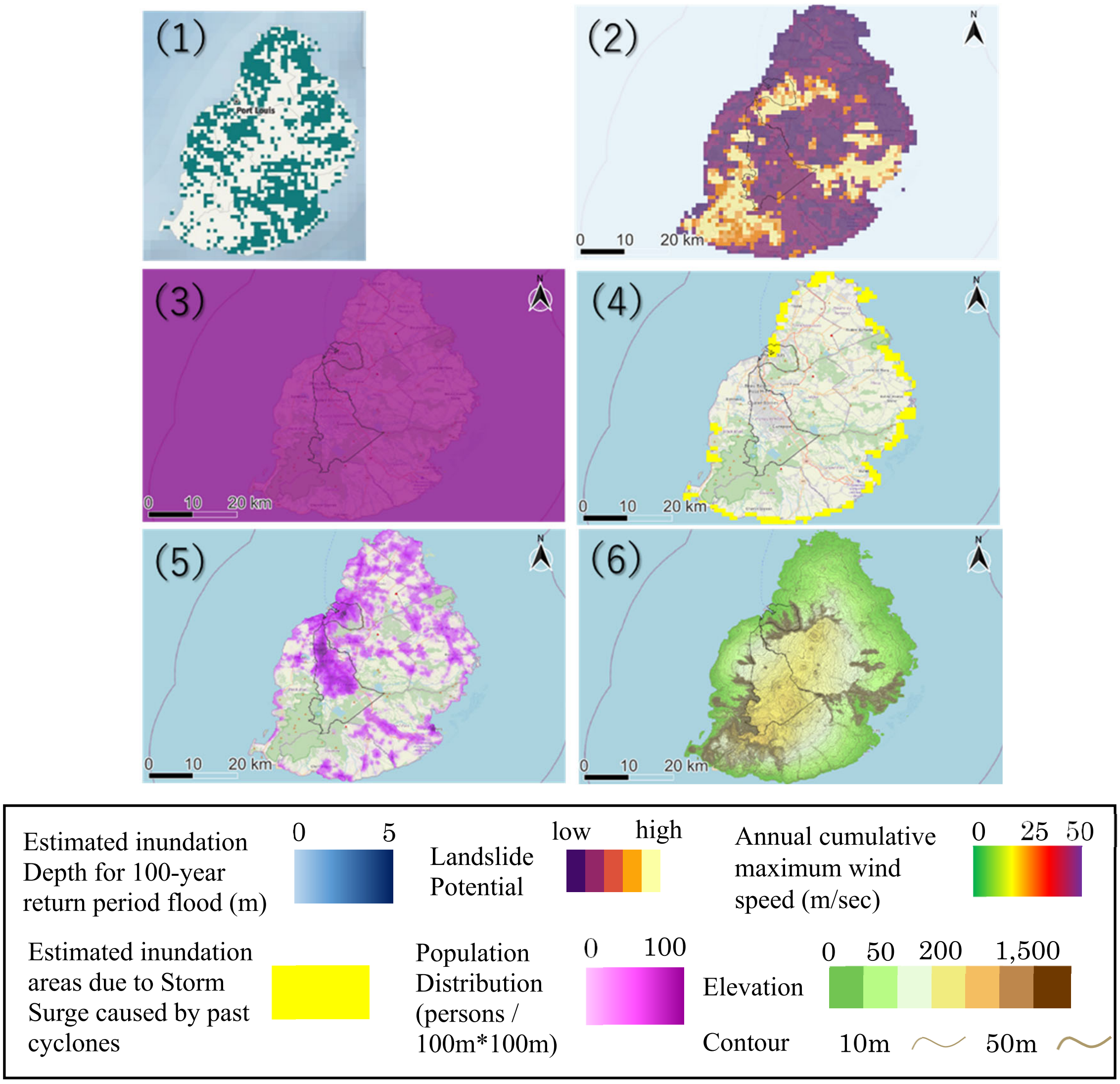


Figure 3–272 Situation of Hazard Distribution in Port Louis and Plaines Wilhems

Source: JICA Study Team

b) Rodrigues Island

The hazard distribution was also confirmed in Rodrigues Island since during the field survey the related institution has raised high needs for support and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "✓✓" based on the analysis conducted by GFDRR (Figure bellow (1)). Storm surge hazard was evaluated as "✓✓✓" since the inundation area is distributed broadly (Figure bellow (4)). Hazard of the strong wind was evaluated as "✓✓✓" since the Annual accumulative wind speed is over 25m/sec (colour in red to purple) broadly in the city (Figure bellow (3)). Landslide hazard was evaluated as "✓✓✓" in Port Louis since area with high landslide potential score over the medium level exists broadly in the Island. (Figure bellow (2)).

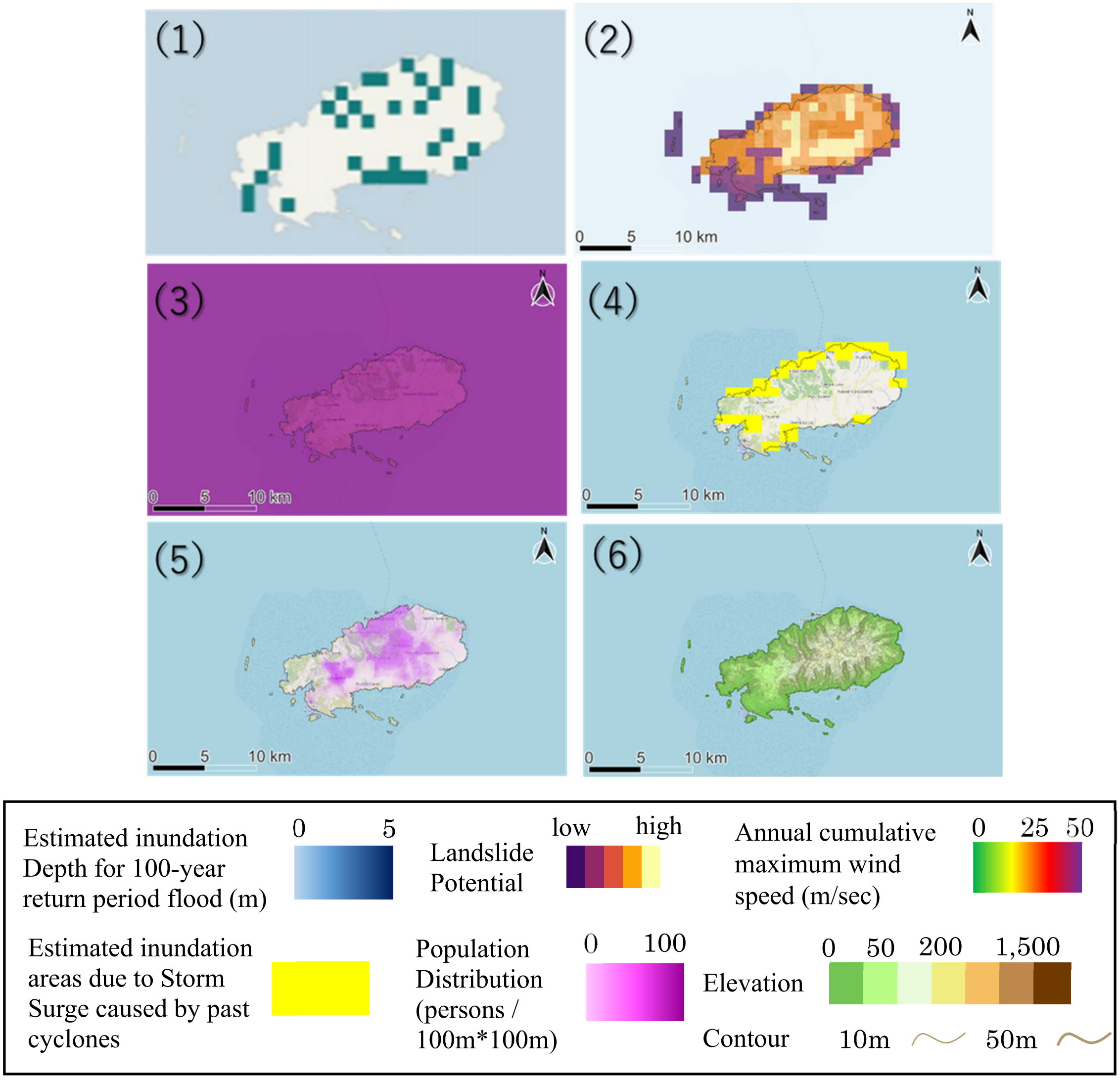


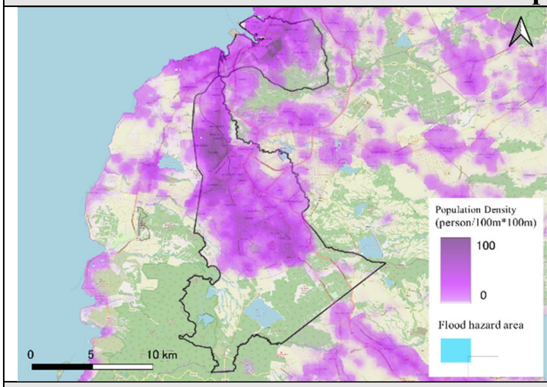
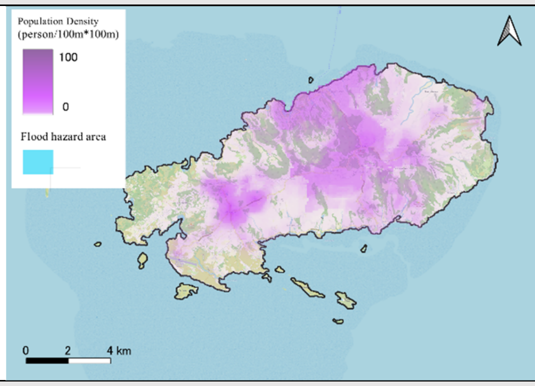
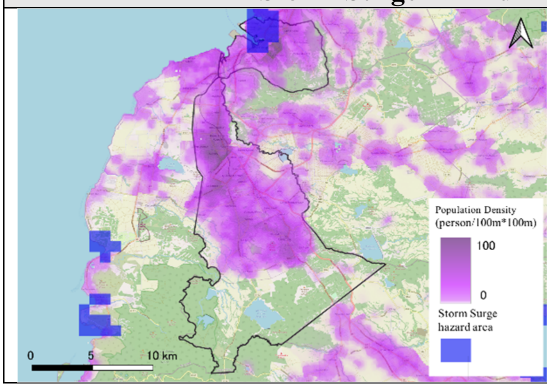
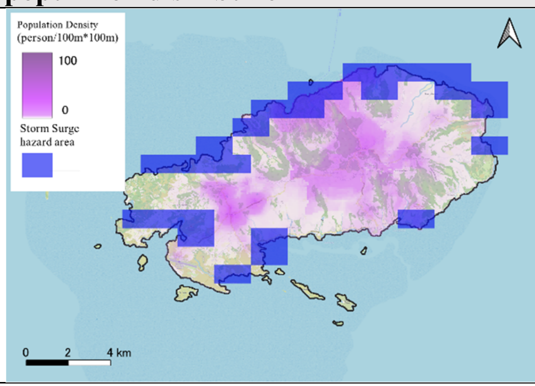
Figure 3–273 Situation of Hazard Distribution in Rodrigues Island

Source: JICA Study Team

(2) Estimation of Potential Economic Loss due to Disasters

Based on the qualitative information on hazard distribution shown above, it was concluded that, in addition to the Port Louis metropolitan area, Rodrigues Island in Mauritius had not yet developed disaster prevention infrastructure. Interviews with Mauritian government officials revealed that Rodrigues Island would have strong needs in the future, and a more detailed analysis of the island was conducted. For GDP per capita, the World Bank's published figures for 2020 were used.

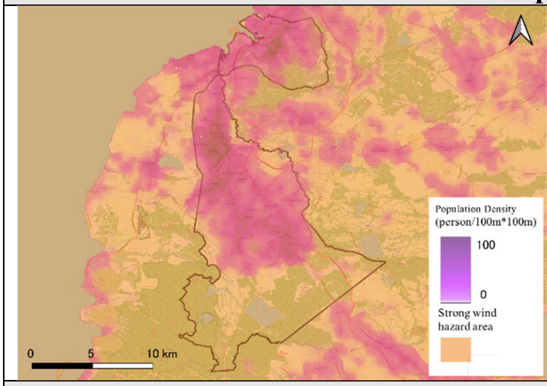
Table 3-209 Distribution of Hazard and Population in in major cities in Mauritius (1/2)

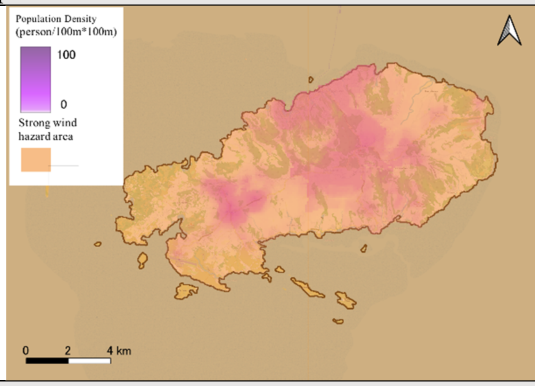
<table>
<tr><th>Port Louis Metropolitan Area</th><th>Rodriguez Island</th></tr>
<tr><td colspan="2">Flood hazard and population distribution</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">Storm Surge hazard and population distribution</td></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Source: JICA Study Team

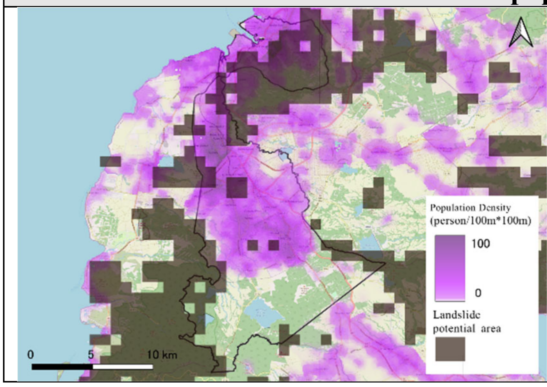
Table 3-210 Distribution of Hazard and Population in in major cities in Mauritius (2/2)

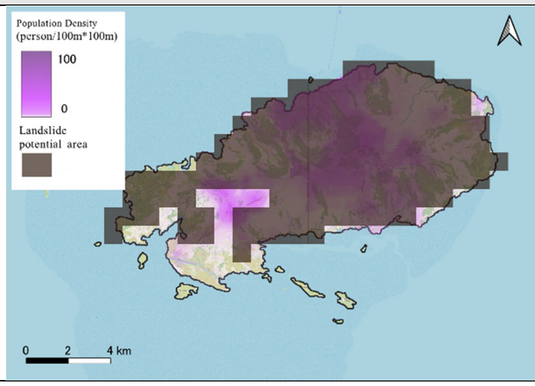
Storm hazard and population distribution





Landslide and population distribution





Source: JICA Study Team

Table 3-211 Potential Economic Loss of Major Cities in Mauritius

Hazard	Target city	Port-louis	Rodrigues Island
Flood	Damaged area (km²)	0	0
	Damage area ratio (%)	0%	0%
	Population affected ('0000 persons)	0.0	0.0
	Estimated damage (million USD)	**0**	**0**
Storm Surge	Damaged area (km²)	6	24
	Damage area ratio (%)	3%	21%
	Population affected ('0000 persons)	2.4	0.7
	Estimated damage (million USD)	**11**	**3**
Strong Wind	Damaged area (km²)	237	114
	Damage area ratio (%)	100%	100%
	Population affected ('0000 persons)	46.6	4.3
	Estimated damage (million USD)	**220**	**20**
Landslide	Damaged area (km²)	63	95
	Damage area ratio (%)	26%	83%
	Population affected ('0000 persons)	10.9	3.7
	Estimated damage (million USD)	**51**	**17**

* GDP per Capita (Current USD / person) used the data from WB
the value in the year 2020 which is (8,627.8 USD / person) was used

Source: JICA Study Team

Since the whole of Mauritius is a cyclone prone area, the potential economic loss due to strong wind is equal to the GDP per capita multiplied by the total population of the region. Since the impact of strong wind is not necessarily the same in all areas, it is necessary to consider wind countermeasures for buildings and infrastructure rather than region-specific measures.

Comparing the potential economic loss of storm surge and landslide, the figure for landslide is larger. As an island nation, Mauritius is exposed to storm surge risk along the entire coastline, but this may reflect the fact that the population is more concentrated on sloping terrain inland than in coastal areas. As for floods, the economic loss potential could not be verified because there is no hazard distribution in the global-scale analysis.

Since landslides and small-scale floods (flash floods, etc.) are localized events, it is difficult to grasp the detailed situation in the global-scale analysis. In addition, in order to calculate specific estimated damages, it is necessary to understand in detail the location of buildings and infrastructure in the hazard distribution area.

Therefore, a more detailed analysis of hazards is needed to prioritize specific disaster countermeasures.

(3) Damage and Loss Disaggregated by Sector

1) GFDRR Disaster Risk Profile

In Mauritius, damage estimates for cyclone and flood hazards are examined separately for residential buildings, commercial and industrial facilities, public facilities, and infrastructure. Damage estimates are calculated for each sector on a 10-year probability scale, a 100-year probability scale, and a 250-year probability scale. Furthermore, based on these probability scale damage estimates, the average annual loss (AAL) is calculated.

Table 3-212 Sectoral damage estimates in Mauritius in GFDRR disaster risk profiles

Disaster type		Cyclones	Flood
Conditions for analysis		Estimated annual damage	Estimated annual damage
Building (residence)	Amount of damage (Thousand USD	45,000	15,000
Commercial and industrial	Amount of damage (Thousand USD	25,000	4,500
Public facilities	Amount of damage (Thousand USD	4,500	1,500
Infrastructure	Amount of damage (Thousand USD	5,500	650

Source: Summarized by the JICA Study Team from GFDRR Disaster Risk Profile (Mauritius)

In the GFDRR disaster risk profile the distribution of disaster risks by province is visualized by disaster type and by sector as follows:

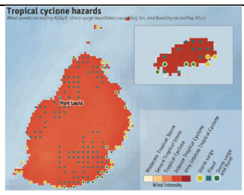
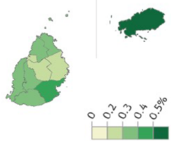
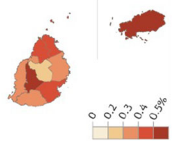
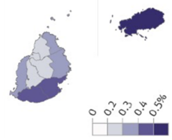
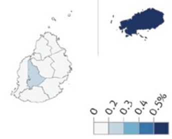
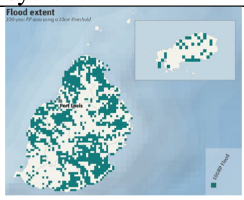
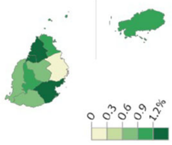
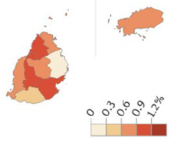
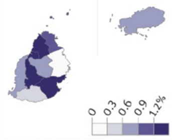
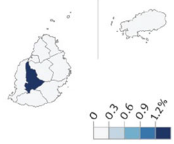
	Hazard distribution	Residential buildings	Commercial and industrial	Public facilities	Infrastructure
Cyclone	 *Wind speed of 200 km/h or more, Storm Surge of 2 m or more, and inundation from flooding due to a 100-year probability cyclone.	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)
Flood	 *Extent of inundation by 100-year probability flood	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)

Figure 3–274 Distribution of disaster risk by type and sector in Mauritius

Source: Summarized by the JICA Study Team from GFDRR Disaster Risk Profile (Mauritius)

From the above results, the damage to residential buildings is the largest in terms of damage by sector, and compared to other countries, the damage in the commercial and industrial sectors is also large. This is because the country has a higher concentration of industries than other countries, and disaster prevention measures for these facilities are also considered important.

Both floods and cyclones have increased disaster risk in areas along the Grand River basin from Port Louis and in eastern Mahebourg.

As for cyclones, disaster risk is high on Rodrigues Island, which is located about 600 km east of the main island of Mauritius. This is because Rodrigues Island is a small island in the southern Indian Ocean and is highly susceptible to cyclones. In addition, potential for Storm Surge hazard in the eastern part of Mauritius is significant and should be taken into account when considering countermeasures.

Disaster prevention measures for flooding are assumed to be a high priority for the Port Louis and Grand River basins, as there is a high concentration of industry and population there as indicated above.

2） Disaster Damage and Loss Statistics

In the disaster damage statistics of Mauritius, for the targeted disasters (floods, cyclones, Storm Surges and landslides), the actual number of deaths, damage to houses, economic losses, agricultural land and livestock damage from 2,216 events between 1960 and 2014 are aggregated and organized as shown in the table below.

Table 3-213 Disaster damage statistics for Mauritius by sector

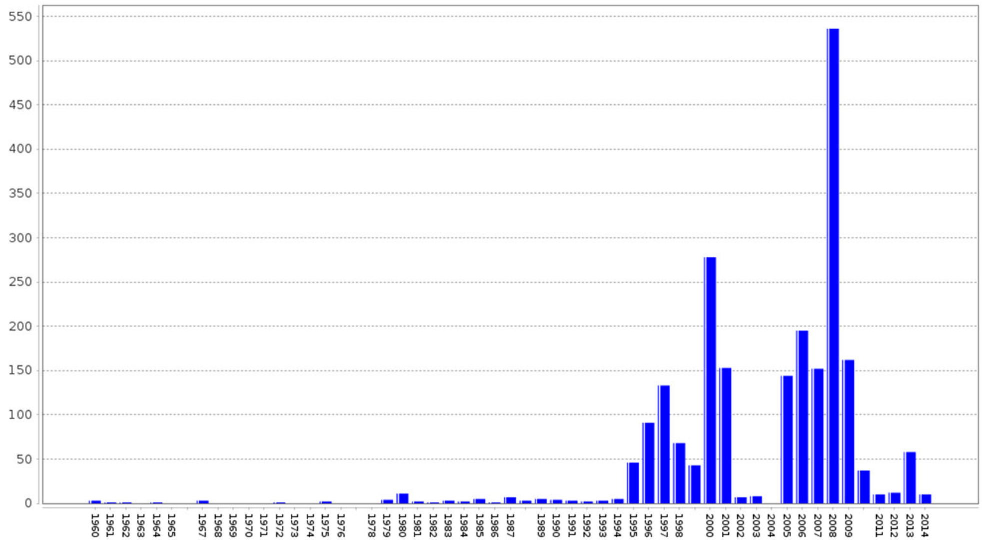
Targeted disaster types	Floods, cyclones, high waters, landslide
Target year	1960-2014
Number of disaster events	2,216
Number of deaths	179
Total destruction of houses (buildings)	41,837
Partial damage to houses (buildings)	135,715
Economic loss (local currency)	14,196,211,752
Agricultural land (ha)	10
Livestock (head)	132

Source: Data collected from DesInventar and summarized by JICA Study Team

In addition, the annual trends of the number of disaster events and the number of deaths were confirmed to analyse the trend of damage.

The number of disaster events shows an increasing trend as the number is highest in the year 2009 as 550 times. In terms of the number of deaths the value is highest in year 1960 and this is due to Cyclone Carol have caused death of 1,700. There is now increasing trend in the number of deaths, but the value is high in 2007 and 2019.

Recently (after around 2000), due to the improvement of capacity to collect disaster damage and loss data including small-scale disasters, it is difficult to compare the previous and past statistics on the same basis. On the other hand, DesInventar has summarized information on large-scale disasters from the past, so it is possible to identify the rough trends. In DesInventar, information collected after 2005 will be used to evaluate the achievement of the indicators for the global target of the Sendai Framework for Disaster Risk Reduction, so it is expected that the information will be summarized on a uniform basis. Therefore, it is important to check the trend of the statistics continuously in order to understand the damage trend.



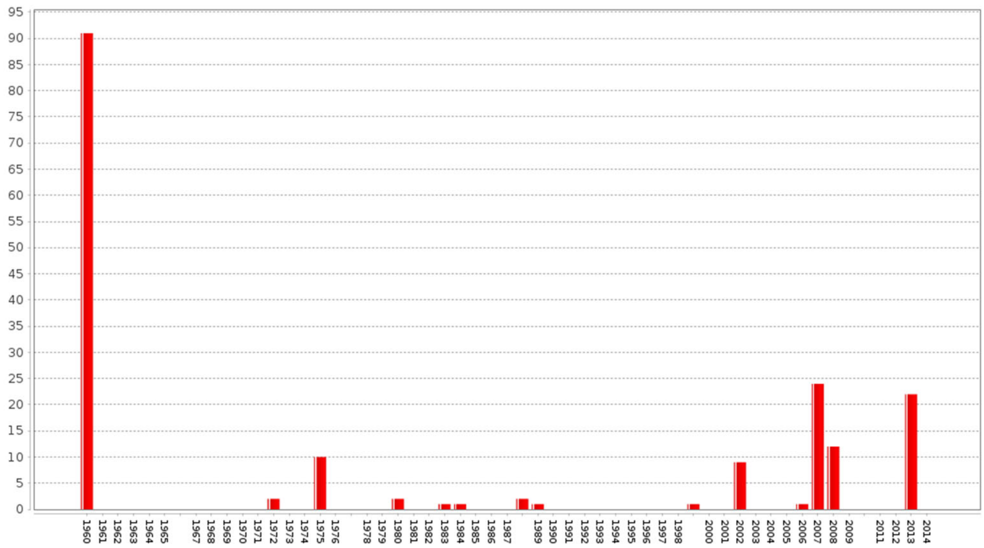


Figure 3–275 Trend of Disaster damage and loss in Mauritius from 1960 to 2014
(Above: Annual Disaster Event, Bellow: Annual damaged houses (destroyed+partial damaged))
Source: DesInventar

3.5.2 Climate Change

(1) Observed and Projected Climate Change

Mauritius, as a Small Island Developing State (SIDS), is vulnerable to climatic hazards such as cyclones, floods, droughts and sea level rise. Mauritius is ranked 51st in the world in terms of disaster risk in the World Risk Report (2021). A breakdown of this ranking shows that exposure risks are high and various measures are being taken to reduce these risks.

Rank	Country	WorldRiskIndex	Exposure	Vulnerability	Susceptibility	Lack of coping capacities	Lack of adaptive capacities
39.	Madagascar	10.44	14.97	69.71	65.83	86.32	56.97
40.	Burundi	10.42	14.88	70.02	62.29	90.43	57.34
41.	Kenya	10.33	16.63	62.13	50.80	85.50	50.10
42.	Angola	10.28	15.61	65.86	52.89	86.89	57.80
43.	Viet Nam	10.27	22.04	46.60	23.73	76.73	39.34
44.	Cote d'Ivoire	9.98	15.57	64.10	47.26	85.61	59.43
45.	Senegal	9.79	16.50	59.31	44.64	77.87	55.42
46.	Japan	9.66	38.51	25.09	17.92	39.42	17.94
47.	Sierra Leone	9.40	13.65	68.87	55.15	85.39	66.07
48.	Ghana	9.32	16.38	56.88	41.60	78.75	50.29
49.	Zimbabwe	9.30	14.51	64.11	55.02	88.44	48.88
50.	Mozambique	9.11	13.26	68.73	62.60	88.45	55.13
51.	Mauritius	9.04	23.85	37.92	17.39	58.21	38.17
52.	Malawi	8.94	13.97	64.00	56.49	83.21	52.30
52.	United Rep. of Tanzania	8.94	13.35	66.98	59.46	84.68	56.79

Figure 3–276 Ranking of Mauritius

Source：World Risk Report 2021

It is a mild tropical maritime climate throughout the year, with warm and humid summers from November to April and relatively cold and dry winters from June to September. Average temperatures is 24.7°C in summer and 21.0°C in winter, with relatively small temperature differences between the two seasons. The wettest month is February, the driest month is October, and cyclones strike from November to mid-May.

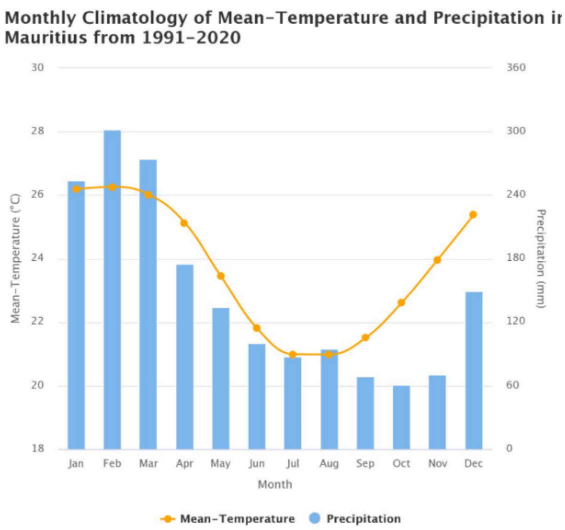


Figure 3–277 Monthly averages of temperature and precipitation (1991-2020)

Source: Climate Change Knowledge Portal, WB

In terms of past changes in temperature and precipitation, it has been shown an upward trend of about 1.2°C in average temperature from 1960 to 2014. The number of days with low temperatures have been decreased and the frequency of heat waves has been also decreased (Climate knowledge portal site, WB). In addition, the Mauritius Meteorological Department predicts that temperatures will increase by 3.14-3.64°C by 2100 under the SSP5-8.5 scenario (Update of the NDC of the Republic of Mauritius, 2021).

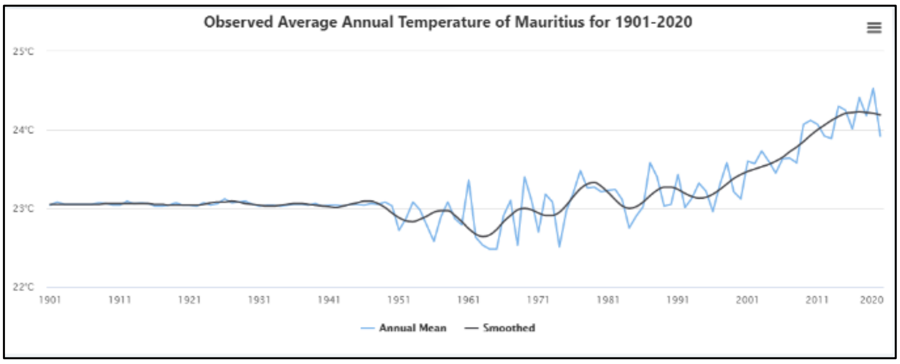
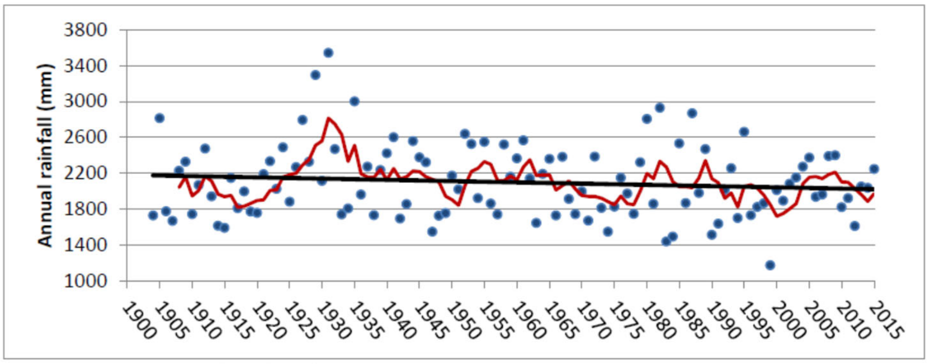


Figure 3–278 Trend of average temperature (1901-2020)

Source: Climate knowledge portal site, WB

Regarding the change in precipitation, the observed precipitation change from 1900 to 2015 shows an overall decreasing trend. On the other hand, it is not predict that significant changes in rainfall patterns in the RCP4.5 and RCP8.5 scenarios, but changes in seasonal cycles (increased precipitation between May and October) are predicted.



Source: Mauritius Meteorological Services

Figure 3–279 Precipitation change (1900～2015)

Source: National Communication 3, Manutius

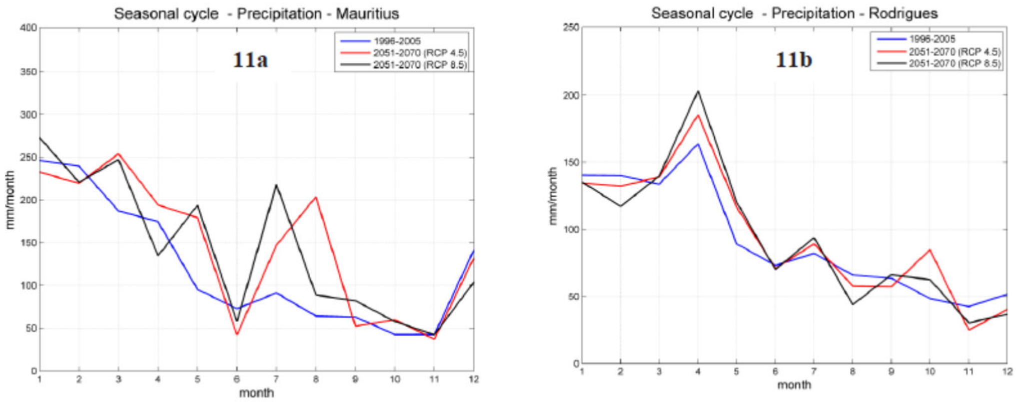
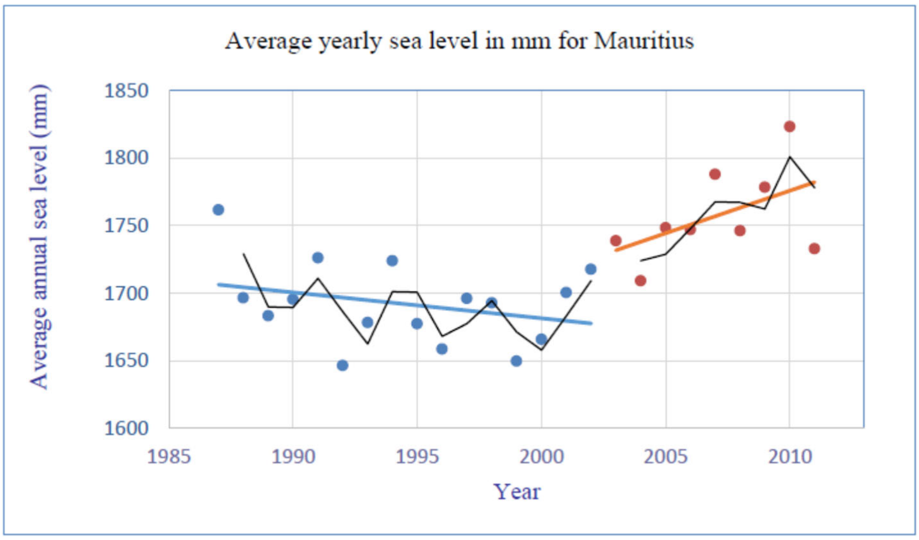


Figure 3–280 Projection of precipitation

Source: National Communication 3, Marutius

In addition, observed sea level rise in Mauritius is averaging about 5.6 mm/yr in the past 10 years, compared to the global average of 3.2 mm/yr (Climate knowledge portal site, WB). Also, sea level is projected to be raised by 18-59 cm by the end of this century. In Port Louis, in particular, the sea level rise over the past 10 years (2011-2020) has been 8 mm/year, which is higher than the rise over the period 1987-2020 (4.7 mm/year). And it is projected that 49 cm of sea level rise will be occurred by 2100 (Update of the NDC of the Republic of Mauritius, 2021).



Source: Ministry of Environment, Sustainable Development, Disaster and Beach Management (MoESDDBM)

Figure 3–281 Circumstance of sea level rise

Source: National Communication 3, Manutius

As for cyclones, the country is located at the end of the cyclone belt in the Indian Ocean, so cyclones have rarely hit the country in the past. However, recent studies identified that the intensity of cyclones in the region has been increasing and the probability of a major cyclone has risen by 18%.

According to data from the Mauritius Meteorological Department, the number of cyclones per year has doubled between 1960 and 2009. Cyclones have caused extensive damage to buildings, crops and livestock on the island, and the wind, floods and storm surges associated with cyclones are expected to cause direct damage of about US$91 million per year. According to a 100-year projection, the damage caused by cyclones is estimated at US$1.9 billion. Mauritius is susceptible to flooding from cyclones, while Rodrigues Island tends to be affected by strong winds and storm surges.

The impacts of climate change as indicated above may cause water scarcity in the country, which may adversely affect agricultural production and terrestrial and marine biodiversity. It is also feared that extreme weather events and sea level rise may affect infrastructure and tourism, and negatively impact people's livelihoods, ecosystem services, and the economy due to increased frequency of vector-borne diseases. It has predicted that Mauritius could become a water scarce region by 2030, and if no action is taken to address the catchment area, the available water resources could be reduced by up to 13% by 2050 (Update of the NDC of the Republic of Mauritius, 2021).

(2) Policies and Strategies for Climate Change

Both adaptation and mitigation measures for climate change have been carried out in Mauritius. One of them is the National Climate Change Adaptation Policy Framework (NCCAPF), which was developed in 2012 under the auspices of the African Adaptation Program (AAP). The NCCAPF aims to strengthen measures in the areas of water, agriculture, and coastal zone management, as well as disaster mitigation measures in infrastructure and residential areas, and to reduce the number of people affected by extreme weather events. It also calls for the mainstreaming of climate change in development policies, strategies and plans to avoid, mitigate and adapt to the negative impacts of climate change. In 2013, the Disaster Risk Reduction Strategy and Action Planit was formulated, which includes risk maps and other information on floods, landslides, coastal erosion, etc. Existing laws and regulations related to them are as follows.

- National Disaster Risk Reduction and Management Act 2016
- Land Drainage Authority Act 2017

- Local Government (Amendment) Act 2018
- Mauritius Meteorological Services Act 2019

In addition, the Climate Change Act was promulgated on November 28, 2020, and came into effect on April 22, 2021. In the Act, the Department of Climate Change is responsible for the implementation of international commitments related to climate change, and an interagency council on climate change has been established. It also establishes a framework for the development of national climate change strategies and action plans for mitigation and adaptation in coordination with relevant stakeholders.

A document presented at the Les Assises de I' Environtment conference in December 2019 identifies the following as challenges and needs in light of current climate change impacts.

- Mainstreaming climate change in all sectors, including private sector-led activities
- Legal framework for addressing climate change issues
- Mobilization of climate change finance for the implementation of adaptation and mitigation measures
- Reduce vulnerability to the impacts of climate change
- Capacity building on vulnerability assessment, GHG inventory, down-scaling of climate models and carbon footprint assessment
- Strengthening awareness, education and training on climate change at all levels
- Gender balance in decision-making processes for climate change governance

Government of Mauritius ratified the Paris Agreement and submitted its first Nationally Determined Contribution (NDC) in 2016, and submitted an updated NDC to the UNFCCC in November 2021. In this updated NDC, especially for adaptation, it focuses on the potential of Nature-based Solutions (NbS) and suggests new policy directions for building resilience in key areas based on the National Climate Change Adaptation Policy Framework updated in 2021 as follows.

- Strengthening the knowledge for the risks of climate change and its impacts on local communities
- Develop and implement an integrated approach that combines fisheries (blue economy), tourism, biodiversity (terrestrial and marine), forestry, agriculture, and coastal zone sectors
- Strengthening the strategic framework for addressing policy gaps and strengthening capacity in the health sector by integrating climate risk into the planning of national adaptation planning policies
- Strengthening resilience in people's activities while maintaining the functioning of ecosystems through enhanced governance and disaster preparedness and response

mechanisms in the infrastructure and disaster risk reduction sectors. Information on climate change adaptation impact assessments and adaptation measures in rural areas have not been found.

•

(3) Climate Change Adaptation Measures

To realize the goals which are set in the NDC and other documents, the adaptation actions are listed in the table below. In addition, the National Adaptation Plan is currently being developed, and efforts to strengthen resilience to climate change have been carried out continuously.

Table 3-214 Prioritized adaptation actions (NDC 2021)

Sector	Climate Change adaptation measures
Infrastructure & Disaster Risk Reduction	- Enhance knowledge base related to climate change risks to coastal ecosystems and communities; - Mainstream climate change in the sectoral policies/strategies/plans; - Enhance disaster preparedness and response mechanisms and implementing risk reduction measures; - Improve the governance to build resilience in an uncertain future; - Reduce vulnerability to natural disaster risks; and - Increase resilience of human-led activities whilst preserving ecosystem functions
Water	- Water Resources Management - Improved forecasting, management protection and quality of water resources, including upgrading and building of new treatment plants and reservoirs and reducing water losses in the distribution system - Rainwater Harvesting - Procurement and installation of rainwater harvesting systems and improvement in policy, legal and regulatory water framework in mainland Mauritius, Rodrigues and other outer islands - Desalination - Desalination plants - Rodrigues - Strengthening the development of rainwater harvesting with each household having 10 or 15m^3 installations - Small desalination plants

Sector	Climate Change adaptation measures
Agriculture	- Integrated Pest and Disease Management - Development of an integrated strategy and policy to foster adoption of integrated Pest and Disease Management (IPDM) practices including the review of policy and regulatory framework to facilitate the upscaling of IPDM technology and regulate the use and disposal of pesticides - Enhance Knowledge - Enhance the knowledge base regarding the risks of climate change for the agricultural sector and the impacts on communities; - Mainstream Climate Change - Mainstream climate change adaptation in the different sectoral policies, strategies and plans, for example in the Strategic Plan (2016 - 2020) for the Food Crop, Livestock and Forestry Sectors, through the advancement of technical studies; - Efficient Irrigation Techniques Development - Investment in water infrastructure to support irrigation projects and development of a policy framework to enhance access to, and productive use of water in the agricultural sector. - Develop and promote climate smart agriculture practices
Tourism and Coastal Zone Management	- Develop and implement an integrated approach aligned with coastal zone and biodiversity/forestry sectors - Implement the component on Integrated Coastal Zone Management (ICZM) part of the Draft Master Plan on Environment – Adopt Ecosystem-based approach - Enhance the knowledge regarding the risks of climate change for coastal ecosystems and communities – develop storm surge models to assess vulnerability in terms coastal inundation and prepare hazard maps - Awareness raising, enhanced rehabilitation and strengthened regulatory framework for the protection of beaches, dunes, and vegetation
Climate Smart Fisheries and Blue Economy	- Development and implementation of sustainable fishing management plans, strengthening of institutional capacity and adaptation of infrastructure (quay) to climate change (sea level rise) - Enhance the knowledge base regarding the risks of climate change for the fisheries sector and the impacts on communities - Establish an integrated framework for the management of fisheries founded on the Blue Economy concept, which includes coastal zone management and marine biodiversity conservation - Foster an integrated approach combining the goals and targets for the fisheries sector with the coastal zone management sector, and additionally also with the marine biodiversity sector. - Rodrigues - Resilient artisanal fishery with policy on marine co-management of resources and measures for off-lagoon fishing
Marine and Terrestrial Biodiversity Resilience	- Improve management of marine and terrestrial protected areas and expansion of protected area network including rehabilitation of wetlands, seagrass, mangrove plantation, increase in tree coverage areas and coral reef rehabilitation/farming - Rodrigues - Development of sustainable landscape management and Ecosystem-based adaptation/nature based solutions

Sector	Climate Change adaptation measures
Health Sector	- Mainstreaming of climate change adaptation in the health sector to respond to population increase and its additional climate-related health burden. - Development and implementation of a communication, education and awareness strategy with respect to climate change risks and impacts on human health. - Improve surveillance of diseases associated with climate change and develop and implement a decentralized alert and rapid response mechanism
Cross-cutting	- Gender - Education - Social security

Source: Update of the NDC of the Republic of Mauritious, 2021

The following measures are identified to be implemented as adaptation measures to climate change in updated NDC.

- Rehabilitation of degraded coastline
- Development of a coral restoration strategy
- Increase of conservation area for terrestrial biodiversity
- Develop climate smart agriculture and sensitize farmers of vulnerable areas
- Develop novel systems of irrigation and sensitize planters in vulnerable areas on water saving systems
- Construction and upgrading of drain projects across the island
- Construction of housing units equipped with solar energy for water heaters
- New development to comply with an increase in building setback
- Increase water production capacity of existing desalination plants in Rodrigues
- Restoration of lagoon in Rodrigues through the planting of corals
- Construction of break water e.g. in the Port Area.

While climate change adaptation for Rodrigues Island, a territory of Mauritius, is also mentioned in the updated NDC, there are some adaptation measures that are being implemented independently in Rodrigues Island. In Rodrigues Island, the Rodrigues Regional Assembly (RRA) is leading the environmental and sustainable development efforts. For example, the Sustainable Integrated Development Plan for Rodrigues (SIDPR) was developed in 2009, and it specifies the following points. Activities based on this plan have been implemented in the short term (2009-2011), medium term (2012-2015) and long term.

- Raise awareness of environmental and sustainability issues among all citizens
- Pursue economic development and social progress while limiting the impact on environmental resources and fragile ecosystems.

- Reduce consumption of all natural resources
- Maximize energy efficiency and the proportion of energy from renewable sources
- Conserve and enhance the diversity of forests and wildlife.
- Encourage sustainable activities and lifestyles in all organizations and individuals.
- Minimize pollution levels
- Minimize the environmental impact of waste and promote resource reduction, reuse, and recycling

Climate change is raised as a cross-cutting issues as one of the short-term action items[90]. Currently, it seems that the efforts to revise the SIDPR are underway[91].

(4) Supports from Other Donors

In Mauritius, a number of international organizations and national donors have been providing various types of support for climate change-related policy formulation and project formation.

Table 3-215 Support from donors (as of 2021)

Donor	Sector	Outline
GCF	Infrastructure, bridges and culverts, DRR-flood prone areas and coastal zones, health sector	- NAP is preparing to enhance resilience to climate change: (a) one on Infrastructure, bridges and culverts, DRR-flood prone areas and coastal zones, for a total of USD 2.5 million from the Green Climate Fund (GCF) and (b) another on health for a total of USD 425,000 from the GCF
AFD	Overall	- The Adapt' Action Programme financed by AFD to the tune of EURO 2 million for the implementation of first Mauritius Nationally Determined Contribution (NDC). Technical assistance programs on institutional, methodological, and operational aspects for the implementation of climate change measures - Development of long term strategies (2050) for the following sectors: energy, transport, agriculture and tourism (Euro 1.1 million)
SADC	Agriculture	- Vulnerability Assessment and Analysis in the Agriculture sector (USD 105,000) under the SADC regional climate change programme

Source: UPDATE OF THE NATIONALLY DETERMINED CONTRIBUTION OF THE REPUBLIC OF MAURITIUS,2021

[90] http://chiefcomm.rra.govmu.org/English/sidpr/Pages/Short-Term-Action-Plan.aspx
[91] https://www.developmentaid.org/#!/jobs/view/1011042/experts-for-the-review-and-update-of-the-2009-sustainable-and-integrated-development-plan-for-rodrig

3.5.3 National and Urban Development

(1) National Axis and Strategic Cities

The urban population of Mauritius is not concentrated only in the capital city of Port Louis, but also in the four cities in the Wilhelm Plains with around 100,000 people if combined. Port Louis is located in the western part of the island and has developed as an important port city. With Port Louis as the shipping port, sugar cane farms and sugar factories, which have been industries for a long time, are located in the northern and southeastern areas of the island. This contributed to forming of urban activities of Wilhelm Plain Prefecture. Grand Baie, which is the second most famous tourist city after Port Louis, is a bay that is used as a marina where cruise ships are anchored, and the town is formed in an area that can be reached on foot from a resort hotel. The table below shows the population of major cities in 2021, and the figures below show the location of cities and arterial roads, and the status of economic land use.

Table 3-216 Population of Major Cities in Mauritius (Year 2021)

	Name	Population	Prefecture
1.	Port Louis	155,226	Port Louis
2.	Vacoas-Phoenix	110,000	Wilhelm Plain
3.	Beau-Bassin Rose-Hill	111,355	Wilhelm Plain
4.	Curepipe	84,200	Wilhelm Plain
5.	Quatre Bornes	80,961	Wilhelm Plain
6.	Triolet	23,269	Pamplemousses
7.	Goodlands	20,910	Riviere du Lampard
8.	Centre de Flacq	17,710	Flacq
9.	Bel Air Rivière Sèche	17,671	Flacq
10.	Mahebourg	17,042	

Source: World Population Review

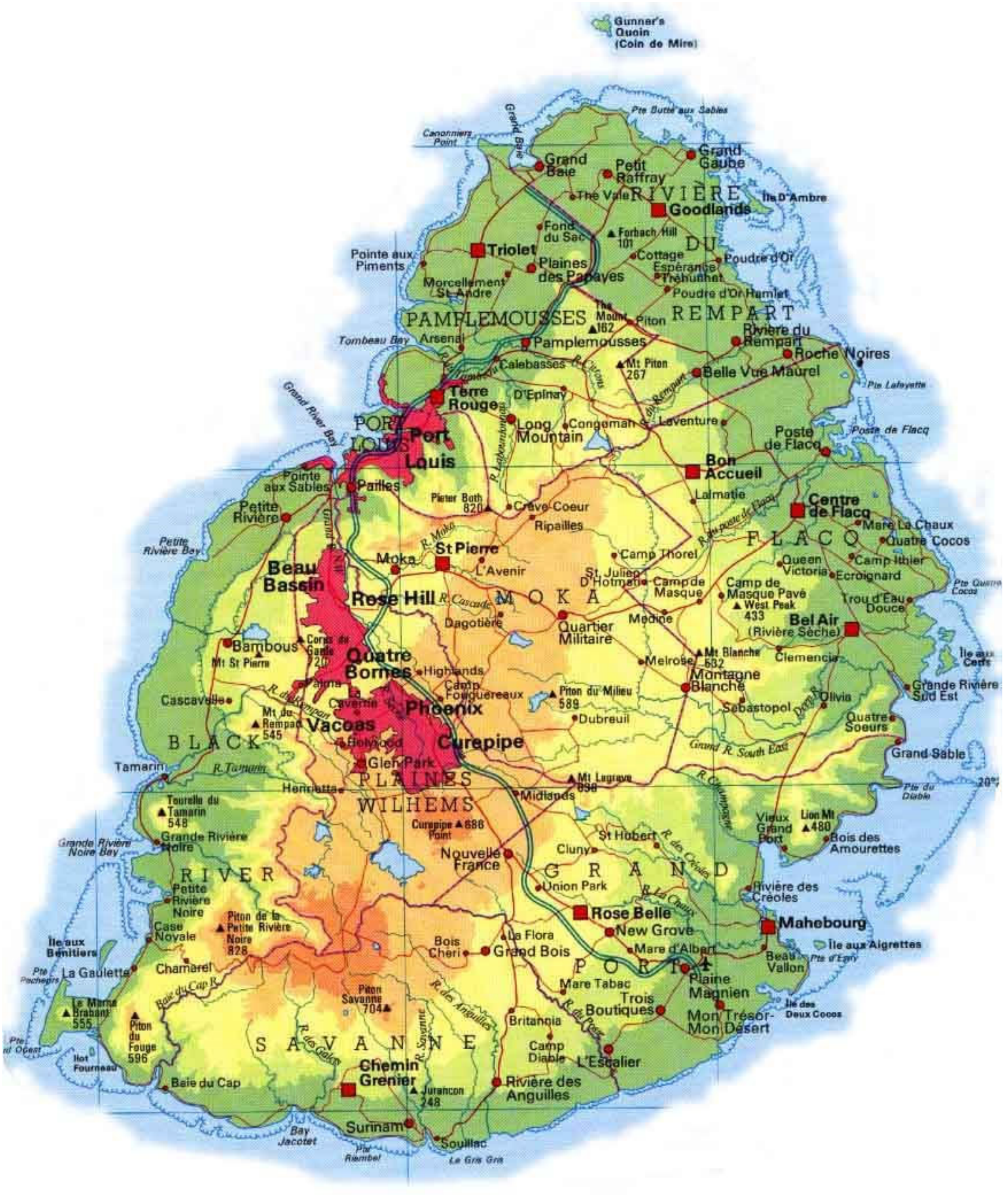


Figure 3–282 Distribution of Cities and Trunk Roads

Source: Mauritius & City maps[92]

92 https://www.maurinet.com/maucit1.html

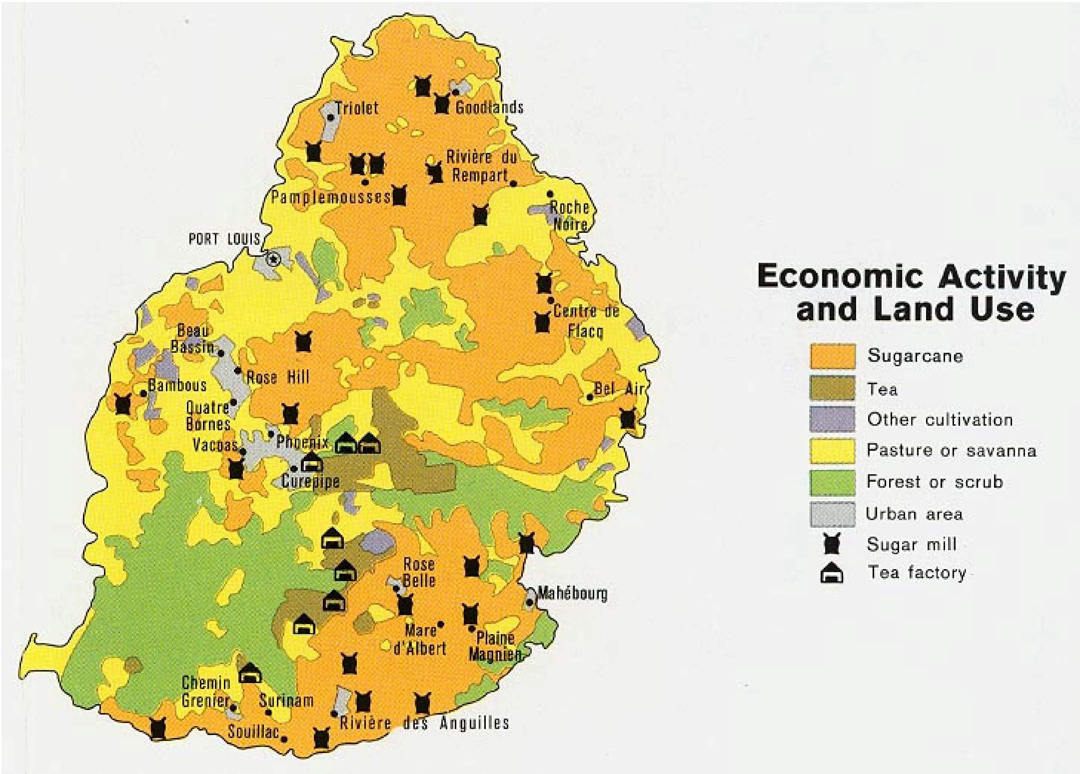


Figure 3–283 Economic Land Use

Source: University of Texas at Austin[93]

(2) Cross-border infrastructure

Mauritius is an island country and relies on air and sea routes for international transportation and logistics. Tourism, which is one of the major industries, is often a long-term stay of 10 days or more from Europe, including France. The main export partners are the United Kingdom and France, and the main import partners are India, China, South Africa and France.

Sir Seewoosagur Ramgoolam International Airport is located in the southeastern part of Mauritius Island. The Airport of Mauritius Ltd is modernizing the airport and is seeking the participation of private partners. The Airport Master Plan states that a new cargo and free port zone will be established in the south. It has already secured 34.6 hectares of land and is leasing lots to developers and companies interested in building freight, free ports and logistics facilities.

The Mauritius Free Port was established in 1992 with the main purpose of developing Mauritius as a competitive logistics and distribution center for international trade. Currently, there are 231

[93] https://maps.lib.utexas.edu/maps/mauritius.html

operating businesses, 8 third-party free port developers, and 3 private free port developers, with approximately 3,500 employees. The area of the building, which was 5,000 m2 in 1993, has increased to 300,000 m2 in 2018.

(3) Location of Important Industries

Mauritius is an island nation with a population of only 1.3 million, but has undergone economic transformation since its independence in 1968. From a low-income agriculture-based economy, it has promoted substantial manufacturing, finance, ICT and tourism sectors with steady results.

Sugar used to be the predominant export that has supported economic growth. The share of the textile industry increased sharply, which have been located in the export processing zone, gradually developed in the latter half of the 1970s. By the rose of labor costs, some major textile companies have moved to Madagascar where operation of labor-intensive industry met more competitiveness. Large textile factories have shifted their focus to the luxury market for the past 15 years and are gradually mechanizing. Unlike other countries, Mauritius' export processing zones are not limited to any particular area. EPZ certified companies can operate anywhere in the country.

A business park has been established in the Ebene district in the central part of the island, and attracting IT companies from such as India. Leading Mauritius companies are also moving to the area to relocate their headquarters from Port Louis.

Tourism is also known as a luxury marine resort, and although the number of foreign tourists (mostly French) and tourism income are increasing rapidly. However, there is a concern that the natural environment has been deteriorated by such activities as the sand injection on coral area for beach conservation purposes, and he construction of a golf courses on uninhabited islands.

(4) Issues Related to Land Use

Land use composition of the country is 45% for agricultural, 28% for forest / pasture, and 24% for urban use. Among the cultivated land, 90% of is sugar cane fields, and natural vegetation remains only slightly near the Black River Gorges in the southwest. The table below shows the changes in land use by category provided by the Land Use Planning Profile (LUPP) and observations in 2019. According to this, the change in land use from 1995 to 2019 can be seen as a decrease in green space and an increase in urban areas, with the following characteristics.

(A) Agricultural land (green space) decreased (46.3% to 34%).

(B) Forests, shrubs and grazing land (green areas) decreased significantly from 30.6% to 18%.

(C) Urban area (gray) increased from 19.5% to 33%.

(D) Infrastructure land increased from 2.1% to 6%.

Table 3-217 Change in Land Use

Sr No.	Land Use	1995*	2005*	2019 as estimated	Ideal Situation
	Agriculture (sugar and others)	46.3	43.3	34	35
	Forest, Shrubs, grazing land	30.6	25.3	18	20
	Built Up Area	19.5	24.9	33	35
	Infrastructure	2.1	2.3	6	6
	Inland water resources system	1.4	1.6	4	4
	Abandoned sugar cane fields	-	2.5	5	-

Source: JICA Study Team based on DR PARENIVEL PILLAY MAUREE, "Re-visiting our Land Use Planning Strategy in Mauritius"

With the sugar and textile industries stagnant, the government has begun selling real estate as part of its tourism strategy. The Real Estate Scheme (RES) and Real Estate Development Scheme (PDS) have been repackaged to promote the attraction of foreign capital as an integrated resort scheme (IRS). This includes the conversion of vast privately owned farmland, which is considered to be less productive, to residential and industrial use, as well as the construction of villas for sale to foreign capital. Along with this, the prices of the surrounding land are soaring, which is reducing the purchasing power of the Mauritius people, increasing poverty and illegally occupying public land.

3.5.4 Disaster Management Plan and Implementation Structure

(1) Legal Framework and Planning for Disaster Management

Mauritius did not have a specialized agency for disaster management until the 2000s, however since 2010, the government has been promoting the establishment and strengthening of a disaster management system to cope with frequent cyclones, floods, sediment disasters, and other natural disasters. Specifically, the National Disaster Risk Reduction and Management Centre (NDRRMC) was established in 2013, the National Disasters Scheme (NDS) was formulated in 2015, the National Disaster Risk Reduction and Management Act (NDRM) was enacted in 2016; and to cover the ten years of 2020-2030, the National Disaster Risk Reduction and Management Policy, the National Strategic Framework, and the National Action Plan were formulated in 2021. Major natural disasters are expected to include cyclones, storm surge, heavy rains and flooding, sediment disasters, sea level rise, coastal flooding, and tsunamis.

The National Disaster Risk Reduction and Management Act (2016) stipulates an integrated and cross-sectoral approach to address disaster risk and damage reduction, preparedness, emergency response, and recovery and reconstruction, as well as the implementation system and roles of relevant organizations. The law provides a legal basis for declaring a state of emergency and requesting international assistance in the event of a disaster. The National Disasters Scheme (2015) organizes the roles of relevant organizations for before, during and after disasters according to the aforementioned disaster types. The National Strategic Framework lists five strategic pillars: understanding disaster risks, strengthening governance, investing in disaster mitigation in advance, enhancing advance preparation for recovery and reconstruction, and strengthening capacity for resilience, which are being studied based on the Sendai Framework for Disaster Risk Reduction and others. The National Action Plan (2020-2030) is organized into four strategic objectives: disaster risk governance, disaster risk reduction, warning and alert, and preparedness, response and recovery. While the formulation of policies related to disaster reduction at the national level has progressed, detailed analysis of hazard areas and formulation of disaster reduction plans at the local government level remain a challenge for the future.

(2) Implementation Structure of Disaster Risk Reduction and Management

As shown in the figure below, Mauritius has clearly divided the two phases into normal times and post-disaster emergency response, and has established a system to promote discussion on disaster risk reduction and management for each phase. In the event of an emergency, officials from ministries of agencies related to disaster management will gather at the National Disaster

Prevention and Mitigation Center to share information and respond to the situation. This method has been practiced in past disasters such as floods. In addition, during normal times, high-level discussions are held once a month to promote disaster prevention and mitigation, indicating that the government is aiming to establish a system that includes the development of disaster prevention infrastructure.

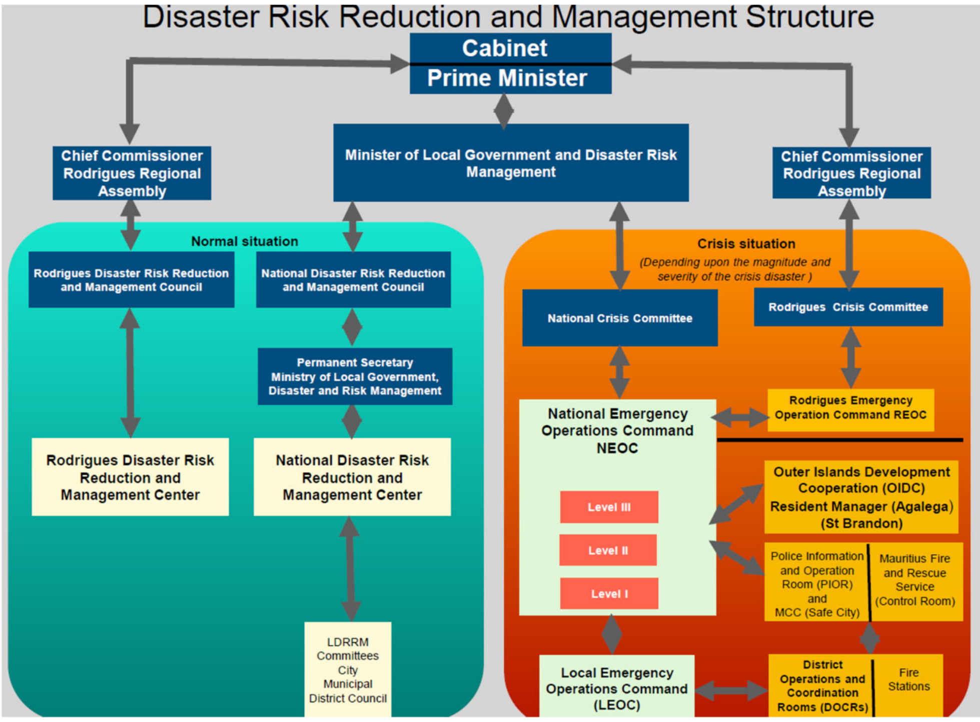


Figure 3–284 Implementation structure of DRR and management in Mauritius

Source: NDRRMC

(3) Examples of DRR efforts by NDRRMC

NDRRMC is implementing the following DRR efforts based on the National Disaster Risk Reduction and Management Policy and Strategic Framework and Action Plan 2020-2030.

- Disaster Information Management System (MauDIMS)

The MauDIMS is an online database which stores disaster related information and is located on the Government Cloud located at the Government Online Centre and accessible only by selected officers of the NDRRMC, who will update the data from Ministries/Departments after each disaster event. The MauDIMS will allow for analyzing disaster data for Disaster Risk Reduction, development planning, or monitoring global progress in line with Sendai Framework Monitor

(SFM), established at the level of the UNDRR.

- Paul Hayden Report on Education to Disaster Risk Reduction Management

The NDRRMC in collaboration with the office of the UNDP initiated a project in connection with Education to Disaster Risk Reduction Management in Mauritius which is an important element of the disaster risk reduction and management. The aim of the project was to make the country more resilient through an informed population committed to a culture of prevention and mitigation of disaster risks, awareness of risks faced and action to be taken in the event of a disaster as well as how to avoid the creation of future risks.

- Capacity for Disaster Reduction Initiative (CADRI) Partnership

The CADRI Partnership is a global UN led partnership that works towards strengthening countries' capacities to pursue integrated and coherent solutions to reduce disaster and climate risks across the Sustainable Development Goals (SDGs). On the request of the Mauritian government and funded by the UNDP, a scoping mission was undertaken by the CADRI team from 26 to 28 February 2019 to define the scope, thematic focus, modality and timeline of CADRI engagement and mobilize national stakeholders to lead the CADRI process.

- Workshop on Urban Risk Reduction and Making Cities Resilient

This capacity building workshop organized from 02-04 July 2019 was funded and facilitated by the UNDRR and promoted the importance of effective climate change adaptation and disaster risk reduction.

- Training Workshop on 'Post Disaster Needs Assessment (PDNA)/ Disaster Recovery Framework

The PDNA training workshop held from 08-12 October 2018 and funded by the UNDP, aims towards a harmonized and standardized approach in government-led efforts to estimate the needs for recovery after a disastrous event and to plan and implement recovery strategies to help rebuild the physical, social and human capital of disaster affected communities. The main objective is to establish a national cadre of officials to undertake needs assessment and formulate recovery frameworks in Mauritius.

- Online Training on 'Community Based Disaster Risk Reduction 2021' by JICA Kansai from 22 October 2021 to 26 November 2021.

During the online training, participants were trained on the significance of disaster risk reduction against natural disasters, needs of self-help, mutual-help and public-help, and how to promote community-based disaster risk reduction in each country, through the disaster management activities at community level in Japan.

- Mental Health Services after Disaster and Combat

A 5-day workshop on 'Mental Health Services after Disaster and Combat' was organized jointly by the NDRRMC, the US Embassy and the Defence Institute of Medical Operations (DIMO). It was a continuum of a first workshop on 'Advanced Disaster Planning' held in 2016 whereby participants made an appeal to the US Embassy to conduct more advance workshops on Post Traumatic Stress Disorder.

- World Bank Mission on Disaster Risk Management and Contingency Financing, December 16-20, 2019

The joint mission on Disaster Risk Management and the Development Policy Operation with Catastrophe Deferred Drawdown Option (Cat DDO) that visited Mauritius, December 2019 consisted of the World Rank and the Agence Francaise de Développement (AFD). The World Bank and AFD expressed their willingness to combine forces in the financial and technical assistance aspects of the Cat DDO, in building on successful experience in the region.

3.5.5 Trends in Donor Support

(1) Overview of Donor Support

According to the data of the International Cooperation Bureau of the Ministry of Foreign Affairs of Japan on Official Development Assistance (ODA) by country for the period 2000-2017, trends in donor assistance to Mauritius show that European Union (EU) institutions, such as the European Commission and the European Investment Bank, are the largest donors among international organizations, while France is the largest donor among major donors. According to the main areas of support by donor as shown in the COUNTRY STRATEGY PAPER (CSP) 2021-2025 of the African Development Bank, AfDP and AFD are also providing support to many areas.

Table 3-218 Top five institutional donors for economic cooperation achievements
(in millions of dollars)

Economic cooperation performance of institutions		Economic cooperation performance of major donors	
EU Institutions	716.4	France	722.7
GEF	20.09	Japan	58.8
GFATM	12.36	The United Kingdom	53.0
UNTA	9.32	Australia	8.0
BADEA	9.13	Germany	6.1

Source: Compiled by the research team from the Official Development Assistance Country Data Collection (2000-2017), International Cooperation Bureau, Ministry of Foreign Affairs of Japan

Table 3-219 Main areas of support by donors

DEVELOPMENT PARTNER / SECTOR/THEMATIC AREA	AfDB	AFD	EU	UNDP	WB
Direct Budget Support	✱	✱	✱	✱	✱
Education, Science, Technology and Research	✱		✱	✱	✱
Health	✱	✱	✱	✱	
Agro-industry		✱	✱		
Transport	✱	✱	✱		✱
ICT		✱			
Energy	✱	✱			
Water and Sanitation	✱				✱
Ports	✱	✱	✱		
Social Integration, Social Security & Empowerment	✱	✱	✱	✱	✱
Environment and Climate Change	✱	✱	✱	✱	
Public Sector Governance and PFM		✱			✱
Private Sector, Industry, Financial Sector and SME	✱	✱			
Regional Integration	✱		✱	✱	

Source: AfDB COUNTRY STRATEGY PAPER (CSP) 2018-2022

(2) Trends in Aid from World Bank (WB)

As a high-income country, Mauritius is one of the few African countries that can receive support from the International Bank for Reconstruction and Development (IBRD). Currently, the World Bank does not have any lending activities in Mauritius, but most of the assistance it provides is through technical assistance and other knowledge-based activities. Recently, it has supported the government's reform of basic education (nine years of schooling), the development of the Economic Development Board’s sector planning capabilities, and the strengthening of banking supervision.

According to the COUNTRY PARTNERSHIP FRAMEWORK (CPF) for 2017-2021, which sets out the WB's aid policy, it supports three priority areas: improving competitiveness, fostering inclusion, and strengthening resilience and sustainability.

Disaster risk reduction is not included in the support policy, although there is a description of its importance. As aid to Mauritius, a high-income country, has been limited, it is likely that aid in the area of disaster risk reduction will also be limited. Support for infrastructure was last provided in 2009 for the transportation, energy, and water resources sectors.

As for the future, analysis shows that the goal of Mauritius to achieve a high-income economy will be difficult to achieve unless certain infrastructure policies are reviewed and resilience is built in terms of location, direction, construction codes, and land management of infrastructure, both public and private. Since sustainability also depends on the ability to mitigate the effects of climate change and to manage water and natural resources, the report states that the role of the public sector needs to be carefully considered and appropriate fiscal and financial instruments need to be secured to deal with potential external shocks, both environmental and economic. Even though it is difficult to secure public budgets due to the aging of the population and the resulting need for medical and pension expenditures, the analysis shows that sufficient financial and public resources to cope with disasters, such as disaster risk financing tools and insurance, need to be reallocated to new priorities such as infrastructure and human capital development. It also states that unplanned and unregulated development in narrow coastal fringes and near-shore areas has led to inter-sectoral interference, poor placement of infrastructure, overlapping use of land marine areas, marginalization of poor communities, loss and degradation of critical habitat, and an increased vulnerability to coastal erosion and extreme weather events. In addition to identifying priority policy actions and investments, the WB will continue to assess how to ensure long-term environmental sustainability and resilience to climate change.

(3) Trends in Aid from the African Development Bank (AfDB)

The COUNTRY STRATEGY PAPER (CSP) 2014-2018, which sets out the AfDB's aid policy, was based on two pillars in particular: infrastructure development and public-private partnerships (PPPs), and skills building and technology development. These were intended to stimulate the country's growth and help it achieve its ambition of becoming a high-income country (PRE), a goal that was achieved during the 2019-2020 CSP renewal period.

Building on the success of the CSP 2014-2018, the CSP 2021-2025 proposes two priority areas for initiatives: strengthening economic resilience, high added-value production, and regional integration; and investing in sustainable infrastructure and protecting the environment. The latter of these initiative areas will help address critical environmental issues, protect unique ecosystems, and help build the capacity of island economies in the areas of disaster preparedness and response.

Although the only disaster assistance in the past has been the rehabilitation of bridges and roads after cyclones, the need for disaster risk reduction is mentioned in the CSP and specific directions for assistance have been recognized. In the Mauritius Country Diagnostic Note, it is specifically stated that the focus will be on the development of climate-resilient transportation systems, renewable energy, climate change-resilient agriculture, integrated waste and water management, and the use of technology and innovation to conserve resources and improve efficiency. An oil spill incident also highlighted the urgent need for an appropriate and robust disaster preparedness and response framework. Although a national disaster preparedness and response framework is in place, it states that there is a need to further develop early warning systems and improve coordination among the extensive network of organizations involved in crisis management and response.

Although there is strong cooperation among authorities, communities, and the private sector in the areas of disaster risk reduction and crisis response, there are gaps in coordination that require enhanced knowledge sharing and capacity building. In addition, to reduce the impact of water-related disasters, authorities and the private sector are being urged to pay special attention to lakes, swamps and peatlands and to increase investment in ecosystem restoration and protection.

(4) Trends in Aid from Other Donors

Since Mauritius has various aspects as an African and Indian Ocean island country and a former French suzerain state, it belongs to many international networks and has received cooperation and support in the field of disaster management and other areas.

UNDP has provided support to strengthen the capacity of the NDRRMC by dispatching experts and reviewing the National Disaster Management Plan. The disaster information system has been upgraded to include a more accurate storm surge early warning system. In addition, the Adaptation Fund has been implementing climate change adaptation projects in the coastal zone, including the construction of shelters, storm surge embankments, and beaches and artificial reefs in three communities.

According to interviews with the local government, in addition to this, an operational study of coastal risks (coastal erosion and marine flooding) in the islands of Mauritius from AFD and the development of disaster management related projects with PIROI, SADC, IORA, UNRC, UOM, NE&CF and others are underway.

3.5.6 Selection of Key Cities

Taking into account the overall situation of disaster risk, climate change, land development and urban development in Mauritius, as well as trends in donor support, this study focuses on the Port Louis metropolitan area as a key urban area, examining the issues of disaster risk reduction and the possibility of support projects at the city level. For inter-city infrastructure, it was decided to focus on areas such as metros. The study will focus primarily on these important cities and inter-city infrastructure, however the examination of potential support projects will not be limited to these areas, but will be adapted as needed based on sectoral conditions, local needs, and issues related to regional disaster risk reduction.

3.5.7 Information Collection and Analysis for Cooperation in the field of Disaster Risk Reduction in each sector

(1) Urban Development and Disaster Risk Reduction

Mauritius is an island about the size of Tokyo (2040 km^2). Because of its small size and its location in the eastern most part of the Southern African region, it is the most cyclone-sensitive country in this study. There are not many landfalls, but being an island nation, the whole surrounding area is affected by storm surge. The capital city, Port Louis, is also located in the northwest of the island and is vulnerable to storm surges.

For storm surge, there is a real-time observation system of MMS (Mauritius Meteorological Service), based on which early warnings are implemented. Cyclone forecasting is handled through wide-area coordination, and tsunami and earthquake observations are also under the jurisdiction of MMS. It is expected that the ongoing technical cooperation project (which is behind schedule due to COVID-19) will help to promote radar operations and utilization of acquired data on a practical level.

As a countermeasure against storm surge, roads and houses have been set back and infrastructural measures such as seawalls have been developed, but there is still a risk of landslides and other sediment disasters due to the hilly terrain behind the area.

Figure 3–285 Setback project for storm surge protection
Left: Status of seawall maintenance, Right: Remaining risk of landslide
Source: JICA Study Team

The most dangerous and damaging disaster in the past 20 years has not been a cyclone but a flash flood in a small basin caused by heavy rains. The Land and Drainage Authority (LDA) is currently preparing a hazard map of the natural water flow of the entire island, which is organized and analyzed in GIS (not disclosed). The main causes of flooding are the country's topography, which tends to cause water to accumulate easily, and insufficient drainage capacity of drainage pipes. With the support of the AFD (French Development Agency), a National Land Drainage Master Plan is being formulated, and detailed hazard maps of 16 model areas and a vulnerability assessment are being prepared. Based on the results of the assessment, countermeasure plans such as drainage pipe improvement projects will be formulated, designed, and implemented. In addition to the Drainage Master Plan, the city plans to promote building regulations and land use systems based on zoning, the details of which are currently under consideration.

Figure 3–286 Disaster situation in Mauritius
Left: Flood situation (photo provided by LDA), Right: Urban situation in landslide risk area
Source: JICA Study Team

In addition, since the plains on the island are limited, the infrastructure is mostly in place and a repair system has been established. However, the concept of prior investment on how to utilize the hazard map and what measures to implement has not yet been established. The government of Mauritius wants to train people to help solve these challenges.

As mentioned above, the priority disaster types are flash floods and landslides caused by cyclones/rainstorms. The main measures currently being implemented include observation systems, early warning systems, coastal area setbacks and seawall maintenance, and the development of natural water drainage hazard maps. Mauritius is currently at the stage of correctly understanding this information and hazard maps, and using them to consider and implement appropriate countermeasures.

However, there are concerns about a shortage of human resources necessary to implement these activities, and there is a need for cooperation in each of these areas regarding capacity building and human resource development in terms of technical and organizational skills. In particular, increasing system building skills and raising the capabilities of local governments, engineers (geotechnical and drainage systems), and communities in regard to disaster risk reduction is an issue that needs to be addressed.

Rodrigues Island, located 400 to 500 km east of the main island of Mauritius, is promoting tourism development. Since Rodrigues Island is an island with various disasters such as cyclones, storm surges, floods, landslides, etc., and is further east of the main island of Mauritius, putting radar on this island will allow information on cyclones to be obtained more quickly. In addition, since it is located in the eastern most part of the Southern African region as a whole, it is a strategic location in terms of radar observation network and early warning. However, the installation of the radar requires electricity, and it is necessary to propose a combination with power generation facilities.

(2) Transportation

1) Overview of Relevant Organizations and Legal systems

Table 3-220 shows the main relevant institutions such as the ministries and agencies that have jurisdiction over the transportation sector in Mauritius, and the organizations that manage or operate each subsector.

Table 3-220 Key Institutions in the Transportation Sector in Mauritius

Subsector	Key Institutions
Road	Ministry of National Infrastructure and Community Development
	Road Development Authority
Railroad	Ministry of Land Transport and Light Rail
	Metrro Express Ltd.
Port	Ministry of Defence, Home Affairs and External Communications
	Mauritius Port Authority
	Cargo Handling Corporation Ltd
Airport	Ministry of Defence, Home Affairs and External Communications
	Department of Civil Aviation
	Airports of Mauritius Co. Ltd
	Airport Terminal Operations Ltd
	Airport of Rodrigues Ltd

Source: JICA Study Team

a) Road

The Ministry of National Infrastructure and Community Development (MNICD) is responsible for the overall development, maintenance and operation of road infrastructure in Mauritius. Within the Ministry, the National Infrastructure Division is in charge of road infrastructure, and the Road Development Authority (RDA) is in charge of administration. In addition to the RDA, there is the Construction Industry Development Board (CIDB), which is related to the construction industry.

According to the Digest of Road Transport and Road Accident Statistics - Year 2019, Statistics Mauritius, 2021, which contains the latest data from Statistics Mauritius, Ministry of Finance, Economic Planning and Development, the total length of roads in 2019 was 2,772 km, with 104 km of motorways, Main Roads (Main Road A and Main Road B) totaling 1,140 km, Secondary Roads of 913 km, and others equaling 615 km (Figure 3–287). Most of these roads are paved with a paving rate of 98%. The road length per unit area (km^2) is 1.48 km, and there are 209 vehicles per kilometer of road. The road length is increasing every year. Three motorway routes (M1, M2, and M3) are in use.

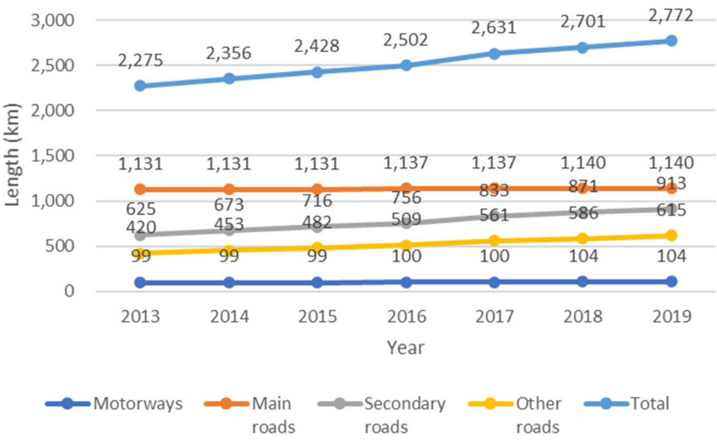


Figure 3–287 Status of road network development in Mauritius

Source: Prepared by JICA Study Team based on information from the Digest of Road Transport and Road Accident Statistics - Year 2019, Statistics Mauritius, 2021.

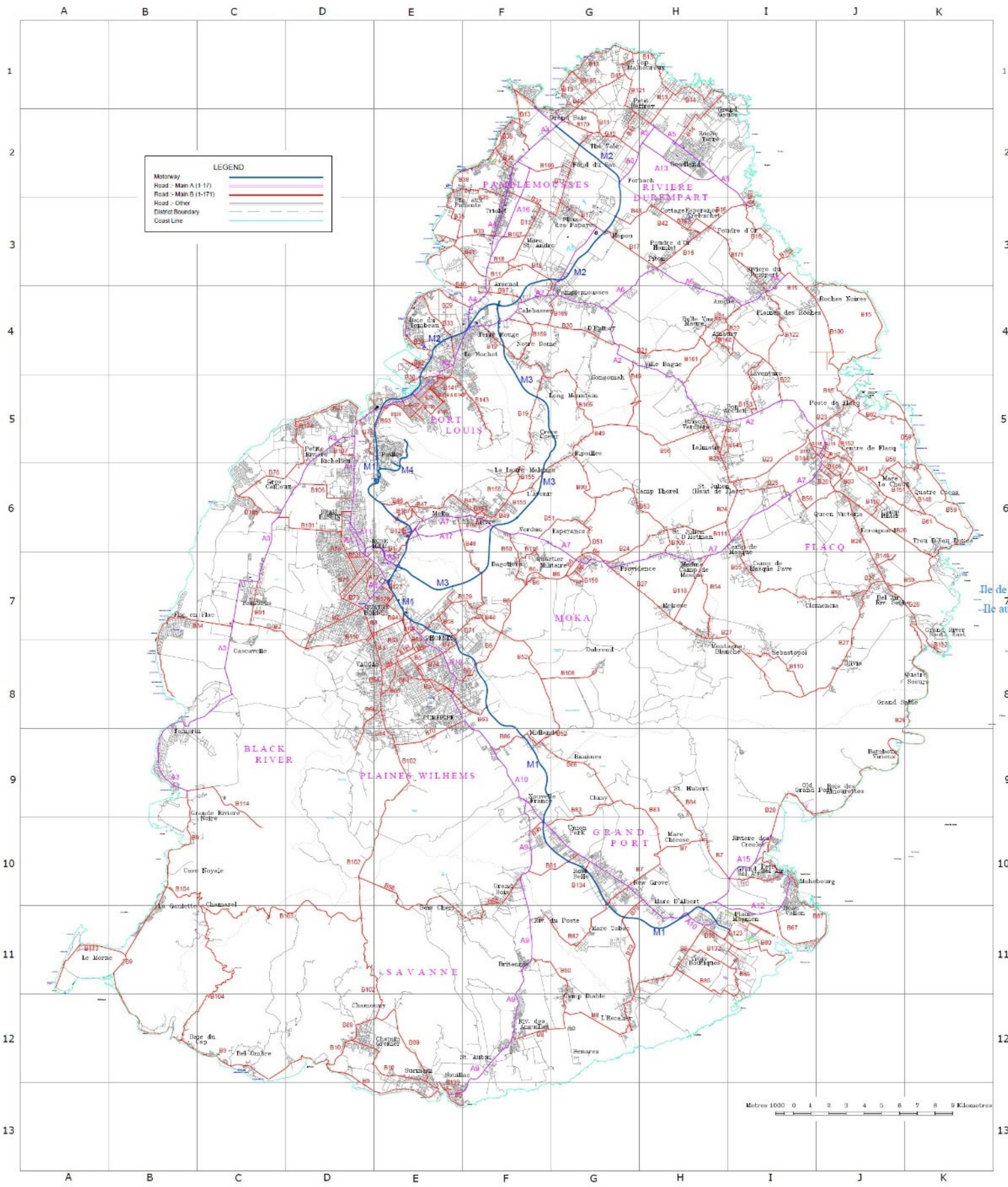


Figure 3–288 Road Network in Mauritius

Source: Road Map of Mauritius, RDA, 2017

b) Railroad

In recent years, an LRT system called Metro Express has been developed and is in operation in Mauritius. It connects Port Louis, the capital of Mauritius, with surrounding cities and began operation in December 2019 with the aim of reducing road congestion and improving the convenience of travel between cities. Currently, there is no rail system in Mauritius other than the Metro Express. The government ministry responsible for Metro Express is the Ministry of Land

Transport and Light Rail (MSTLR). Metro Express Limited (MEL), a state-owned company, is in charge of the maintenance, management, and operation of the trains.

MEL is a Mauritius government-owned company established on October 26, 2016. The company develops, finances, constructs, operates, and maintains the Metro Express infrastructure. The Metro Express project was launched as part of various projects funded by a grant worth US$353 million presented by the Government of India in 2017. Phase 1, Rose Hill Central to Port Louis Victoria Station, opened on December 22, 2019, and Phase 2 is currently underway. With the opening of Phase 2, the entire 25.95 km stretch of the planned Metro Express will be completed, reducing travel time from Curepipe Central to Port Louis, relieving road congestion, and creating new jobs.

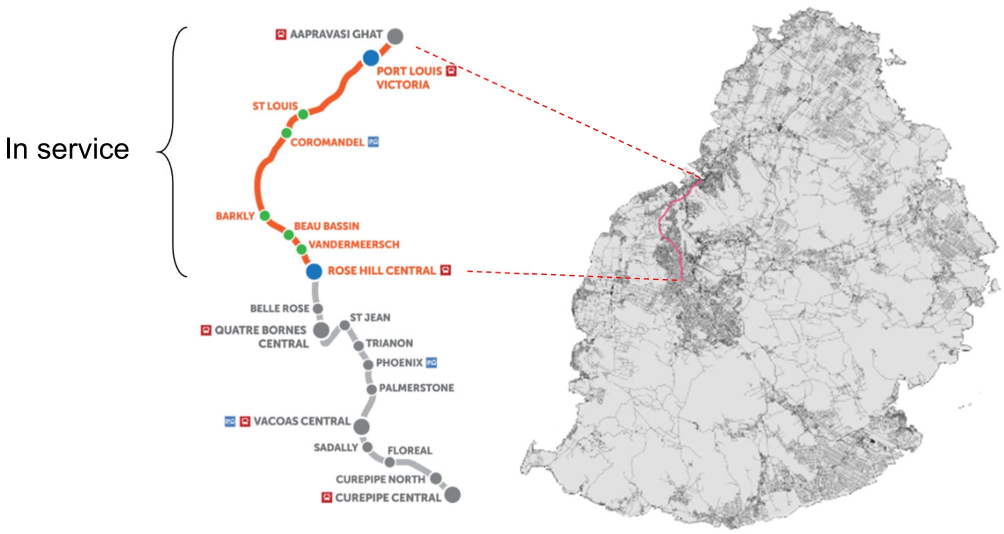


Figure 3–289 Map of Metro Express routes and locations in Mauritius

Source: MEL website (https://mauritiusmetroexpress.mu/my-experience/?lang=en#facilites)

JICA Study Team

c) Port

The ministry in charge of ports in Mauritius is the Ministry of Defense, Home Affairs and External Communications (MDHAEC). The Prime Minister serves concurrently as Minister of Defense, Home Affairs, and External Communications. Within MDHAEC, ports and airports in particular are under the jurisdiction of the External Communications Division, while the Mauritius Port Authority (MPA) is specifically responsible for port and maritime affairs. The MPA is a government agency established under the Ports Act 1988 to manage the nation's ports and is responsible for the supervision and management of the ports on the islands of Mauritius and Rodrigues. It also develops and manages port infrastructure and related facilities, provides maritime services, aids navigation, and coordinates and regulates all activities in ports. All container handling at Port Louis is carried out by Cargo Handling Corporation Ltd (CHCL), a state-owned private company. In addition to containers, CHCL also handles general cargo and bulk cargo that does not use pipelines.

Port Louis Harbour, the main gateway to Mauritius, handles 99% of the country's international cargo and is a very important part of transportation infrastructure for the country. Over the past few decades, Port Louis Harbour has been transformed into the country's economic center through modernization of its facilities, designation as a free port, and intensive investment in port facilities, including dedicated cruise ship facilities. Table 3-221 shows the MPA's performance in 2018, and the trends in container and cargo volumes since 1974 are shown in Figure 3–290 .

Table 3-221 MPA Transportation Performance in 2020

Type	Total Traffic in 2020
Cargo Traffic (tonnes)	7,421,764
Dry Bulk	1,678,469
Liquid Bulk	2,023,574
Containerized	3,579,898
General Cargo (excl. Fish)	34,186
Fish	105,636
Container Traffic (TEUs)	438,078
Vessel Traffic	2,776
Containerized vessels	465
Dry Bulk Carriers	49
Tankers (Liquid Bulk Carriers)	98
General Cargo Vessels	24
Fishing Vessels	765
Cruise Vessels	20
Others	1,355

Source: Port Trade Statistics (CY 2020), MPA.

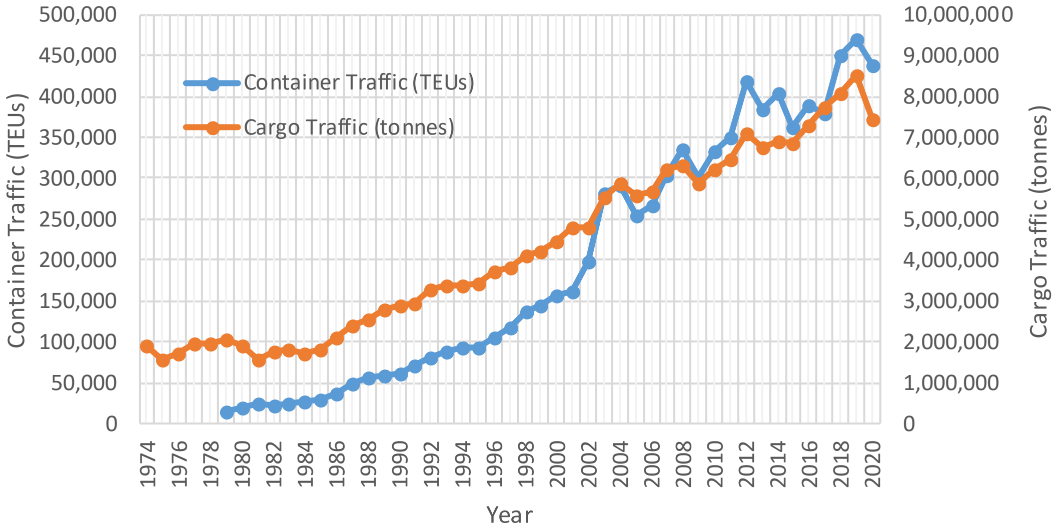


Figure 3–290 Trends in container and cargo handling in Mauritius
Source: Prepared by JICA Study Team based on information in Port Trade Statistics (CY 2020), MPA.

d) Airport

The ministry in charge of airports in Mauritius is the Ministry of Defense, Home Affairs and External Communications (MDHAEC). The Prime Minister serves concurrently as Minister of Defense, Home Affairs, and External Communications. Within MDHAEC, ports and airports are under the jurisdiction of the External Communications Division, while the Department of Civil Aviation (DCA) is in charge of general civil aviation practices. DCA is responsible for the administration, regulation and services of all civil aviation related matters, including air traffic control. Airports of Mauritius Co Ltd (AML), a private company, is in charge of the maintenance and operation of Sir Seewoosagur Ramgoolam International Airport (SSR Airport), located on the main island of Mauritius. AML was established in May 1998 and became operational in April 1999, with the government of Mauritius as its major shareholder. AML is the owner and operator of SSR Airport. In addition, the passenger terminal at SSR Airport is operated and managed by Airport Terminal Operations Ltd. Rodrigues Island is home to Sir Gaëtan Duval Airport, which is operated by the Airport of Rodrigues Ltd.

According to the AML website[94], SSR airport has one runway (3,040 m in length and 75 m wide) and one emergency runway (2,279 in length and 60 m wide). There are eight boarding bridges on the tarmac and one gate that can accommodate the A380, which is currently the largest passenger aircraft.

[94] https://aml.mru.aero/index.php/ssr-international/facts-figures

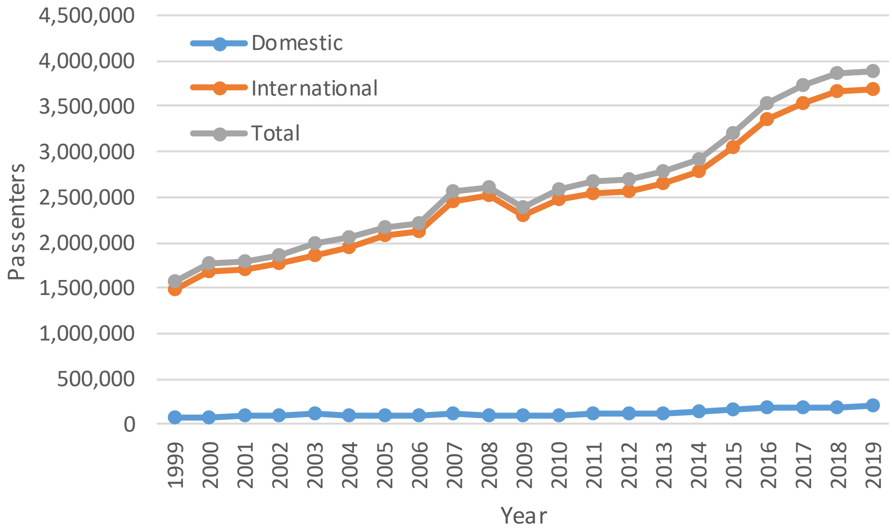


Figure 3–291 Annual Passengers of Sir Seewoosagur Ramgoolam International Airport

Source: Prepared by JICA Study Team based on information from the AML website (https://aml.mru.aero/index.php/ssr-international/facts-figures)

SSR Airport has been awarded several times as the "Best Airport – Africa Region" for airport service quality in the 2-5 million passenger category by Airports Council International (ACI) and has also received awards from various organizations including travel organizations. As mentioned above, SSR Airport is capable for accommodating large-size aircrafts and highly evaluated in terms of service quality, and it is considered that the airport is being maintained and operated at a high level even in the environment with natural disasters including cyclones.

2) Overview of Related Plans and Development Status

The major projects listed on the Mauritius government website are shown in Table 3-222. In addition, the website[95] of the Mauritius Road Development Corporation provides information on ongoing road and bridge construction and rehabilitation projects.

[95] http://rda.govmu.org/English/News/Pages/default.aspx?NewsD=On+Going+Projects

Table 3-222 Major projects under implementation in Mauritius

Subsector	Major Project
Road	A1 – A3 Link Road
	A1 – M1 Link Road
	Construction of Grade Separated Junctions at PontFer JumboDowlut Roundabounts
	Reconstruction of Ste Marie Bridge on B9 Road at Baie Jacotet
	Reconstruction of Albion Bridge
	Construction of third lane along Motorway M2 between Roche Bois Roundabout and Jin Fei Roundabout
Railway	Extension of Metro Express

Source: Government of Mauritius website[96], as of October 2021.

a) Road

According to the information in the Government of Mauritius "e-Procurement System" (IFB Reference No: RDA/IFB/2020/66), the tender for a new motorway construction was held in October 2020. It is for Phase 1 (13 km section from Bel Air to Pont Blanc) of the construction of Motorway M4 between SSR Airport and Forbach, which will be constructed as a single carriageway with a lane width of 3.5 m and a shoulder width of 1.5 m. No information is available on the number of lanes.

The RDA's website[97] has information on bridge rehabilitation projects, road improvement projects, landslide and other sediment disaster countermeasures, slope protection works, new road and bridge construction, and other ongoing works. Information on active investment in road infrastructure and sediment disaster countermeasures is also available on the website.

b) Railroad

Other than Phase 2 of Metro Express by MEL, no other rail-related plans are known at this time.

c) Port

In May 2017, the MPA developed the Port Louis Master Plan. This is an updated version of the Master Plan developed in 2009, which covers the period up to 2040. The plan estimates that the volume of cargo handled in 2040 will be 20.9 Mtpa, about 2.7 times the 2015 volume of 7.9 Mtpa.

[96] https://govmu.org/EN/infoservices/transport/Pages/projects.aspx
[97] http://rda.govmu.org/English/News/Pages/default.aspx?NewsD=On+Going+Projects

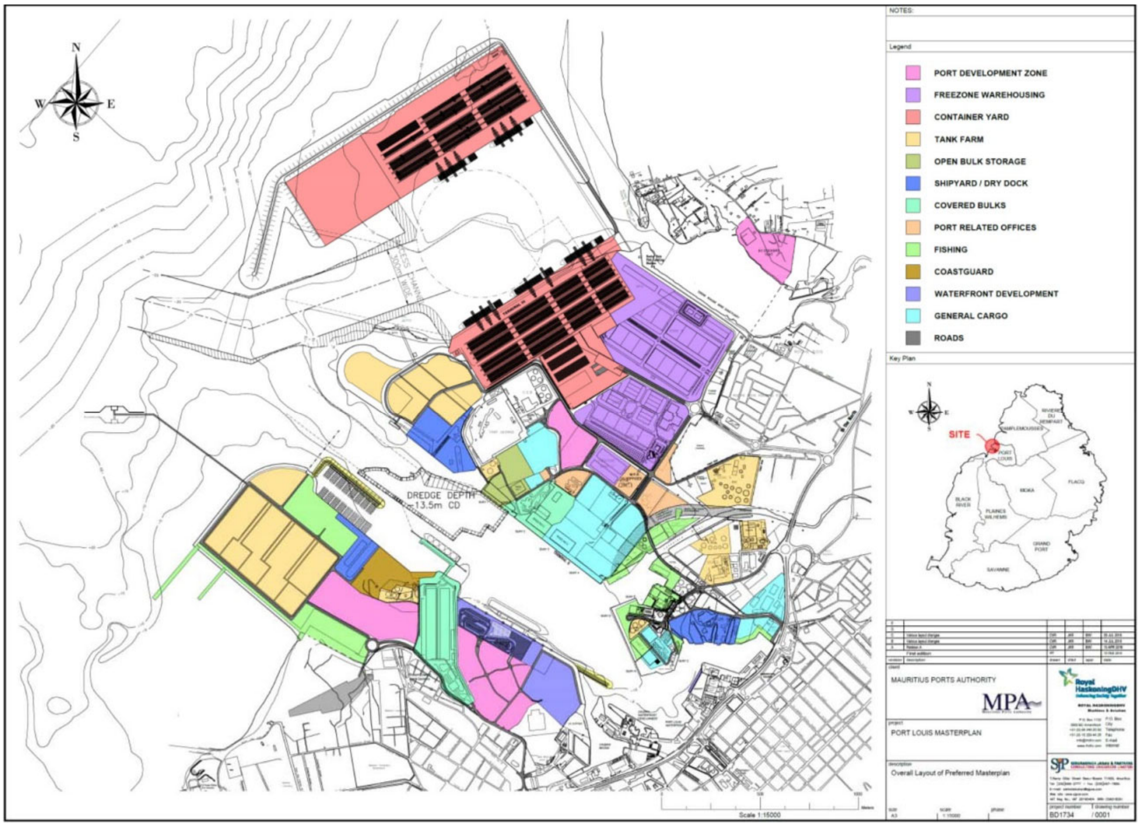


Figure 3–292 Future Plans in the Port Louis Master Plan

Source: Port Louis Masterplan Executive Summary, MPA, May 2017.

d) Airport

The AML website[98] indicates that an Airport City project is being developed in accordance with the Airport Master Plan for SSR Airport, which was formulated in 2019. A new control tower 70 meters high is also under construction.

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Mauritius is located in the path of many cyclones that have occurred in the past. Both Mauritius and Rodrigues Islands are at high risk of cyclone hazards, and there is a high risk of storm surge damage in many coastal areas of the main island of Mauritius (Figure 3–293). Also, due to the topographical and geological conditions, sediment disaster such as landslide, slope failure, etc.

[98] https://aml.mru.aero/index.php?option=com_content&view=article&id=121:feasibility-study-for-the-second-runway& amp;catid=19:expired-tender-notices&Itemid=133

are one of the most serious natural disasters in Mauritius (Figure 3–294).

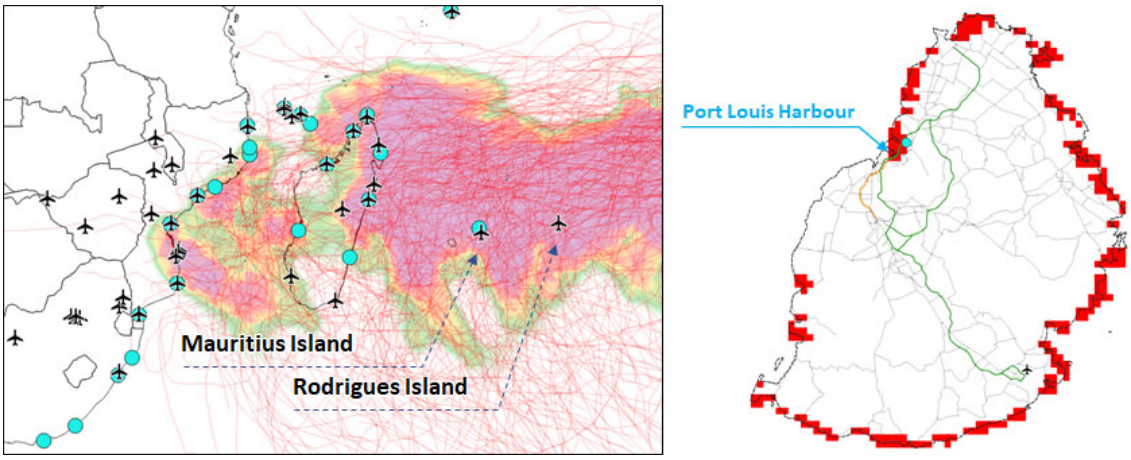


Figure 3–293 Risk of Cyclone (Left) and Storm Surge (Right) in Mauritius
Source: JICA Study Team

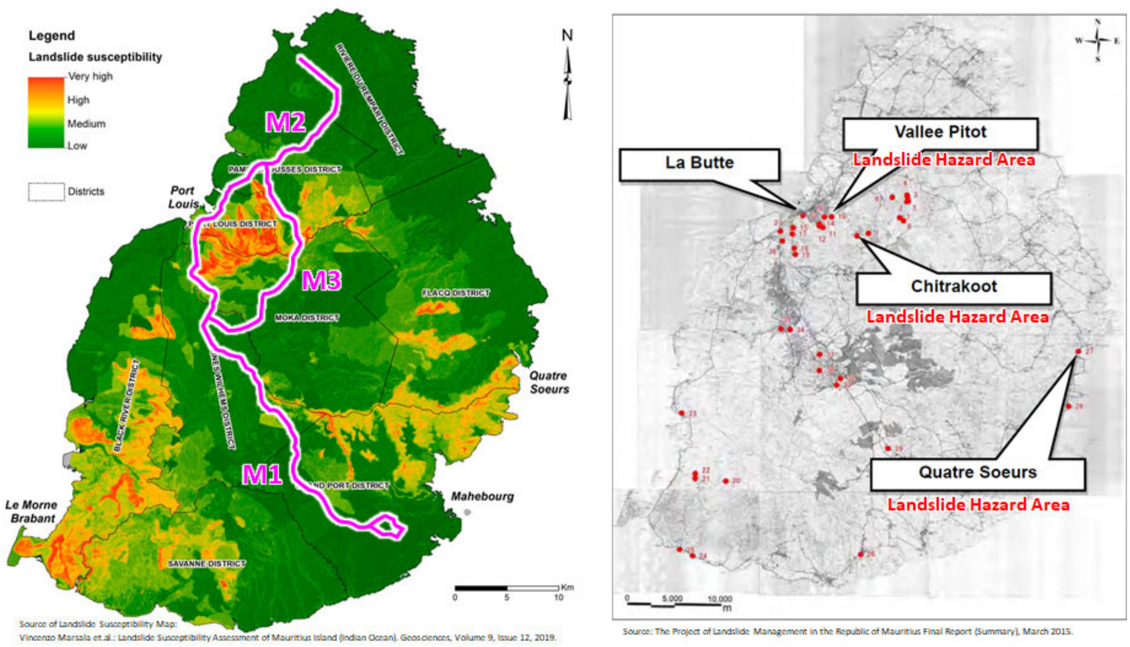


Figure 3–294 Landslide Risk in Mauritius
Source: Compiled by the JICA Study Team, based on information from the sources specified in the respective figures.

Figure 3–294 shows the landslide risk on the Mauritius Island. There are three major areas of high landslide risk. The first is the mountainous area centered around the Le Pouce Mountain Peak, which is located south of the capital city of Port Louis and surrounds Port Louis along with the ocean. The others are the Black River Gorges National Park and its surrounding mountainous area in the southwest of Mauritius and the mountainous area near the coast in the southeast. These three areas are all mountainous and have steep slopes.

Table 3-223summarizes the critical transportation infrastructures on the Mauritius Island and the type of disaster that can affect those infrastructures. Three Motorways (M1, M2, and M3) and Metro Express traverse adjacent area of Le Pouce Mountain Peak, where the landslide risk is high as mentioned above. Port Louis Harbour has a risk of damages caused by cyclones and storm surges. SSR Airport is affected by strong winds, heavy rains, and cyclones that involves strong winds and heavy rains.

Table 3-223 Critical traffic and transportation infrastructure for disaster management in Mauritius

Subsector	**Critical infrastructure for disaster risk reduction**	**High-risk disaster**
Road	Motorways M1, M2, M3	Sediment disaster
Railroad	Metro Express	Sediment disaster
Port	Port Louis Harbour	Cyclone, storm surge
Airport	SSR Airport	Cyclone

Source: JICA Study Team

4) Consideration of Disaster Risk Reduction Measures

Although damage to roads and bridges due to natural disasters does occur, no serious damage has been identified for the critical transportation infrastructure shown in Table 3-223. Road closure caused by rockfall, slope failure, etc. happens at road sections in risky areas of sediment disasters including landslide, but three Motorways and Metro Express avoid those risky areas and are strengthened with slope protection. Road sections damaged by those disasters are restored and strengthened with countermeasures by the Government of Mauritius. Although flights to/from SSR Airport are cancelled due to adverse weather condition, serious damage on aviation and airport facilities has not been reported. Influence of storm surge is usually considered for port planning and design. Details about Port Louis Harbour are unknown, but no serious damage on facilities of the port has been reported.

Figure 3–295 Road Recovery Works and Slop Protection in Mauritius
Source: JICA Study Team

Because sediment disasters including landslide are caused by natural conditions such as topographical and geological conditions, it is important to implement not only tangible measures but also intangible measures. The Government of Mauritius is implementing resettlement for the residents in the landslide-risky areas, and JICA has implemented cooperative projects in Mauritius for intangible measures against landslide, such as technology transfer about warning systems, monitoring systems, etc. (Technical Cooperation Project: Landslide Adviser for Mauritius Final Report, JICA, February 2018)

(3) Power

1) Overview of Relevant Organizations and Legal systems

The power sources include heavy oil-fired, light oil-fired, hydro, bagasse/coal-fired, PV, wind, and landfill gas. The ratio of power generation is 40% coal, less than 40% heavy oil, and 14% bagasse. Hydropower is the largest contributor of renewable energy sources, and the capacity of PV and wind power has already exceeded 100MW. Peak demand is 507 MW. Overall, a loop system has been realized. Transmission and distribution losses are 2% and 4% respectively, which is comparable to developed countries.

CEB (Central Electricity Board), EEMO (Energy Efficiency), and MARENA (Renewable Energy) exist under MEPU (Ministry of Energy) as regulators, and there is a separate regulatory body for UTL in general called URA.

The share of renewable energy generation in 18-19 was 18% (CEB annual report 2018-19).

IPP installations have increased since 2015, with more than 90 MW interconnected, and small power producers have also increased their interconnection, with 15 MW added so far. In addition, as part of its policy to increase the adoption of renewable energy, the CEB has started installing grid-scale battery energy storage systems (BESS) and has installed 18 MW of energy storage systems in substations.

2) Overview of Related Plans and Development Status

Diesel Engine Generator, wind power, and PV are under construction (2017-20COD). In addition, a GTCC (gas turbine combined cycle) using LNG and a new PV plant are planned. The current policy is to increase the share of electricity generation to 35% RE by 2013. In addition, storage batteries have already been installed in existing thermal power plants for grid regulation. From overseas donors, UNDP/GCF and others are promoting grid improvement for large-scale introduction of renewable energy sources.

The use of fossil fuels is important for stable power supply in Mauritius, but there is also a move to expand the use of LNG to reduce CO2 emissions (CEB annual report 2018-19). In Fort George Power Plant, 120-140 MW of GTCC is planned to be installed, with an initial 40 MW of GTSC (gas turbine simple cycle) to be driven by diesel and converted to combined cycle when LNG becomes available. This project was under evaluation for bidding in 2019. As the demand for electricity in Mauritius continues to grow, the grid is being strengthened along with the introduction of renewable energy sources: a new 66 kV line and six new substations were built in 2018-19, and the 22 kV grid was upgraded.

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

It can be seen that storm surge damage tends to occur in coastal areas and that the Fort George and Nicolay power plants and the Dumas substation are at high risk.

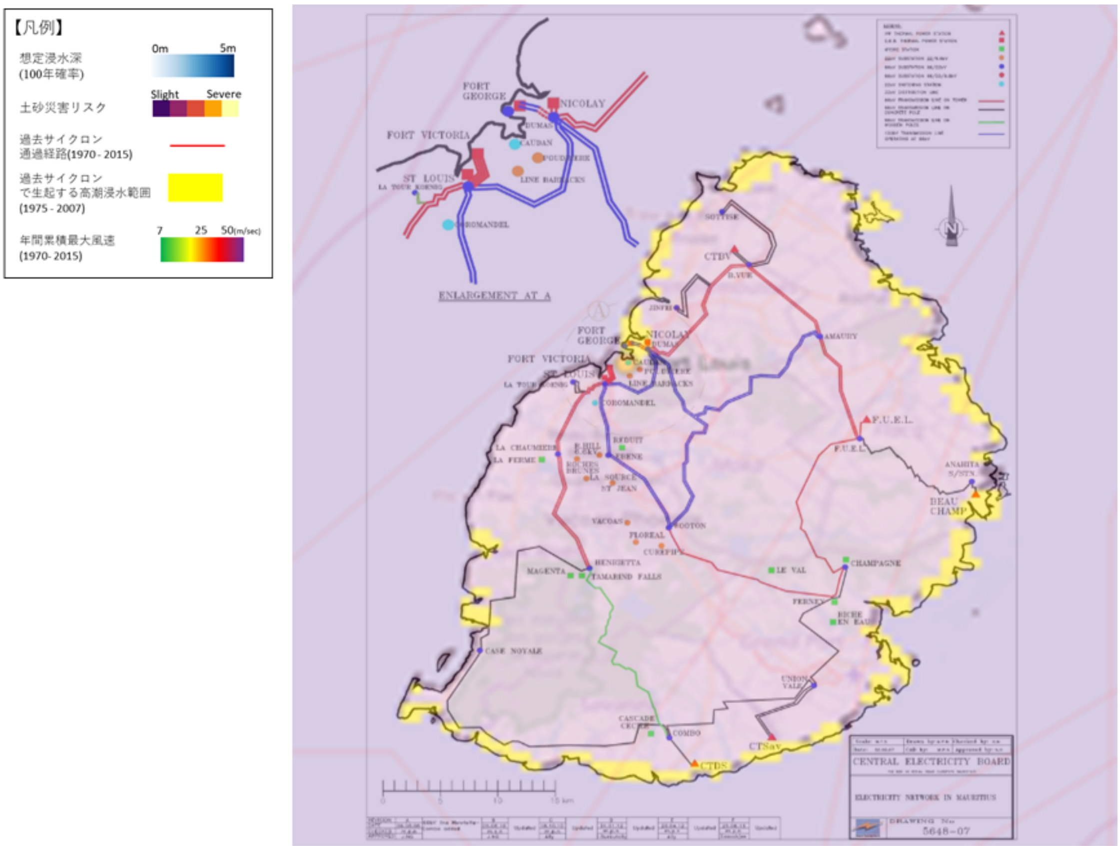


Figure 3–296 Mauritius Power Facilities Map and Hazard Map

Source: Prepared by the study team based on The challenge of integrating Variable Renewable Energy sources on the national grid in Mauritius(2020).

4） Consideration of Disaster Risk Reduction Measures

In Mauritius, cyclones can cause disturbances and damage to the electricity transmission and distribution network, resulting in large scale power outages of thousands of households or more, for example, Cyclone Berguitta in 2018 caused 6,800 power outages on the main island. Rodrigues Island also experienced power outages during two cyclones in 2018-19, with the CEB and SMF (Security Forces) working together to restore power. The power outages were restored within a few hours to a few days respectively. Since the CEB is expected to be affected by major natural disasters several times a year, the CEB has mobilized engineering cadets to help with the recovery from the cyclone (CEB Annual Report 18-19). Some resort hotels are equipped with their own emergency generators.

In the first part of the report, it is explained that the key points for disaster risk analysis and disaster management in Mauritius are the main island, where important political and economic institutions are concentrated, and the remote islands, where vulnerability is more apparent, as the country has achieved some economic development. In the same way, focusing on remote islands in the power sector will lead to better disaster reduction measures in terms of support from Japan.

The concept of disaster reduction measures in the power sector is to enhance the resilience of critical facilities and areas to disasters in order to maintain and sustain public services and industrial activities. For example, in the public sector, it is possible to create and operate facilities that can continue to supply energy to water treatment facilities, hospitals, and communication facilities in the event of a disaster.

Also, as mentioned above, the current power development plan is to supply electricity at the lowest possible cost, to effectively balance the supply and demand of electricity, and to increase sustainability, which is a fundamental part of national policy. However, there is a high dependence on thermal power as a source of power, with coal and heavy oil accounting for 70-80% of power generation on the main island, and hydropower resources have been fully exploited. Solar power is a particularly promising power source, but its output tends to fluctuate, limiting the amount of power that can be introduced to remote islands where the grid scale is small.

Therefore, it is proposed that Rodrigues Island, which is a remote island and susceptible to cyclones, be equipped with a hybrid power generation system consisting of photovoltaic power generation, storage batteries, and engine generators as private power, including renewable energy. The installation will be in the important public sector or major industrial sector. Improving the stability of power supply is important for improving the functioning of government and industry, and for maintaining the functioning of the system in the event of a disaster.

Rodriguez Island is also characterized by a small grid size, which makes it difficult to introduce variable renewable energy sources such as solar power. This proposal will also lead to the realization of stable power supply while introducing renewable energy regardless of grid constraints. The contents of the study are as follows, and if necessary, capacity building can be included in the implementation phase.

- Survey of needs and grid constraints on the remote Rodriguez Island
- Technical and economic studies in cooperation with Japanese heavy industry manufacturers

(4) Water and Sanitation

1) Overview of Relevant Organizations and Legal systems

The agencies involved in the water and sanitation sector in Mauritius are as follows.

Table 3-224 Water and sanitation relative institutions in Mauritius

Institutions	Summary
Ministry of Energy and Public Utilities (MEPU)	Ministry in charge of water resources management
Water Resource Unit (WRU)	Main implementation authority responsible for analysis, management, development and maintenance of water resources
Central Water Authority (CWA)	Responsible for management of water supply infrastructure
Irrigation Authority (IA), under Ministry of Agro-Industry and Food Security	Responsible for state-sponsored irrigation schemes
Wastewater Management Authority (WMA)	Responsible for sewerage system

Source: JICA Study Team

The laws relating to the water and sanitation sector in Mauritius are as follows.

- Central Water Authority Act (1971)
- Environment Protection Act (2002)
- Ground Water Act (1970)
- Irrigation Authority Act (1978)
- Planning and Development Act (2004)
- Public Health Act (1925)
- Rivers and Canals Act (1863)
- Waste Water Management Authority Act (2000)
- The Local Government Act (2011)
- Forest and Reserves Act (1983)
- Fisheries and Marine Resource Act (2007)
- National Disaster Risk Reduction and Management Act (2016)

2) Overview of Related Plans and Development Status

According to UN Water's summary, the percentage of the population with access to basic water in Mauritius will have reached 100% by 2020. The proportion of the population with access to basic sanitation facilities is 99% by 2020.

In Mauritius, the challenge has always been to meet the increasing demand for water. Climate change is also a concern, as is the change in wet and dry seasons, making it important to manage water resources and improve water storage capacity.

The Government of Mauritius has developed the following national plans for water and sanitation.

- National Integrated Water Resource Management (IWRM) Plan (UNOPS and UNEP)

The IWRM identifies targets under eight priority areas, with five-year activities and responsible organisations for each target.

IWRM also mentions water security against disasters and lists storm surges, cyclones and droughts as target disasters. The IWRM states that although there is sufficient capacity to respond to disasters, capacity building and awareness raising activities will be carried out at the community level.

In 2011, JICA carried out a technical assistance to support the smooth implementation of a yen loan project to develop sewage treatment facilities in the Grand Baie area.

3) Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

On 10 November 2021, a meeting was held with one Director and two technical officers of WMA.

WMA is implementing the sewerage project with the support of JICA, but due to the impact of COVID-19, some trainings could not be carried out, and they expressed their expectation for continuous support to strengthen the operation and management capacity. The current management situation is fragile, with no GIS or other management data and inadequate drawings. They desired to have an equipment system that can monitor and diagnose the condition of the sewerage system. They would also expect to be able to simulate the impact of heavy rainfall.

As a disaster issue, there is a problem of rainwater flowing into sewerage pipes during heavy rains, causing sewage and rainwater to overflow. Because the infrastructure is aging, there is also an issue of updating and introducing new technology. In addition, there are concerns about the impact of environmental pollution caused by sewage outflows, both in terms of protecting the natural environment and preserving tourism resources. A master plan exists, but there is no mention of DRR.

4） Consideration of Disaster Risk Reduction Measures

As pointed out in the river sector, improved drainage is an issue to prevent urban flooding during heavy rainfall. In addition to soft measures such as defining roles of sewerage system in the drainage master plan, which is reportedly under development, and indicating the maintenance policy, implementation of improvement of drainage capacity could be considered as a support approach from the sewerage sector, such as extending the sewerage service areas, enhancing drainage pump facilities and updating old facilities. These sewerage improvements also contribute to improved sewage discharge.

It is necessary to consider the support policy while monitoring the results of the yen loans and technical assistance for sewerage facilities under implementation and the status of the drainage master plan development.

(5) Telecommunication

1） Overview of Relevant Organizations and Legal systems

The Ministry of Information Technology, Communication and Innovation (ICT) in Enene is the Ministry responsible for the telecommunications sector in Mauritius, and the Information and Communication Technologies Authority (ICTA) in Port Louis is the telecommunications regulator.

The main law on which ICTA bases its regulation of the telecommunications sector is the Information and Communication Technologies Act of 2001 (Information and Communication Technologies Act), which was enacted in 2001. In addition, ICTA issued The Telecommunication Directive 2 of2017 in December 2017. This new directive amends the treatment provided for by article 3.12 of the Telecommunication Directive 1 of 2014. Specifically, it requires importers and manufacturers to meet the requirements of the label and conform to the standards in Mauritius. In January 2018, the regulations were revised to address the requirements for licensed handlers in Mauritius with respect to type approval. Products that are newly exempted from type approval (e.g. Wi-Fi) are subject to market surveillance and local resellers need to keep a record of the compliance file (ETSI standard).

2） Overview of Related Plans and Development Status

In Mauritius, with its thriving tourism industry and high per capita income, broadband Internet access rates are high. As of 2020, the percentage of the population with access to the Internet has reached about 65%.

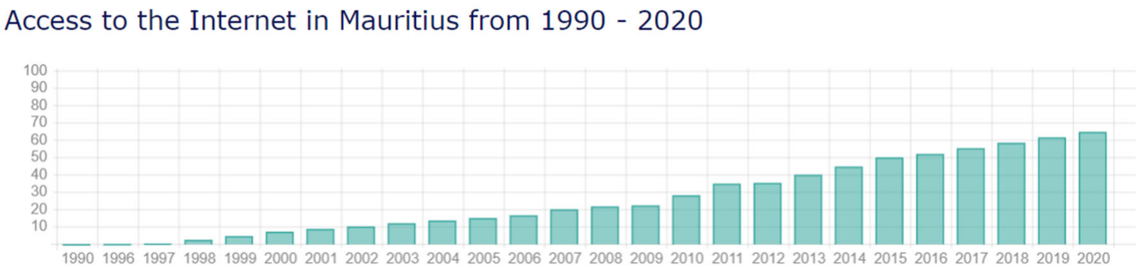


Figure 3–297 Percentage of population with Internet access (1990-2019)

Source: WorldData.info

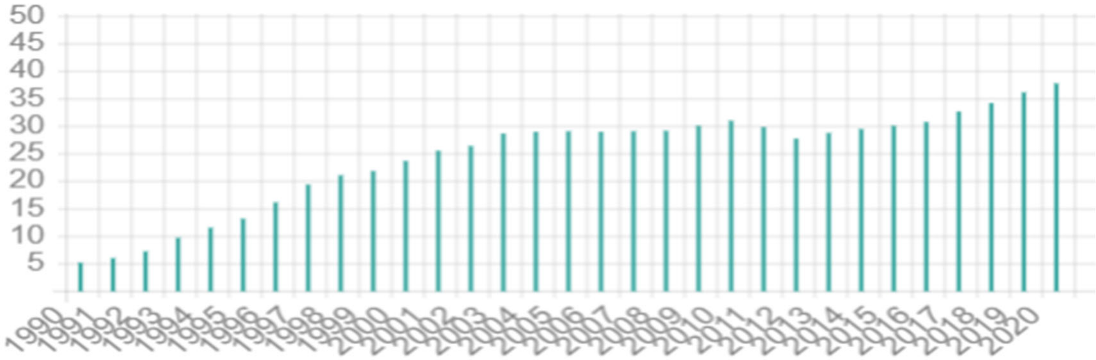


Figure 3–298　Fixed-line subscriber population ratio

Source: WorldData.info

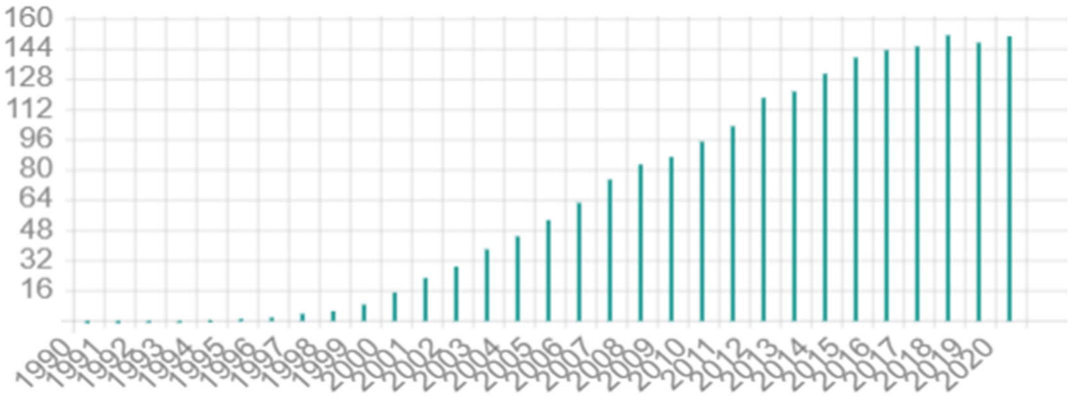


Figure 3–299　Mobile subscriber population ratio

Source: WorldData.info

Table 3-225　Key Indicators for the Telecommunications Sector (ITU estimates, 2017)

Indicator	Mauritius	Africa average	World average
Fixed-telephone sub. per 100 inhab.	32.7	0.9	13.0
Mobile-cellular sub. per 100 inhab.	145.4	74.4	103.6
Active mobile-broadband sub. per 100 inhab.	59.0	24.8	61.9
3G coverage (% of population)	96.0	62.7	87.9
LTE/WiMAX coverage (% of population)	93.0	28.4	76.3
Individuals using the Internet (%)	55.6	22.1	48.6
Households with a computer (%)	61.0	8.9	47.1
households with a computer (%)	68.7	19.4	54.7
International bandwidth per Internet user (kbit/s)	137.0	11.2	76.6
Fixed-broadband sub. per 100 inhab.	19.4	0.6	13.6

Source: ITU

Table 3-226 Number of Telecommunication Line Users and Percentage of Population in Mauritius (2020)

	Total number (subscribers)	Population ratio (%)
Internet user	821,274	64.9
Broadband users	322,100	25.5
fixed-line subscriber	478,700	37.8
Mobile subscribers	1,900,000	151.1

Source: WorldData.info

Due to the small size of Mauritius and its high population density, cell phones are available in almost all areas. There are three mobile operators in Mauritius: EMTEL, CELLPLUS, and MTML.

- EMTEL was a joint venture between Luxembourg-based mobile group MILLICOM and local firm Currimjee Jeewanjee and Co, but the latter bought out the former's stake in 2014. EMTEL launched its first 3G network in Africa in 2004, followed by HSDPA in 2007 and LTE in 2012.
- CELLPLUS is the mobile division of the existing Mauritius Telecom (MT), which entered the market in 1996.
- MTML is a subsidiary of Mahanagar Telephone Nigam Limited, a state-owned telephone company based in Mumbai and New Delhi, India. Initially, the service was launched using the CDMA system, and in 2011, the GSM network was introduced.
- In Mauritius, two fixed-line operators, Telecom (MT) and EMTEL, are operating.
- Mauritius Telecom (MT) was state-owned, but was privatized in 2000 and 40% stock was sold to France Telecom (Orange) at that time. MT is not only a major provider of fixed-line telephone services, but also offers bundled services with TV and Internet in addition to regular wireline services, and in the fixed broadband market, offers ADSL and fiber-optic packages of up to 200Mbps. MT has an extensive backbone network in Mauritius.
- EMTEL provides fixed-line telephone service and fixed-line broadband service up to 140 Mbps.

Mauritius was the first African country to be connected to a optic fiber cable “SAFE” in 2002, and was connected to LION (Lower Indian Ocean Network) which connects Mauritius to Reunion and Madagascar in 2009. In 2010, Mauritius government introduced an open access policy for landing stations to ensure that all telecommunication operators can access equally.

The IXP in Mauritius was launched in 2015 and has 12 members, including major telecom operators and ISPs operating in Mauritius.

- The National Broad band Policy, released in 2012, outlines the national vision for high-speed Internet access by 2020. Its primary objective is to promote affordable and universal access to broadband infrastructure and services, creating opportunities for the country's growth as a knowledge-based society. The following five policy goals are set forth in the report.
- Maximizing consumer welfare and efficient allocation of innovation and investment
- Promote competition through fair assignment of frequency, communication facilities (e.g., poles), and rights of road usage.
- Reform of the current universal service
- Support efforts to promote the adoption and use of broadband
- Promote updating of laws, policies, standards, and incentives
-

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

MT, the largest telecom operator in Mauritius, has set up a data center in Rose Belle under its Tier IV Phase 1 project. This is a 3MW facility that can accommodate up to 336 server racks on a 2,000m^2 site. This facility is the hub center and the most important facility of the telecommunication and ICT sector in Mauritius. This area does not seem to have any particular risk of landslides, according to the "Mauritius Electricity Facility Map and Hazard Map" shown in (3) power sector above. However, since this study was only a desk study and no field survey or interviews were conducted, confirmation is needed before any conclusions can be drawn.

Figure 3–300　MT's data center established in Rosebell

Source: Mauritius Telecom (MT)

4） Consideration of Disaster Risk Reduction Measures

The Landslide Preparedness Unit of the Ministry of Public Infrastructure and Land Transport of Mauritius, "Support for Slope Disaster Preparedness in Mauritius" (completed in 2015), shows that the country needs to strengthen its capacity to respond to slope disasters (landslides, slope failures, rock falls, mudslides, etc.). On the other hand, the ICTA Annul Report (2019) shows that 5G network development is a national policy in Mauritius. Considering the above situation, it is possible to provide more accurate and effective evacuation information in the event of a disaster by installing IoT sensors (IP cameras and, if necessary, water level gauges) at locations where landslides are likely to occur, transmitting the data in real time via 5G networks, and introducing digital platforms such as Smart City OS to cross-check the landslide data observed by IoT with human flow data from mobile network operators. In this way, it will be possible to provide more accurate and effective evacuation information in case of disaster.

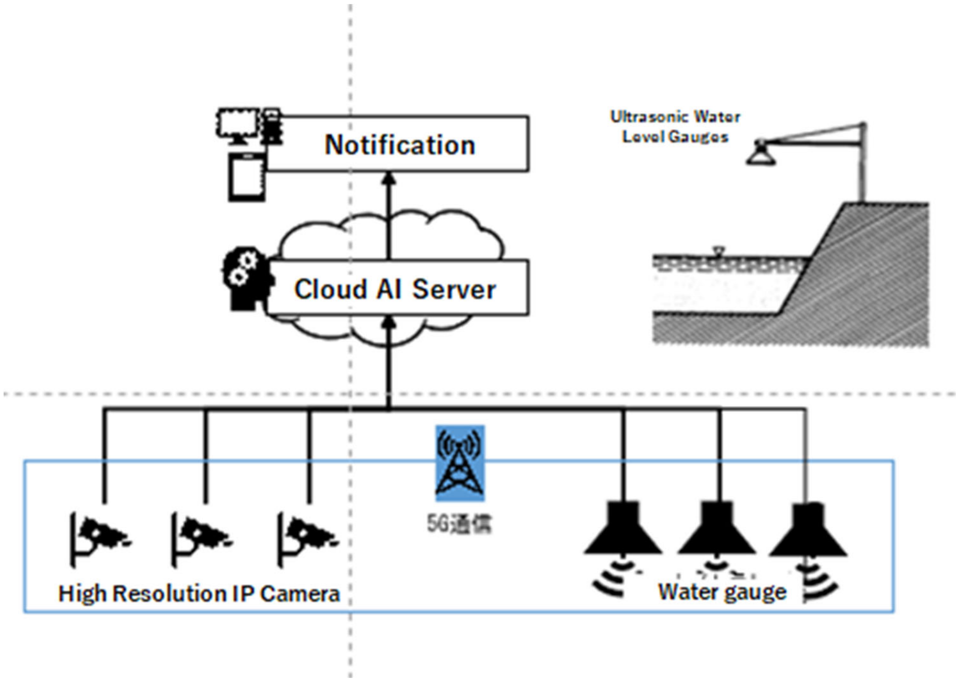


Figure 3–301 Example of a disaster monitoring network configuration with IoT devices connected to a 5G network

Source: JICA Study Team

(6) River Management and Coastal Management

1) Overview of Relevant Organizations and Legal Systems

The Land Drainage Authority (LDA) can be considered as the agency responsible for river management in Mauritius. In addition to creating hazard maps, the Land Drainage Authority (LDA) is identifying areas vulnerable to flooding due to microtopography and formulating a master plan related to drainage (Urban Drainage Masterplan).

2) Overview of Related Plans and Development Status

As a plan for river management in Mauritius, the National Integrated Water Resources Management (IWRM) Plan 2018 has been developed with the support of the United Nations Environment Programme (UNEP) and others.

IWRM predicts that, because of climate change, Mauritius will face more frequent torrential rainfall disasters, longer periods without rainfall, and lower annual rainfall in the future. Therefore, the plan focuses on efforts to improve the storage capacity for securing water resources in Mauritius.

As for national policy on coastal management, the National Development Strategy and the National Environmental Policy also set national objectives for integrated coastal management.

The legal system provides for (1) definition of coastal areas, (2) land ownership in coastal areas, (3) classification of coastal areas, (4) setback rules in coastal areas, (5) regulation of structures behind coastal areas, and (6) waiver of environmental impact assessment procedures.

In addition, as an organization for coastal management, the organization for comprehensive coastal management consists of 25 ministries and agencies, and the responsibilities are defined in detail, divided into implementation items such as basic research, coastal protection planning, design and construction, coastal management, and monitoring[99].

3) Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

a) Topographic and climatic conditions in Mauritius

Mauritius is located in the cyclone-prone south-west Indian Ocean, which has been severely affected by natural disasters such as cyclone storms, storm surge, floods and landslides, and as a small island country, its natural environment is vulnerable to the effects of climate change.

In terms of climate, the country has a tropical climate, with no separate wet and dry seasons, but rainfall is concentrated between December and May. Cyclones occur most frequently between December and March.

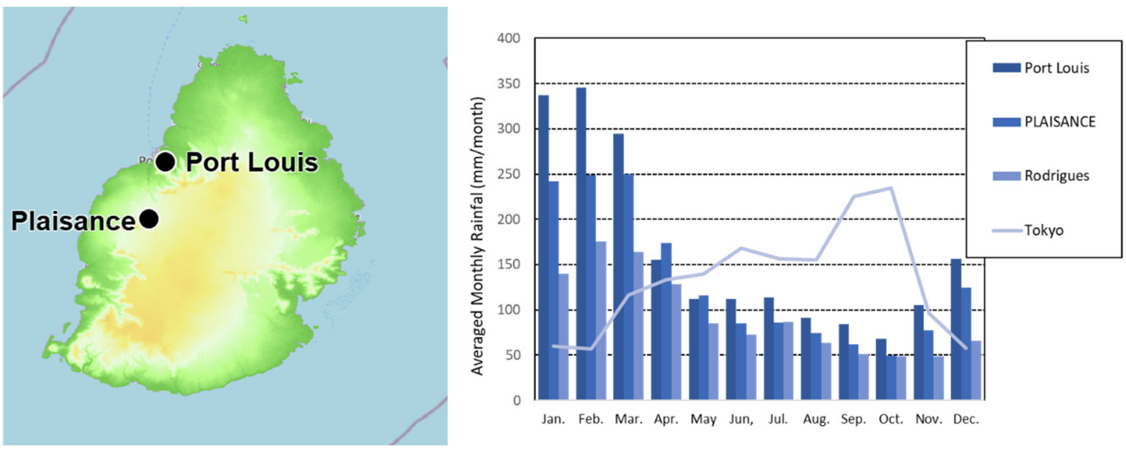


Figure 3–302 Average rainfall in Mauritius

Source: Japan Meteorological Agency website

[99] JICA, Capacity Building Project on Coastal Conservation and Restoration, Mauritius

b) Overview of Rivers in Mauritius

Mauritius is an island country with several rivers flowing down from the highlands in the south-central part of the country. In particular, Grand River, which flows from the capital city of Port Louis through the populated area of the Plain Wilhelm Province, the Latanier River, which has its mouth in the port area of the capital city of Port Louis, is assumed to be a priority river in terms of its potential to cause disasters.

The Grand River is about 10 km long with a bed slope of 1/30, and the Latanier River is about 7 km long and has a bed slope of 1/100, which is about the same as the bed slope in the mountainous areas upstream of rivers in Japan. The slope of the floodplain is also large, and it is highly likely that a downstream type of flooding will occur, in which flooded water flows downstream with storm surge depth and high velocity.

Figure 3–303 Location of major rivers in Mauritius

Source: JICA Landslide Prevention Project, Mauritius

c) Damage from previous disasters

Cyclones have been a major disaster in Mauritius, and most of the natural disasters that occurred in Mauritius between 1960 and 2009 were caused by cyclones. In addition to the location and Port Louis, there has been frequent damage on the Rodrigues, located in the Indian Ocean to the east of the main island.

Some of the largest cyclones were Carol in 1960, Gervaise in 1975, Hollanda in 1994 and Dina in 2002. The Cyclone which caused a severe damage is mentioned in red in the table below.

Table 3-227 Major Cyclone Damage in Mauritius

Start	End	Place	Category	Name	Killed	Victims	Ecomic loss (US$Million)
2007/02/05	2007/02/25	-	Cyclone	Gamede	2	-	-
2002/01/22	2002/01/22	Port Loius	Cyclone	Dina	3	1,050	50
1999/03/10	1999/03/10	-	Cyclone	Davina	-	1,000	-
1999/01	1999/04	Whole country	Drought	-	-	-	-
1996/12/09	1996/12/09	West and South	Cyclone	Daniella	3	-	-
1994/02/09	1994/02/11	Port Loius and Rodriguez Island	Cyclone	Hollanda, Ivy	2	2,300	135.4
1991/01/25	1991/01/25	Rodriguez Island	Cyclone	Bella	-	7,500	-
1989/01/29	1989/01/29	-	Cyclone	Firinga	1	4,507	60
1985/01/29	1985/01/29	Rodriguez Island	Cyclone	Ditra	-	-	-
1984/02/07	1984/02/07	Rodriguez Island	Cyclone	Haja	-	-	-
1983/12/08	1983/12/08	-	Cyclone	Andy	1	351	-
1982/02	1982/02	Rodriguez Island	Cyclone	Frida	-	500	0.323
1982/01/16	1982/01/16	Rodriguez Island	Cyclone	Damia	-	32,000	0.65
1979/12/22	1979/12/22	Agarega Islands	Cyclone	Claudette	5	105,257	175
1979/02	1979/02	Rodriguez Island	Cyclone	Celine	-	-	-
1975/02/06	1975/02/06	Whole Island	Cyclone	Gervaise	9	826,258	200
1972/02/17	1972/02/17	Rodriguez Island	Cyclone	Fabienne	2	25,016	-
1967/12/25	1967/12/25	Rodriguez Island	Cyclone	Carmen, Monica		23,524	5
1962/02	1962/02	-	Cyclone	Jenny	18	8,000	-
1960/02	1960/02	-	Cyclone	Carol	42	-	-

Source: Preparatory Survey Report for the Meteorological Services Plan, Republic of Mauritius, JICA.

d) Status of Hazard Map Maintenance

In Mauritius, according to an interview with the Land Drainage Authority (LDA) (conducted in November 2021), hazard maps for flood areas have been prepared but are not yet published. The data is organized in GIS, including surface water and groundwater flow, along with flood hazard maps.

On the GIS, data such as the Flood Prone area, where areas at risk of flood of 1-2m are shown in red, as well as the drainage infrastructure network and the linear data of the river network are organized. Specific hazard assessment methods need to be confirmed in more detail.

However, according to the interview with Mr. Ichikawa, Advisor and Ministerial Adviser to the Ministry of Public Infrastructure and Land Transport (November 2021), although Mauritius has prepared hazard maps, the concept of infrastructure development based on hazard maps has not been widely adopted. The government of Mauritius is also planning to implement a public works project on comprehensive flood control, but it is not yet known what kind of measures will be implemented in which areas, and this needs to be confirmed.

Based on the results of the interviews mentioned above, it is assumed that support will be needed not only for the development of hazard maps, but also for the application of the results of various hazard maps to infrastructure development.

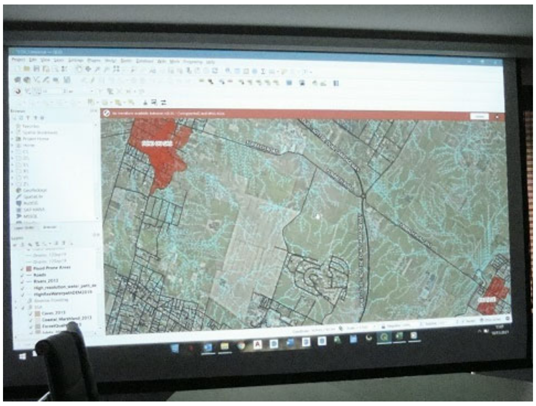
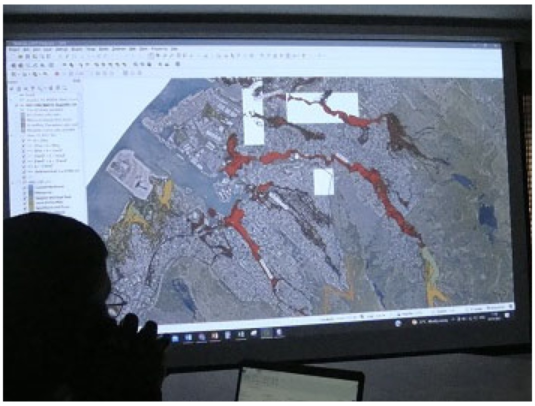



Figure 3–304 Results of flood risk analysis on GIS prepared by the Land Drainage Authority (LDA).

Source: JICA Study Team

e) Existing plans and studies in the field of river management

In Mauritius, which is an island country, rivers flow rapidly to the sea after rainfall, and it is assumed that appropriate drainage measures from land and other areas where rainwater tends to accumulate would be effective for flood control, so interviews were held with the Land Drainage Department.

According to the interview (in November 2021), the drainage Master Plan includes vulnerability assessment and detailed hazard mapping in model areas, as well as consideration of drainage pipe maintenance projects, consideration of land use, and formulation of nationwide design guidelines, and the Master Plan will include prioritization of measures and budget planning.

The details of the master plan will need to be understood in more detail, including through fieldwork.

Figure 3–305　Situation of drainage infrastructure in the urban area of Mauritius

Source: JICA Study Team

f) Existing plans and studies in coastal related fields

In the coastal areas of Mauritius, the main JICA project is the "Capacity Building Project on Coastal Conservation and Rehabilitation in Mauritius", which has developed a plan for the conservation and restoration of beaches with significant coastal erosion throughout Mauritius.

Figure 3–306 Coastal Conservation Plan Formulation 14 Coastal Location Map

Source: Climate Change Vulnerability and Adaptation Study for the Port of Port Louis

The city of Port Louis is a major city on the coast of Mauritius with a particularly high population density, and a project of the UN Climate Technology Centre & Network, the "Climate Change Vulnerability and Adaptation Study for the Port of Port Louis," is examining coastal adaptation measures considering climate change. The measures present adaptation measures related to tangible and intangible aspects of disaster risk reduction and port operations, and each is evaluated. As a representative example, Figure 3–307 shows the breakwater improvement plan that is being considered as a tangible measure to reduce floods in Port of Port Louis.

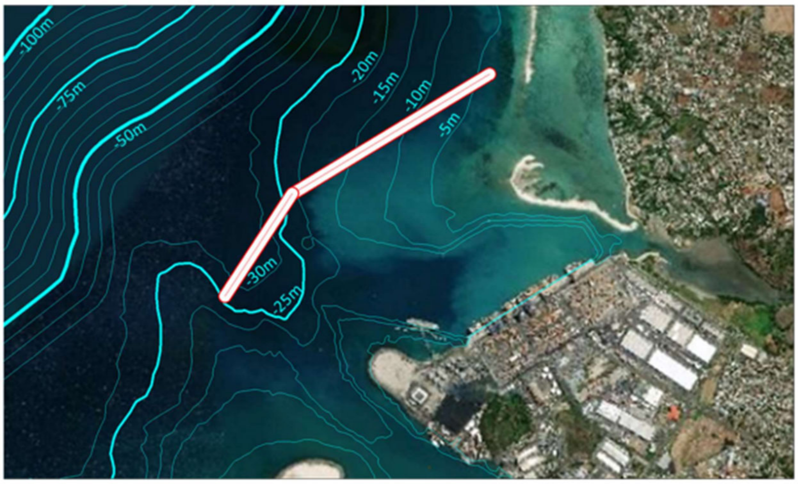


Figure 3–307　Examples of climate change adaptation measures near Port Louis.
Source: Climate Change Vulnerability and Adaptation Study for the Port of Port Louis

4） Consideration of Disaster Risk Reduction Measures

In Mauritius, a lot of support has been provided by JICA, mainly measures related to coastal protection, meteorological observation, and landslide control. Therefore, it is assumed that it is important to implement support based on the results of these supports.

Regarding river management, it is assumed that measures for an island country will include securing water resources and reducing flood damage through appropriate drainage, as well as strengthening land use regulations in flood-prone areas.

Particularly regarding drainage planning, as the Land and Drainage Authority is currently developing a Master Plan, it is assumed that understanding of the content of these Master Plans and coordinated support will be required.

3.6 Comoros

3.6.1 Disaster Risk Profile

(1) Qualitative Evaluation of Hazard Distribution

1) Situation of Hazard Distribution in Madagascar

The hazard data described in "2.1.2 How to identify overview of disaster risk" was visualized in GIS to identify the profile of hazard as shown in the figure below.

- Although it is located in the route of cyclones, it is not included in the area of major storm damage caused by past cyclones, and the flooded area due to Storm Surge is not described. The risk of cyclones is low compared to the island states of Mauritius and Madagascar.
- The risk of Landslides is high in the mountainous areas of Grand Comoro as well as on the other two islands.
- Since the hazard of flood disaster cannot be confirmed by the global model analysis, it was confirmed by previous reports. There is a high risk of flooding in the capital, Moroni, and also on the other two islands, mainly in the coastal areas.

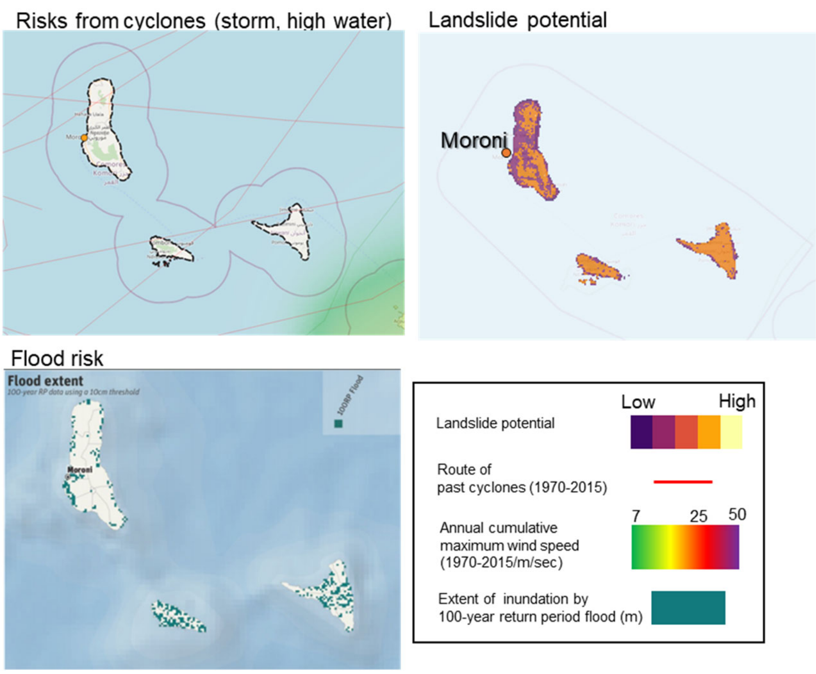


Figure 3–308 Hazard distribution in the Comoros
Source: Each data source is listed in Chapter 2, Open Street Map (background map)

2） Situation of Hazard Distribution in Major Cities of Madagascar

Situation of hazard distribution in each major city was identified according to the criteria shown in "2.1.2 Basic Idea and Methodology to Identify Disaster Risk Profile ". The population of major cities was confirmed based on UN-Habitat and World Population Review, and the major cities with large population sizes were sorted out.

Table 3–228 Hazard Status in Major Cities in the Comoros

City name	Population size (thousand person)	Hazard Status			
		Floods	Cyclones	Storm Surge	Landslides
Moroni	42	✓✓	✓	✓	✓
Mutsamoudou	23	✓✓	✓	✓	✓✓
Fomboni	14	✓✓✓	✓	✓	✓
Domoni	14	✓✓	✓	✓	✓✓

Source: JICA Study Team

a) Moroni

Moroni is the capital city located in the Grand Comoro Island and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "✓✓" based on the analysis conducted by GFDRR (Figure bellow (1)). Storm surge hazard was evaluated as "✓" since although inundation area is not distributed but it is located in an area affected by Cyclone. Hazard of the strong wind was evaluated as "✓" since the Annual accumulative wind speed is not distributed but it is located in an area affected by Cyclone. Landslide hazard was evaluated as "✓✓" in Port Louis since area with high landslide potential score over the medium level is distributed in the city. (Figure bellow (2)).

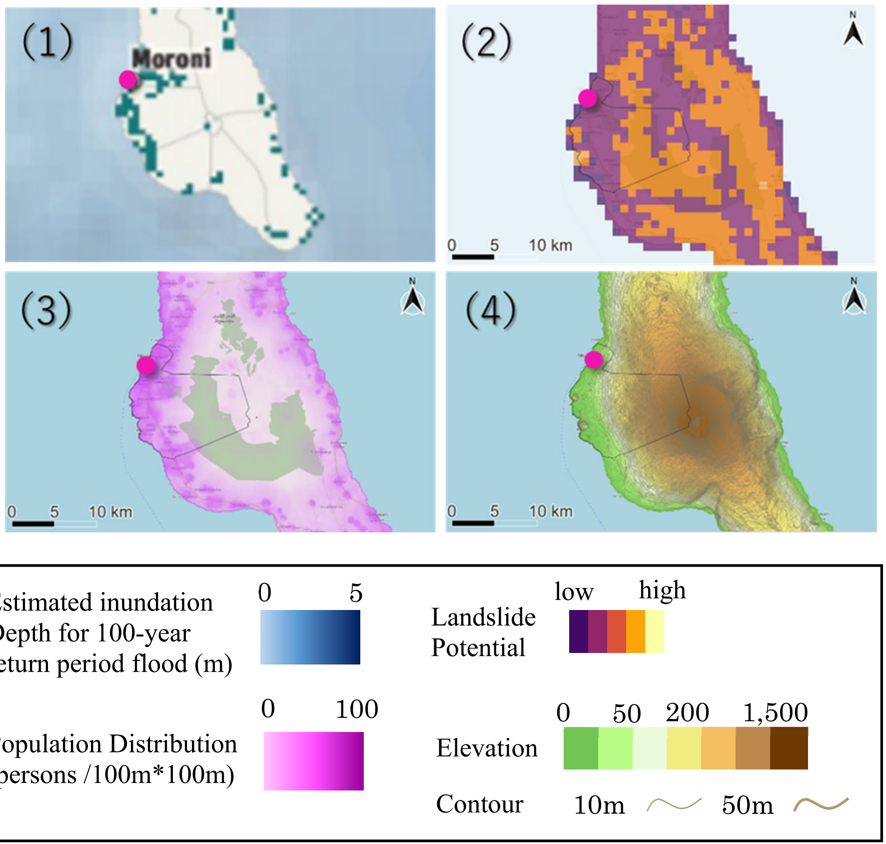


Figure 3–309 Situation of Hazard Distribution in Moroni

Source: JICA Study Team

b) Mutsamoudou and Domoni

Mutsamoudou and Domoni is the city located in north and east respectively in the Nzwani Island and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "✓✓" based on the analysis conducted by GFDRR in both cities (Figure bellow (1)). Storm surge hazard was evaluated as "✓" sinze although inundation area is not distributed but it is located in an area affected by Cyclone in both cities. Hazard of the strong wind was evaluated as "✓" since the Annual accumulative wind speed is not distributed but it is located in an area affected by Cyclone in both cities. Landslide hazard was evaluated as "✓✓" in Port Louis since area with high landslide potential score over the medium level is distributed in both cities. (Figure bellow (2)).

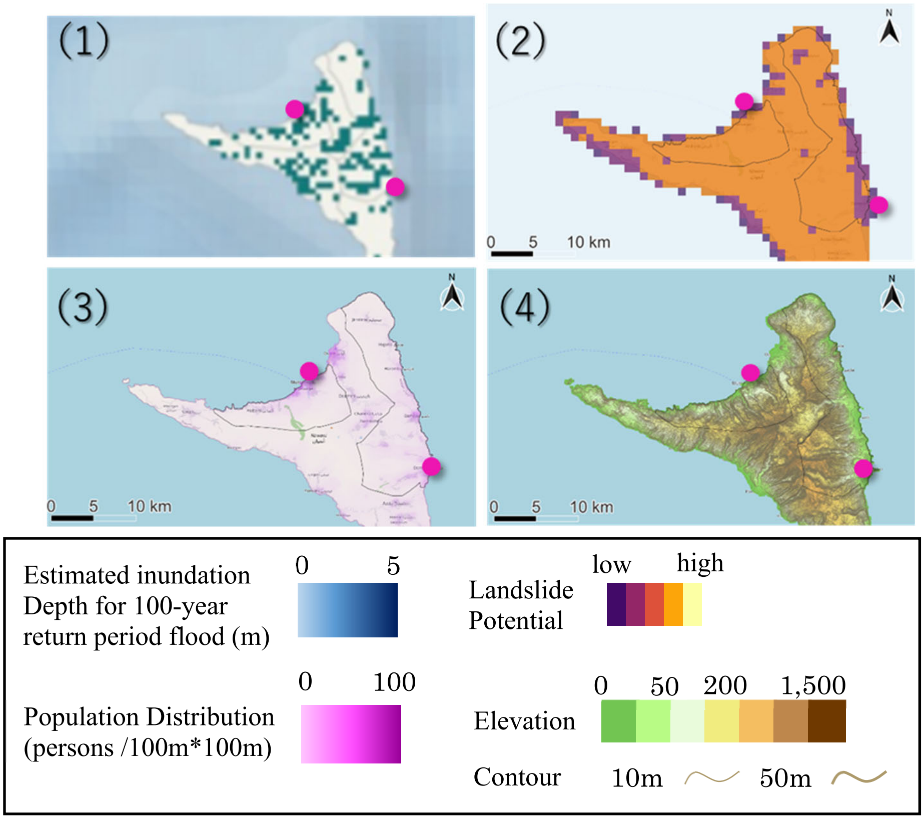


Figure 3–310 Situation of Hazard Distribution in Mutsamoudou and Domoni

Source: JICA Study Team

c) Fomboni

Fonboni is the city located in north in the Mwali Island and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "✓✓✓" based on the analysis conducted by GFDRR in both cities (Figure bellow (1)). Storm surge hazard was evaluated as "✓" since the although inundation area is not distributed but it is located in an area affected by Cyclone. Hazard of the strong wind was evaluated as "✓" since the Annual accumulative wind speed is not distributed but it is located in an area affected by Cyclone. Landslide hazard was evaluated as "✓✓" in Port Louis since area with high landslide potential score over the medium level is distributed in the city. (Figure bellow (2)).

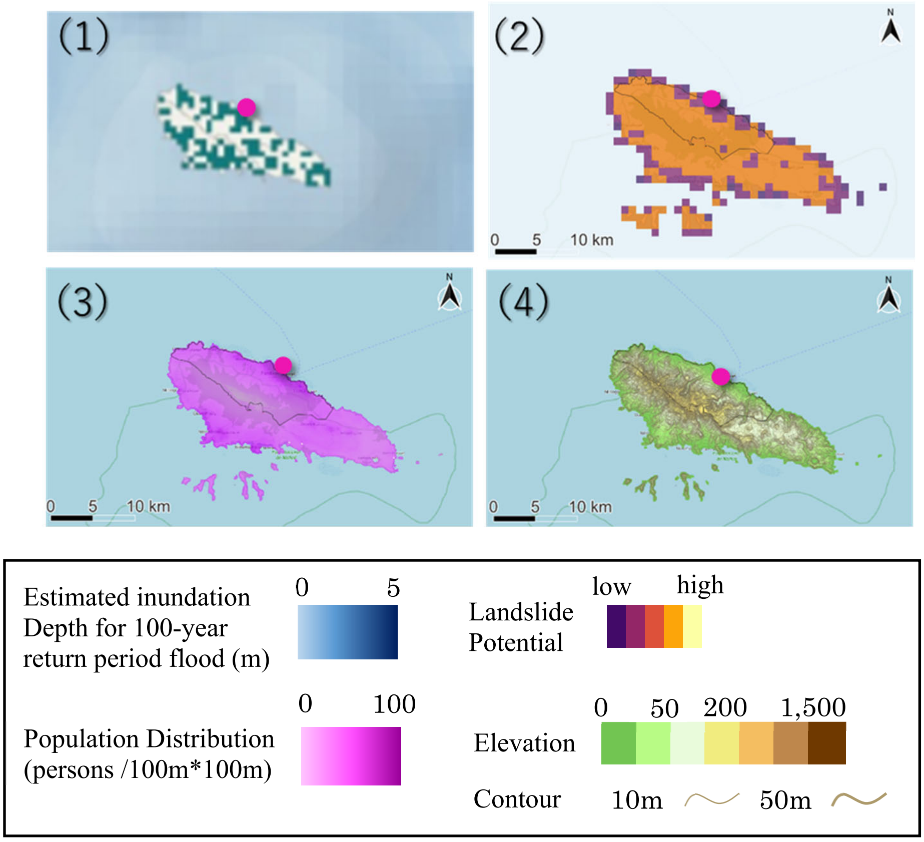


Figure 3–311 Situation of Hazard Distribution in Fomboni

Source: JICA Study Team

(2) Estimation of Potential Economic Loss due to Disasters

Based on the results of the qualitative assessment of the hazard distribution described above, a more detailed assessment of disaster risk was carried out for Moroni and Mtsamdu in terms of population size and hazard risk magnitude. For GDP per capita, the World Bank's published figures for 2020 were used.

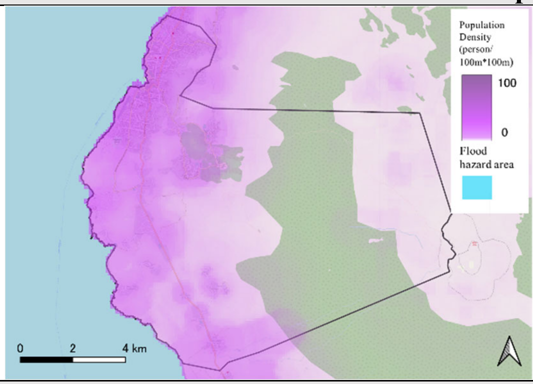
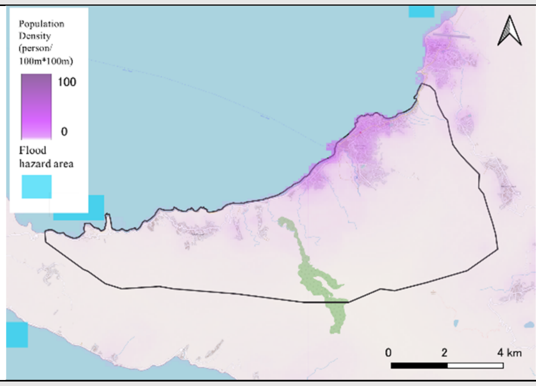
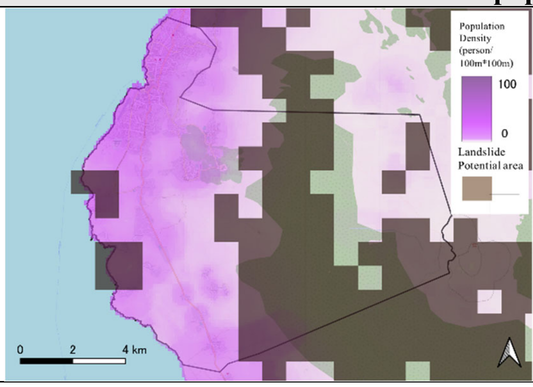
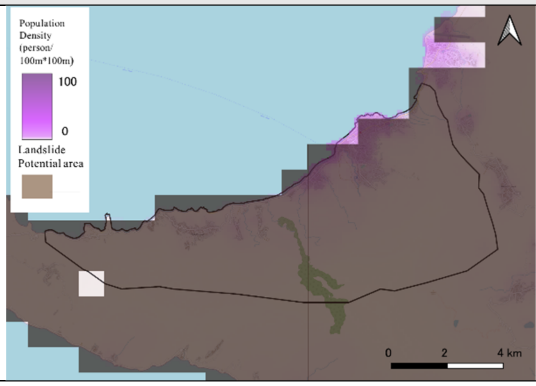
<table>
<tr><th>Moroni</th><th>Mutsamoudou</th></tr>
<tr><th colspan="2">Flood hazard and population distribution</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><th colspan="2">Landslide and population distribution</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Figure 3–312 Distribution of Hazard and Population in in major cities in s in the Comoros

Source: JICA Study Team

Table 3–229 Potential Economic Loss of Major Cities in the Comoros

Hazard	Target city	Moroni	Mutsamoudou
Flood	Damaged area (㎢)	0	0
	Damage area ratio (%)	0%	0%
	Population affected ('0000 persons)	0.0	0.0
	Estimated damage (million USD)	**0**	**0**
Landslide	Damaged area (㎢)	46	61
	Damage area ratio (%)	39%	99%
	Population affected ('0000 persons)	1.5	1.0
	Estimated damage (million USD)	**7**	**5**

* GDP per Capita (Current USD / person) used the data from WB
the value in the year 2020 which is (1,420.7 USD / person) was used

Source: JICA Study Team

The potential economic loss due to landslides is high in Moroni and Mtsamdu because of the wide distribution of landslide hazards, while flood and cyclone hazards are not significant in these areas.

On the other hand, it is difficult to understand localized floods by the inundation area analysis using a global model, so detailed analysis is necessary to understand the potential economic loss of flash floods and mudslides that occur on steep slopes or along rivers. Since these events are localized, it is important to prioritize countermeasures through detailed analysis of the location of important facilities in high hazard areas.

(3) Damage and Loss Disaggregated by Sector

1) GFDRR Disaster Risk Profile

In the Comoros, damage estimates for cyclone and flood hazards are examined separately for residential buildings, commercial and industrial facilities, public facilities, and infrastructure. Damage estimates are calculated for each sector on a 10-year probability scale, a 100-year probability scale, and a 250-year probability scale. Furthermore, based on these probability scale damage estimates, Average Annual Loss (AAL) is calculated.

Table 3–230 Sectoral damage estimates in Comoros in GFDRR disaster risk profiles

Disaster type		Cyclones	Flood
Conditions for analysis		Estimated annual damage	Estimated annual damage
Building (residence)	Amount of damage (Thousand USD)	2,500	1,500
Commercial and industrial	Amount of damage (Thousand USD)	250	90
Public facilities	Amount of damage (Thousand USD)	500	100
Infrastructure	Amount of damage (Thousand USD)	70	20

Source: Summarized by the JICA Study Team from GFDRR Disaster Risk Profile (the Comoros)

In the GFDRR disaster risk profile the distribution of disaster risks by province is visualized by disaster type and by sector as follows.

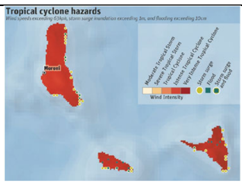
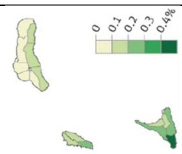
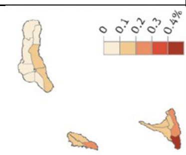
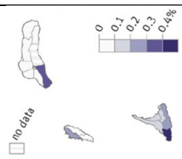
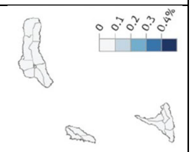
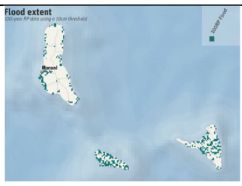
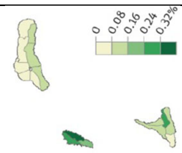
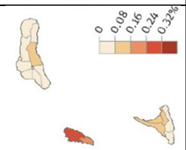
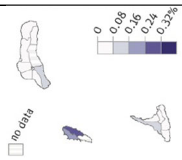
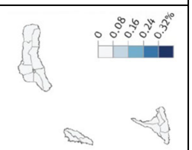
	Hazard distribution	**Residential buildings**	**Commercial and Industrial**	**Public facilities**	**Infrastructure**
Cyclones	 *Flooded area with wind speeds of 200 km/h or more, Storm Surge of 1.5m or more and flood due to a cyclone with a 100-year probability scale.	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)
Floods	 *Flooded area due to100-year probability flood	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)

Figure 3–313 Distribution of Disaster Risk by Type and Sector in in the Comoros

Source: Summarized by the JICA Study Team from GFDRR Disaster Risk Profile (Comoros)

The above results show that the damage to buildings is the largest in damage by sector. In addition, the impact on public, commercial and industrial facilities is greater than that of infrastructure damage, and the proportion of damage to buildings is higher than in other countries where damage to transport and other infrastructure is severe.

Regarding the disaster risk from cyclones, the hazard from strong wind is high, but the hazard from Storm Surge is greater in the eastern and southern parts of each island, which also increases the disaster risk.

Regarding the disaster risk of flooding, compared to Grand Comoro, where the capital Moroni is located, the hazard is higher on Mohéli, which is located in the middle of the three main islands, and on Anjouan, where Mtsamdu, the second largest city, is located. However, in view of the importance of the capital city, it is important to accurately determine the flood risk in Grand Comoro, where Moroni is located, as the disaster analysis using the GFDRR is based on a global model.

2） Disaster Damage and Loss Statistics

In the disaster damage statistics of the Comoros, for the disasters of interest (floods and cyclones), the actual number of deaths, damage to houses and damage to agricultural land caused by the 86 events that occurred between 1808 and 2014 are aggregated and summarized in the table below.

Table 3–231 Disaster damage statistics for Comoros by sector

Targeted disaster types	Flood, Cyclone
Target year	1808-2014
Number of disaster events	86
Number of deaths	621
Total destruction of houses (buildings)	169
Partial damage to houses (buildings)	1,711
Agricultural land (ha)	1,200

Source: Data collected from DesInventar and summarized by JICA Study Team

In addition, the annual trends of the number of disaster events and the number of damaged houses (destroyed + partial damaged) were confirmed to analyse the trend of damage.

The number of disaster events reached its maximum in 2012, but there was no increasing trend. The number of houses affected by the disaster did not show any significant trend of increase. In the Comoros, there is a lack of statistical information on disaster damage, and the development of statistical information itself is a challenge. On the other hand, although it is not possible to determine the trend of increase of disaster damage and loss, it is possible to consider and implement necessary measures for disasters that have caused particularly serious damage. In the Comoros, the disasters that have caused significant damage since Cyclone Elinah in 1983 are Cyclone Doloresse in 1996 and Cyclone Kenneth in 2019. Therefore, it is important to understand the actual damage caused by these cyclones when considering disaster management.

In DesInventar, information collected after 2005 will be used to evaluate the achievement of the indicators for the global target of the Sendai Framework for Disaster Risk Reduction, so it is expected that the information will be summarized on a uniform basis. Therefore, it is important to check the trend of the statistics continuously in order to understand the damage trend.

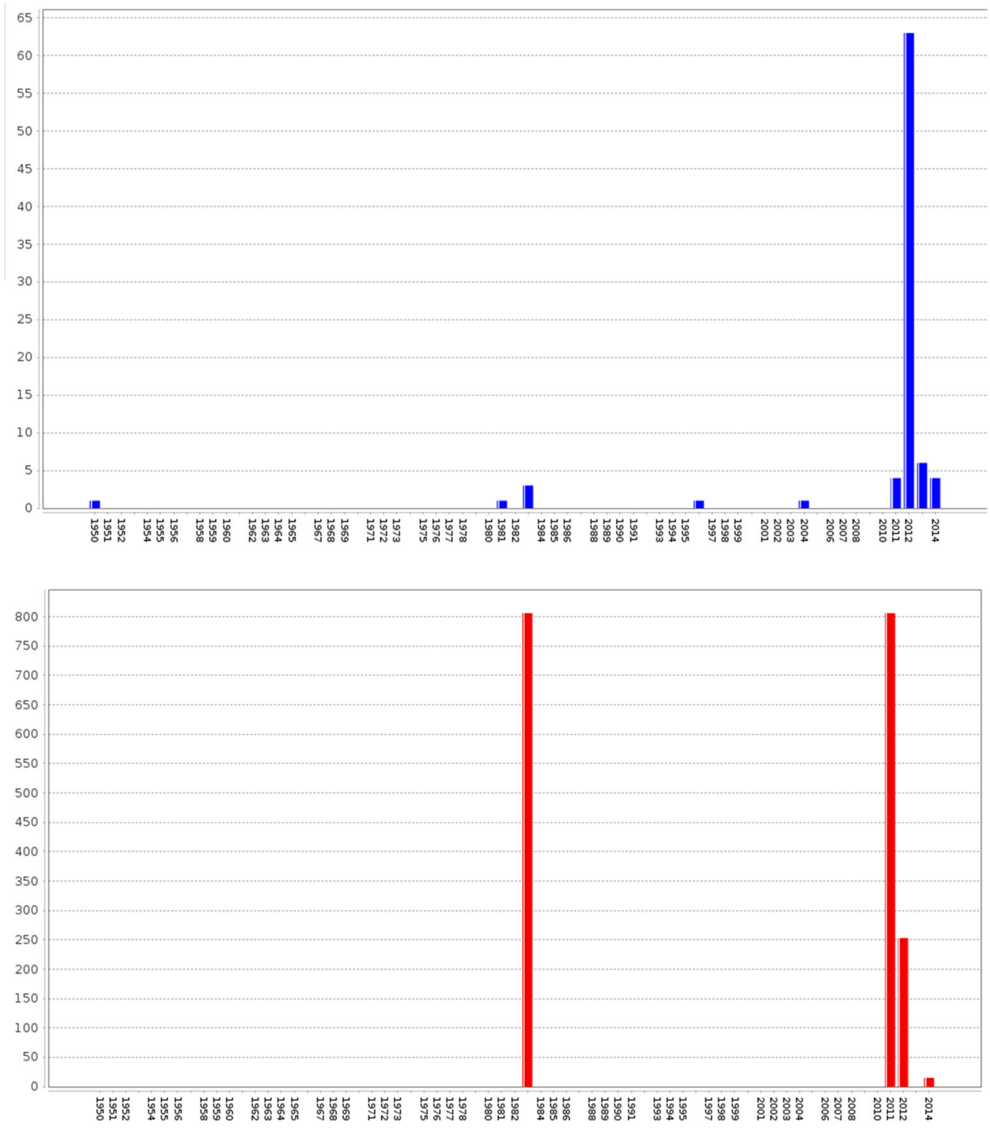


Figure 3–314 Trend of Disaster damage and loss in Comoros from 1950 to 2014
(Above: Annual Disaster Event, Bellow: Annual damaged houses (destroyed+partial damaged))
Source: DesInventar

3.6.2 Climate Change

(1) Observed and Projected Climate Change

Comoros is located at the northern entrance to the Mozambique Channel, between the coasts of Tanzania, Mozambique, and Madagascar in the Indian Ocean.

It is humid tropical climate influenced by the ocean, with two seasons: the wet season and the dry season. Due to differences in elevation and wind, annual precipitation on the three islands ranges from 1,000 to 5,000 mm.

Generally, summer (from mid-November to mid-April) is hot and humid, with average temperatures in the lowlands around 27°C, maximum temperatures between 33°C and 35°C, and minimum temperatures between 21°C and 24°C.

The average monthly precipitation is about 200 to 250 mm. Winter (from mid-June to mid-October) is cold and dry, with average temperatures of 23°C in the lowlands and maximum temperatures of 27-29°C. Average precipitation is 50 to 100 mm per month, less than half that of summer.

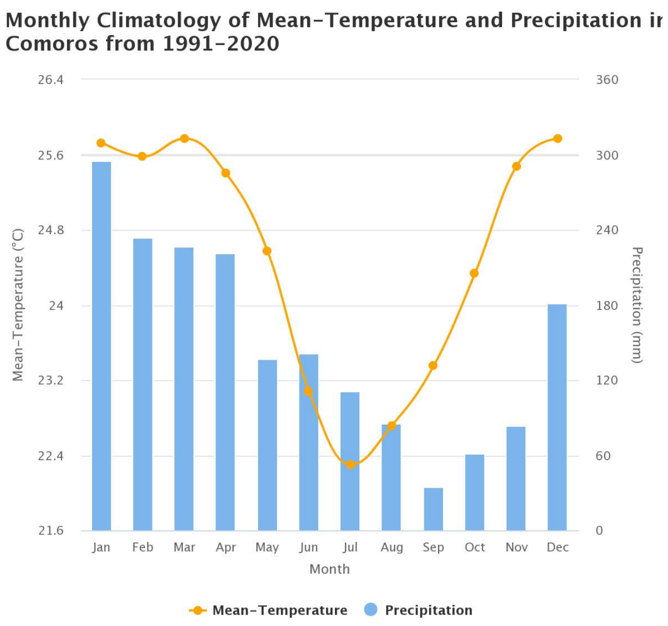


Figure 3–315 Changes in average temperature and precipitation from 1991 to 2020

Source: Climate Change Knowledge Portal, WB

At present, one of the observed meteorological phenomena that seems to be affected by climate change is the temperature rising. As shown in the figure below, the average annual temperature has increased by 0.9°C between 1901 and 2020. The temperature rises the most during the rainy season, especially from March to May.

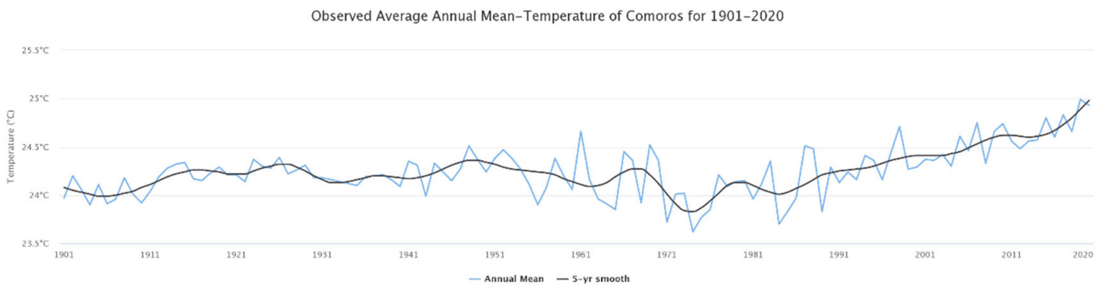


Figure 3–316　Observed average mean-temperature (1901～2020)

Source: Climate Change Knowledge Portal, WB

As for changes related to precipitation, the irregularity of the rainy season has increased and the overall duration of the rainy season has shortened from six months to about three months.

From 1960 to 1975, precipitation had been decreased in Comoros, but in 1976, there was a sharp increase in precipitation, followed by increasing of the irregularity of the precipitation from 1977 to 1989. In the late 1990s and early 2000s, prolonged droughts were observed.

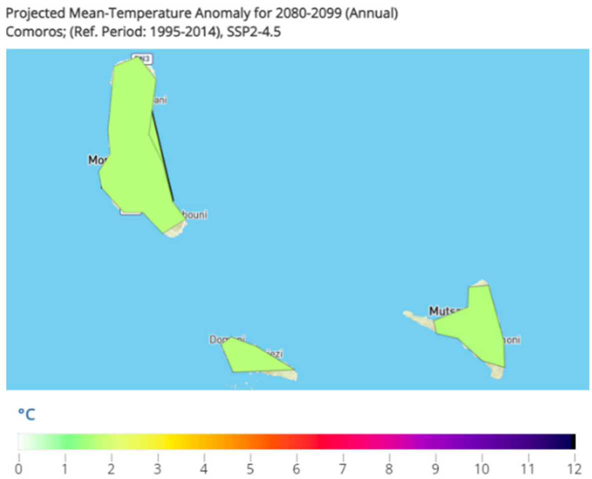


Figure 3–317　Projected mean-temperature for 2080-2099, SSP2-4.5

Source：Comoros - Climatology | Climate Change Knowledge Portal (worldbank.org)

As an extreme weather events, storms occurred frequently from 1980 to 2010, and caused many floods. In April 2012, heavy rainfall, 1,738 mm of rainfall over seven days, far exceeding the average rainfall of 267 mm for April, caused flash floods and landslides throughout the country. Approximately 64,000 people were affected and the damage was estimated at US$18-20 million. Also in January 2016, floods occurred in Mohéli, affecting 1,049 people, including 574 school children. In February of the same year, 76 families were affected in Moroni, Grand Comore, and 22 families lost their homes. In addition to the floods, landslides in 2013 and 2014 were occurred and affected 6,000 people in Anjouan. According to a World Bank survey, windstorms were the most common natural disaster between 1980 and 2020, followed by volcanic activity, epidemics, floods, droughts, and earthquakes.

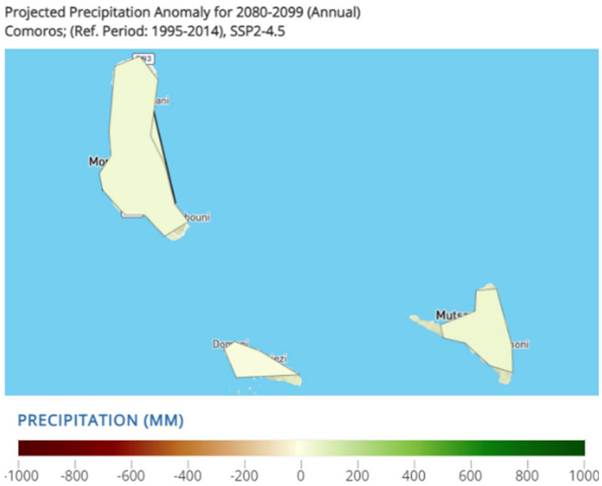


Figure 3–318 Projected precipitation for 2080-2099, SSP2-4.5

Source: Comoros - Climatology | Climate Change Knowledge Portal (worldbank.org)

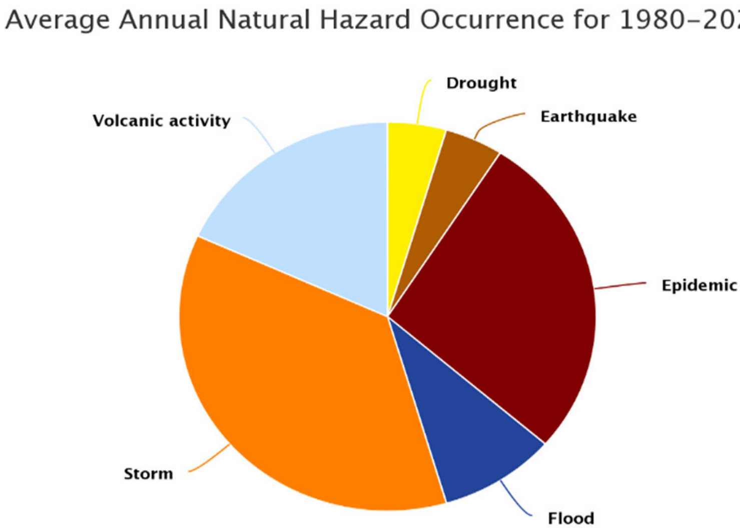


Figure 3–319 Average annual Natural Hazard Occurrence for 1900-2020

Source: Climate Change Knowledge Portal, WB

As for future projections on climate change, gradual decrease of precipitation, an increase of temperature, sea level rise, an increase o of aridity and an increase of drought are projected. In terms of temperature, it is projected that the average annual temperature in the Comoros will be 28 degrees Celsius, 1 degree Celsius higher than the current temperature by 2050. In addition, the sea level is projected to rise by 4 mm per year, or a total of 20 cm by 2050. The expected impacts of these climate changes include saltwater intrusion into coastal aquifers, increased mass food poisoning due to malaria and ingestion of marine animals, reduced crop yields, agricultural production and fisheries, displacement of 10% of the coastal population whose settlements will be submerged, and destruction of coastal infrastructure and settlements. The estimated cost of damage is estimated at US$400 million, which is equivalent to 2.2 times the 2001 Gross Domestic Product (GDP)[100].

Table 3–232 Impacts of climate change

Sector	Impacts
Water	Precipitation decreasing has had a negative impact on the quantity and quality of water resources. Fluctuation of precipitation, seasonal variations, and prolonged droughts are causing water shortages, adverse effects on food production, and poor sanitation. In addition, high temperatures have reduced the rate of groundwater availability through increased evapotranspiration. Vulnerabilities such as fragile freshwater-saltwater balance, groundwater contamination, and quantitative and qualitative decline of surface water need to be addressed.
Agriculture	Prolonged drought and high temperatures caused fruit ripening and corn production. New diseases and pests have also occurred, lead a decline of production and income. The degradation of the fertility of cultivated land leads to chronic famine and increased poverty, deforestation and forest destruction, especially in rural areas.
Forestry	Due to land degradation, 400 acres of forest are disappeared annually. Between 1974 and 1985, the forest area were decreased from 19100 to 12375 acres. The deforestation rate was reached 36% (-5000 ha) in the Grand Comoros, 74% (-5950 acres) in the Anjouan, and 53% (-1800 acres) in Moheli.
Fishery	Fish catchment have been gradually decreased. Coral bleaching have been occurred and a lot of coral have been died due to the sea temperature rise. This has accelerated coastal erosion and the decline of coastal fisheries. High temperatures, lack of cooling facilities, and limited fishing hours during cyclones and heavy rains have resulted in significant economic loss.
Coastal area	It is necessary that at least 10% of the population will need to be relocated due to salt intrusion into groundwater and accelerated coastal erosion. In addition, 734 acres of cultivated land may be lost. This could result in the disappearance of most of the major cities, roads, ports, airports, tourism infrastructure, warehouses, power plants, and historical buildings near the coast. Storm surge damaged coastal infrastructure in the villages of Mirontsi and Pomoni on Anjouan Island. The total socioeconomic losses in coastal areas directly related to climate change are projected to reach 170 billion Comoros francs (e.g. USD 486 million) in current value by 2050.
Transportation	Due to the sea levels rise and changing coastal currents, the supply of sea sand

[100] UNFCCC Initial National Communication On Climate Change Executive Summary

Sector	Impacts
and infrastructure	and coral used as construction materials may be declined. On the islands of Anjouan and Moheli, roads and bridges are blocked and sometimes damaged by landslides. Surrounding lands have been submerged, and public facilities such as hospitals, schools, and sports facilities have been damaged.
Health	Climate change, especially rising temperatures, has caused an increase in the spread of malaria, diarrheal diseases, and acute respiratory infections. It is also causing frequent dehydration among children, the sick, and the elderly. New diseases such as mosquito-borne alphaviruses (chikungunya) are also emerging.

Source: National Adaptation Programmes of Action

Agriculture and biodiversity, forestry, coastal areas, fisheries, water resources, health, and economic and social infrastructure are identified as the most vulnerable sectors to climate change in the updated NDC.

(2) Policies and Strategies for Climate Change

As for the policies and measures related to climate change in Comoros, various policies and action plans have been developed to improve climate change adaptation measures such as the National Environmental Policy, the National Adaptation Program of Action (NAPA), the 2011-2016 Strategic Plan on Natural Environment, Climate Change and Disaster Risk Reduction, and the Strategy for Accelerated Growth and Sustainable Development (SCA2D). (SCA2D), the 2011-2016 Strategic Plan on the Natural Environment, Climate Change and Disaster Risk Reduction, and the Strategy for Accelerated Growth and Sustainable Development (SCA2D), have been developed to improve climate change adaptation. In addition, the NDCs also specify measures for adaptation to climate change. The following is a summary of some of the most relevant items. Information on climate change adaptation impact assessments and adaptation measures in rural areas have not been found.

Table 3–233 Current development status of relevant policies and plan

Category	Status
National Communication	The Initial National Communication, Submitted to UNFCCC in 2002 The Second National Communication, Submitted to UNFCCC in 2013
NDC	Comoros First NDC 2015 – 2030, Submitted to UNFCCC in 2016 Comoros First NDC 2021– 2030 (Updated submission), Submitted to UNFCCC in 2021
National Adaptation Programmes of Action (NAPA)	National Adaptation Programme of Action, Submitted to UNFCCC in 2006
National Adaptation Plan (NAP)	National Adaptation Plan, Preparation process was implemented in 2014
National plan, strategy	National Environmental Policy, formulated in 1993 Framework Law, enforced in 2014 Strategic Program Framework on the natural environment, climate change and reducing disaster risk 2011-2016, formulated in 2011 Strategy for Accelerated Growth and Sustainable Development (SCA2D) 2015-2019, formulated in 2014 SCA2D (2018-2021) revised version, formulated in 2017

Source: JICA Study Team

In 2006, Comoros submitted its National Action Programme of Adaptation to climate change (NAPA) to the UNFCCC. In the NAPA, adaptation action plans have been developed for five main sectors: water resources, fisheries, forests, agriculture and livestock, and health and sanitation. The following are the 13 projects identified as priority projects.

1. Developing drought-torelance varieties
2. Protection and restoration of degraded soils
3. Restoration of watershed slopes
4. Increase water supply
5. Improving water quality
6. Malaria control
7. Use of non-metallic local building materials
8. Production of livestock (goat) feed
9. Production of poultry feed
10. Introduction of fish protection mechanisms
11. Introduction of fish freezing and preservation technology
12. Early warning
13. Support for eye care and surgical care

(3) Climate Change Adaptation Measures

The commitments and priorities for mitigation and adaptation measures were announced through the Nationally Determined Contributions (INDCs/NDCs) on September 17 2015, Comoros signed the Paris Agreement on April 22 2016. In the updated version of the NDC submitted to the UNFCCC in November 2021, the following adaptation measures are identified as to be focused on in the future.

<Agriculture and livestock>

- Formulating a Climate-Resilient Agricultural Policy
- Implementation of irrigation in agro-pastoral areas
- Establishment of an effective domestic early warning and response system in case of epidemic outbreaks in cattle and other animals

<Biodiversity and Forestry>

- Expansion of protected areas
- Expansion of reforestation areas
- < Fisheries, coastal and marine ecosystems>
- Monitoring and restoration of marine and coastal ecosystems
- Raising awareness and providing reassurance to fishermen facing climate disasters

<Water>

- Improving access to water resources
- Adoption and dissemination of integrated water resources management principles

<Health>

- Development of sustainable strategies to combat new infectious diseases such as malaria and COVID-19
- Development and implementation of an effective national early warning and response system for new infectious diseases

<Economic and social infrastructure>

- Formulation and implementation of economic and social infrastructure plans/development plans that integrate climate change
- Rehabilitation of existing road infrastructure

<Disaster Risk Reduction>

- Identification and mapping of areas susceptible to natural disasters
- Adopting building codes that take into account disaster risks

<Raising awareness>

- Raising awareness of the impacts of climate change
- Capacity building at all levels on the definition and implementation of climate change adaptation measures

It should be noted that although climate change action plans and adaptation measures at the national level were collected and analyzed in this study, information at the local level could not be founded.

(4) Supports from Other Donors

A significant part of the projects that are part of the Comoros Emerging 2030 Plan (CEP) were presented at the Conference of Partners for the Development of Comoros (CPAD 2019) held in early December 2019 in Paris, with the support of France, the World Bank Group, the United Nations Development Program (UNDP) and the African Development Bank (AfDB). At the end of this conference, about US$4.3 billion in financial commitments were announced, including US$1.6 billion from bilateral and multilateral partners and US$2.7 billion from private sector actors.[101]

[101] Source: CONTRIBUTION DETERMINEE AU NIVEAU NATIONAL (CDN actualisée) Rapport de synthèse,2021

3.6.3 National and Urban Development

(1) National Axis and Strategic Cities

Since Comoros is an island nation, it is the air and sea that connect the land. International flights arrive and depart at Prince Said Ibrahim International Airport in Hahaya, north of Moroni. The airport is the hub for domestic flights, and in addition to the other two islands, routes to the airports of Ouani in the northern part of Nzwani Island and Bandar Salama on the northern coast of Mwali Island are operated.

On the other hand, shipping activities are rather stagnated mostly by the poor port infrastructure, which is one of the causes of the stagnation of Comoros' economic development. The main ports are Moroni and Mutsamudu> Although Moroni Port is the capital port, its functions have not been strengthened so far. Mutsamudu Port was renovated as a deep-water port in 1985, allowing large vessels to enter the port.

The largest city is Moroni, the national capital, as well as the capital of the island of Grand Comoros. The next largest cities are Mutsamudu, the capital of Nzwani Island, and Fomboni, the main capital of Mwali Island. There are 22 in total that are positioned as cities. (See the figure below)

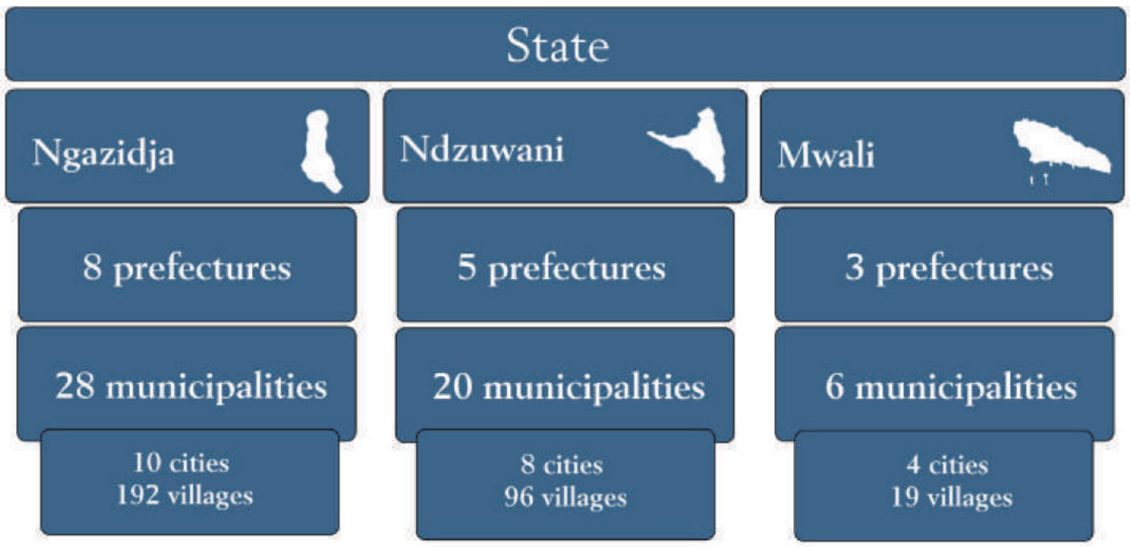


Figure 3–320 Composition of Urban and Local Administrations

Source: Comoros Urbanization Review REIMAGINING URBANIZATION IN COMOROS, WB

The figure below shows the distribution of major cities and villages.

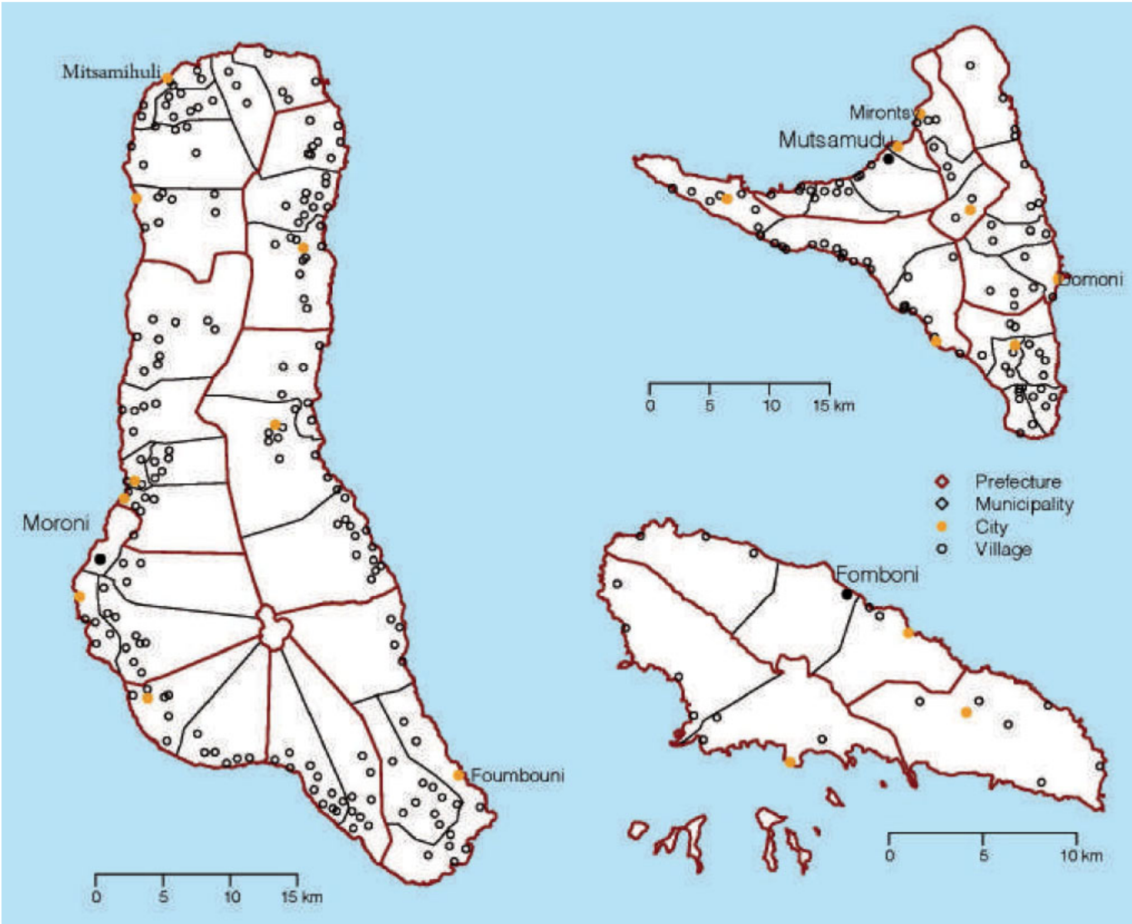


Figure 3–321 Distribution of Major Cities and Settlements

Source: Comoros Urbanization Review REIMAGINING URBANIZATION IN COMOROS, WB

(2) Cross-border Infrastructure

The largest airport in Comoros is Prince Said Ibrahim International Airport in Hahaia, north of Moroni, as mentioned above. The deep water port is currently limited to Mutsamudu port.

(3) Location of Important Industries

Comoros' main industry is agriculture, mainly small-scale subsistence agriculture with bananas, cassava, legumes, and taro combined. The main export products are fragrances such as essential oils of clove, vanilla and ylang-ylang, which account for 80% of the export (2013). Ho wever, fragrance-producing plants were introduced by colonial farm companies, and since the plantation companies withdrew after independence, investment and tree renewal have not been carried out, and thus, production has decreased. Due to the fertile soils of all three islands, plantations were run by French companies which occupies significant land area on the islands.

Fishing industry is underdeveloped, and secondary industries are limited to agricultural processing.

3.6.4 Disaster Management Plan and Implementation Structure

In the Comoros, the General Directorate of Civil Security (DGSC) is the body in charge of disaster management. On each island, Directorate Regional of Civil Security (DRSC) is responsible for coordinating disaster management. In addition, the National Platform for Disaster Risk Prevention and Reduction has been established as a high-level committee to study policies and laws related to disaster reduction.

According to UNDP [102], as a major policy related to disaster risk reduction, the National Strategic Framework for Disaster Risk Reduction and Climate Change (CSP) has been developed as a five-year framework. In CSP 2011-2016, three pillars and five policies are set out, including the application and resilience to climate change at all levels, the protection of the population's safety assets and infrastructure against natural disasters, and the development of partnerships at regional, national and wider levels. However, it was not possible to confirm any plans at local government level.

Related to the development of disaster prevention infrastructure, the Risk Sensitive Budget Review (RSBR) to address disaster risks was carried out in the Comoros between 2011 and 2014. This is an analysis of how much of the major ministries' project budgets have been spent on DRR. The analysis shows that around 7% of the annual budget was used for DRR-related projects (UNISDR[103], 2015).

[102] Project Document on Strengthening Comoros Resilience against Climate Change and Variability related Disaster, UNDP, 2016

[103] Working Papers on Public Investment Planning and Financing Strategy for DRR, UNISDR, 2015

3.6.5 Trends in Donor Support

(1) Overview of Donor Support

According to the Ministry of Foreign Affairs of Japan's International Cooperation Bureau's Official Development Assistance (ODA) Country Data Collection, totals for 2000-2017, donor aid to the Comoros is dominated by the World Bank Group's International Development Association (IDA), the European Commission, the European Investment Bank, and other European Union (EU)institutions. In terms of major donors, France has provided the most aid.

Table 3–234 Top five donor economic cooperation achievements (in millions USD)

Achievements in economic cooperation with international organizations		**Economic cooperation performance of major donors**	
IDA（WB)	199.8	France	357.6
EU Institutions	143.2	Japan	28.7
AfDB	64.6	U.S.	5.6
IMF-CTF	28.93	Canada	3.1
GFATM	15.32	Belgium	2.3

Source: Compiled by the research team from the Official Development Assistance Country Data Collection (2000-2017), International Cooperation Bureau, Ministry of Foreign Affairs of Japan

The main areas of support by donor, as shown in AfDB's COUNTRY STRATEGY PAPER (CSP) 2021-2025, show a high level of support for education and healthcare.

Table 3–235 Policy Consultation and Aid Coordination by Development Cooperation Partners

Areas of Support	AfDB	Arab League	China	EU	France	Global Fund (AIDS, Malaria, Tuberculosis)	IMF	Iran	SNU	Japan	UAE	USA	WB	No.
Private Sector	X												X	2
Tourism			X		X									2
Agriculture				X				X	X					3
Fisheries										X			X	2
Energy	X		X										X	3
Telecommunication													X	1
Transport	X	X	X	X	X									5
Water	X	X	X	X	X									5
Education		X	X	X	X				X			X		6
Health		X	X		X	X		X	X		X			7
Development/Social Protection				X	X				X			X		4
Economic Governance/ Public Administration	X			X			X		X				X	5
Public Finances					X		X						X	3
Number of Sectors	5	4	6	6	7	1	2	2	5	1	1	2	6	

Source: AfDB COUNTRY STRATEGY PAPER (CSP) 2021-2025

(2) Trends in Aid from World Bank (WB)

According to the evaluation of the COUNTRY PARTNERSHIP FRAMEWORK (CPF) 2014-2020, which indicates the WB's aid policy, one item - improving the knowledge base and management of natural hazards, disasters and climate change risks - has largely been achieved. In 2015, National Disaster Risk Reduction (DRR) Strategy and Action Plan providing a strategy and action plan was adopted, and a study on the impact and vulnerability of natural disasters was also completed. In 2017, a multi hazard disaster profile for the country was produced through a hazard impact and sustainability study, and a risk assessment database was made available. An early warning system for meteorological and geological risks has also been activated, but further work is underway to ensure full coverage and to automate the system. These have led to significant progress in improving the knowledge base and management of natural disasters and climate change risks, with improved management capacity demonstrated during Cyclone Kenneth in April 2019, where government action was effective in limiting the human impact. The reconstruction work for Cyclone Kenneth included strengthening the resilience of infrastructure, protecting the coastline, building social housing, supporting affected communities and strengthening disaster risk management.

The subsequent CPF 2020-2024 sets four goals in areas consistent with the Comoros Emerging Plan, with the planning period from 2020 to 2030: building human capital, strengthening disaster recovery and resilience, improving the business environment and governance, and improving connectivity.

As the Comoros, due to its location and topography, is one of the most climate-vulnerable countries in the world, with 54.2 % of the population living in areas at risk, it is stated that it will continue to support the Government's efforts to adopt an integrated and more proactive approach to disaster risk management and to shift towards policies that reduce national vulnerability to the impacts of climate change. On "Strengthening Disaster Recovery and Resilience", the need for collaboration with AFD, AfDB, FAO, FIDA, ILO, UNDP, JICA and France is also indicated.

Areas that need to be strengthened in the short, medium and long term include: institutional, legal and operational frameworks for disaster risk management; integration of risk reduction standards into regional and sectoral planning processes and operational tools, improvement and implementation of land use regulations and building practices, and financial management strategies that enable rapid resource mobilization and spending in times of disaster while protecting the fiscal balance. The Urbanization Review, due to be developed in 2020-2021, will be an important source of analysis on disaster risk reduction and urban resilience.

Table 3–236 Development Partner Intervention Matrix

Donors' interventions	CPF			
	Focus Area I: Crisis Response and Building Resilience		Focus Area II: Economic Recovery & Inclusive Growth	
	(1) Building Human Capital	(2) Disaster Recovery and Resilience	(3) Improving Business Environment	(4) Improving Business Environment
AFD				
AfDB				
China				
CNUSED				
COMESA				
EU				
FAO				
FIDA				
France				
IDB				
ILO				
IMF				
JICA				
Saudi-Arabia				
UNDP				
UNESCO				
UNFPA				
UNICEF				
WHO				
WTO				

Source: WB COUNTRY PARTNERSHIP FRAMEWORK (CPF) 2020-2024

Table 3–237 WB's disaster response / DRR related projects

Project Name	Project Objective	Financier	Approval Year
Comoros Post-Kenneth Recovery and Resilience Project	To support recovery and increase disaster and climate resilience of select public and private infrastructure in the areas affected by Cyclone Kenneth.	IDA	2019
Infrastructure, Water and Environment Project	To improve the living conditions of the population and to speed up the economic growth by providing adequate water/sanitation, safe transport and by protecting and improving the environment.	IDA France (Fund For Aid And Coop)	2001

Souce:WB Website Projects & Operations

(3) Trends in Aid from African Development Bank (AfDB)

The main objective of COUNTRY STRATEGY PAPER (CSP) 2016-2020, which sets out AfDB's aid policy, was the development of basic energy infrastructure to support the diversification of basic energy infrastructure to support the diversification of the economy.

The main objectives of CSP 2021-2025 are to reduce vulnerability, increase national resilience and promote structural transformation and emergence, and to this end to develop sustainable, high quality basic infrastructure in the energy and transport sectors. In transport (road, sea and air), the aim is to promote a greater availability to markets and a better connection of products, and in energy, a more regular and stable supply of reliable and affordable energy to businesses and households. In the transport sector, a multimodal approach covering all modes of transport is gradually being proposed, given the low ADF allocation and the immaturity of the private sector. The stepwise application of this multimodal approach, covering all modes of transport (road, sea and air), is expected to enable spatial and economic integration at national, regional and global levels.

While the need for disaster risk reduction is mentioned in CSP, the policy of ADB support is not provided. Past Cyclone Kenneth disaster relief efforts also focused on post-disaster response, such as providing food to affected households, preventing the recurrence of epidemics (particularly waterborne diseases and malaria) and ensuring continuity of education for affected children.

Table 3–238 AfDB's disaster response / DRR related projects

Project Name	Project Objective	Financier	Approval Year
Emergency humanitarian aid to populations affected by floods	To (i) provide food rations to 7,100 directly affected households; (ii) ensure the prevention of epidemics, particularly those related to waterborne diseases and the resurgence of malaria; and (iii) ensure continuity of education for affected children.	Special Relief Funds	2012
Emergency Humanitarian Assistance to Flood Victims	To provide emergency humanitarian assistance covering: (i) multi-facetted health assistance to the population geared toward providing health care; (ii) education of children aged below twelve and distribution of school kits to all affected primary schools; and (iii) procurement of essential food items.	Special Relief Funds	2009

Source：AfDB Website Projects & Operations

3.6.6 Selection of Key Cities

Based on the above overview of disaster risk, climate change, land development and urban development in the Comoros, as well as the trend of donor support, we have decided to select the capital city Moroni (Njazidja) and Moutsamoudou (Anjouan) as key urban areas for this study, and to focus on issues related to disaster risk reduction and the feasibility of support projects at the city level. The study will focus particularly on these key areas, but the study of potential support projects will not be limited to these areas, but will be conducted flexibly as appropriate based on the situation in each sector, local needs, and issues related to regional disaster risk reduction.

3.6.7 Information Collection and Analysis for Cooperation in the Field of Disaster Risk Reduction in Each Sector

(1) Transportation

The Comoros consists mainly of three volcanic islands: Grand Comoros, Anjouan, and Moheli. Le Karthala (2,361 meters above sea level), the highest mountain in Grand Comoros, is an active volcano (erupting every few decades). Grand Comoros has a very permeable soil made of volcanic ash, and, despite the heavy precipitation, there are no rivers of any kind. Anjouan has a rugged topography and numerous rivers, but high population pressure has led to deforestation and conversion to arable land in the highlands, resulting in severe soil erosion and water loss. Moheli has the lowest elevation with gently sloping topography and the highlands covered with forest and many rivers.

Because of the above topographical conditions, the important roads in the Comoros are the coastal roads that circle each of three major islands. As an island nation, port facilities are essential, but insufficient investment on the port infrastructure in the Comoros and the situation that large-size vessels cannot approach Port of Moroni in Grand Comoros are challenging issues. There is no railroad infrastructure in the Comoros.

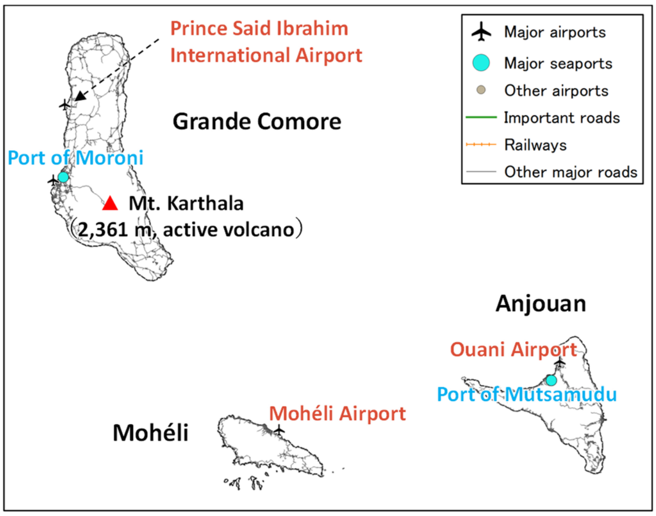


Figure 3–322 The three main islands of the Comoros and their major transportation infrastructure

Source: JICA Study Team

1) Overview of Relevant Organizations and Legal systems

Table 3–239 shows the ministries responsible for the transportation sector in general, and the government agencies in each subsector under them.

Table 3–239 Key Institutions in the Transportation Sector in the Comoros

Subsector	Key Institutions
-	Ministry of Transportation, Post, Telecommunications, Communication & Tourism
Road	National Directorate of Road Transport
Port	National Agency of Maritime Affairs (ANAM)
	Port Authority of the Comoros (APC)
Airport	National Agency of Aviation and Meteorology (ANACM)

Source: JICA Study Team

a) Road

According to AfDB data (Country Strategy Paper 2016-2020 - Union of the Comoros, AfDB, Mar. 2016), the total length of the interregional road network in the Comoros is 800 km, of which 600 km are arterial roads paved with asphalt. However, according to the same document, the infrastructure is ageing rapidly due to the lack of routine inspections and regular maintenance over the past 20 years.

b) Port

The main ports of the Comoros are Moroni and Mtsamdu. The Port of Moroni is located in the capital city of Moroni and is the largest port in the Comoros. However, the size of the port is small in comparison with its importance, and the water depth is not deep enough to allow large vessels to enter. The port of Mutsamudu on Anjouan is the only deep-water port in the Comoros, located in Mutsamudu, the second largest city in the Comoros. Taking advantage of this, the port of Mtsamdu transships container ships bound for the islands of Grand Comoros and Moheli. The port of Mtsamdu handles mainly container cargo, and very little bulk cargo. 75% of all international cargo in the Comoros is transshipped at this port. A summary of each port is shown in Table 3–240.

Table 3–240 Summary of Major Ports in the Comoros

	Port of Moroni	Port of Mutsamudu
Anchorage depth	21.6m - 22.9m	23.2m - OVER
Cargo pier depth	3.4m - 4.6m	7.1m - 9.1m
Oil terminal depth	3.4m - 4.6m	11m - 12.2m
Dry dock	N/A	N/A
Harbor size	Very Small	Very Small
Railway size	N/A	N/A
Harbor type	Open Roadstead	Open Roadstead
Max size	Up to 500 feet in length	Up to 500 feet in length
Repairs	N/A	None
Shelter	Poor	Fair

Source: ANAM website (https://www.comorosmaritime.org/en/)

c) Airport

There are airports on each of the major islands of the Comoros. The only international airport is the Moroni International Airport (Aéroport de Moroni-Prince Saïd Ibrahim).

2) Overview of Related Plans and Development Status

National Road Transport Master Plan (2015-2025) was formulated in 2015 with EU support, but it is not found in the desktop research.

3) Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

The risk of cyclone damage is small compared to neighboring countries (see Figure 3–323). However, as many cyclones have passed through the Comoros in the past, it is considered that high risk of damages by strong wind and heavy rain exists. However, the actual situation is not clear, as the detailed information about those damages in the past could not be investigated.

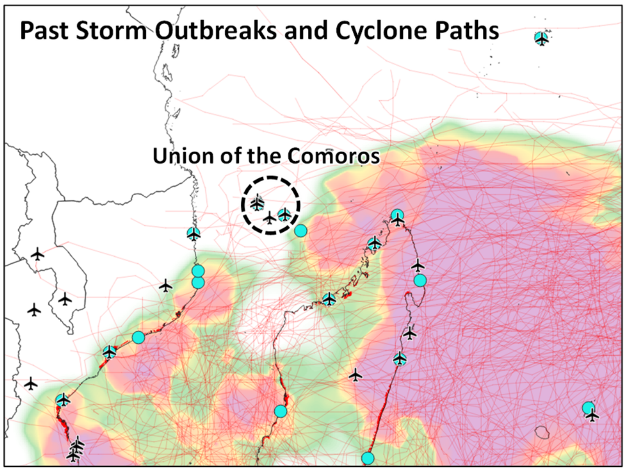


Figure 3–323　Risk of Cyclone in the Comoros

Source: JICA Study Team

Other natural disasters concerned on Grand Comoros are volcanoes and sediment disasters. The risk of sediment disaster is shown in Figure 3–324. Sediment disaster risk is of particular concern on the east side of Mount Kalutara. The impact of coastal erosion on coastal roads also needs to be addressed. Floods do not occur in Grand Comoros, but there is a risk of flooding in Anjouan and a risk of sediment disasters.

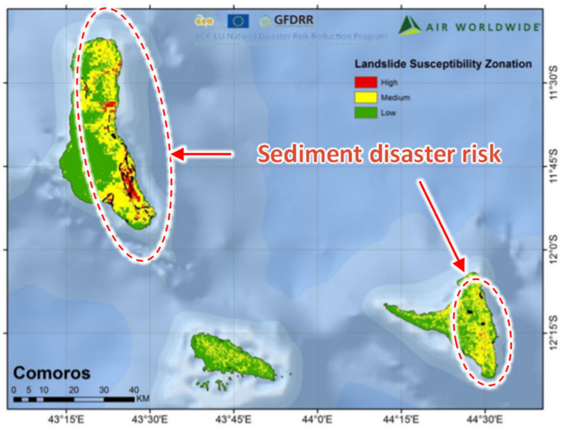


Figure 3–324　Sediment Disaster Risk in the Comoros

Source: AIR Worldwide Southwest Indian Ocean Risk Assessment Financing Initiative (SWIO-RAFI) Component 1 - Hazard

Based on the above limited literature, the key transportation infrastructures for disaster risk reduction are as follows

- National Roads RN1, RN2, and RN3 on Grand Comoros. There is also a high risk of sediment disaster and volcanic damage, especially near the Kalutara volcano on National

Road RN3.

- Strengthening and improvement of the facilities of the ports of Moroni and Mtsamdu against cyclones and storm surges.

4） Consideration of Disaster Risk Reduction Measures

Due to the difficulty in surveying the current status and usage conditions of critical transportation infrastructures, the occurrence of disasters, and local needs related to disaster risk reduction, it was not possible to conduct a study on priority disaster risk reduction measures.

(2) Power

1) Overview of Relevant Organizations and Legal systems

There is no official ministry in charge of electricity supply in Comoros, but the Ministry of Planning monitors the use of fossil fuels. MAMWE, a utility corporation, is responsible for the supply of electricity for the islands of Grand Comoros and Moheli, and EDA is responsible for the supply of electricity for the island of Anjouan.

The current power sources are DEG (heavy oil) and small hydropower. 2 out of 7 DEG-based power plants (number of plants before 2017) are out of order, and failures are frequent and repairs are not proceeding smoothly due to lack of funds and maintenance skills. In 2016, the total possible power generation was 21.5 MW, and the transmission loss was very high at 48%, which includes stolen power (Comoros's energy review for promoting renewable energy sources). To cope with the power shortage, three DEGs have been added since 2017.

In addition, the price recovery rate for electricity was the lowest in Sub-Saharan Africa at 58% in 2014 (Financial Viability of Electricity Sectors in Sub-Saharan Africa, WB2016). While the cost of electricity generation is 59.5cent/kWh, the cost of electricity is only 29.8cent/kWh, which assumes government support. These management problems are behind the inadequate state of facility formation and maintenance. The World Bank and the CIA put the electrification rate at 78% and 70% respectively, while the authorities put it at 48.5%. The difference depends on the definition and the time of availability of electricity (urban 2-6h, rural 12h).

The installed capacity is 32.3 MW, the peak demand is 17.8 MW, and the annual electricity consumption is 54 GWh (Comparative Study on RE and Electricity Access). 91% of the electricity comes from imported oil. The potential of geothermal is estimated at 70 GWh/y.

By 2018, the World Bank was working on electricity sector reform in Comoros (THE UNION OF THE COMOROS FOR THE ELECTRICITY SECTOR RECOVERY PROJECT). Prepaid card meters were adopted and the price collection rate was reduced to 55%=>81% and transmission and distribution losses to 45%=>35%.

There is no comprehensive law on electricity and energy. There is also no reliable statistics on energy. Although detailed renewable energy potential studies have not been conducted, the estimated PV potential is 79 MW. 3 MW of PV is under construction in two locations and several others are planned. The geothermal potential is 10 MW, but the cost is expected to be high and the economics are not promising. Wind power generation is not expected due to weak wind. Hydropower has been adopted, but its potential is only 1 MW.

2） Overview of Related Plans and Development Status

Geothermal development in the Grand Comoros is being pursued in order to reduce power generation and to expand and stabilize the power supply, with the goal of installing 60-80 MW of geothermal power and reducing the current cost of electricity by 70% (promotion of renewable energy in Comoros).

Plans are underway to install 9 MW of PV and 16 MWh of batteries in the Grand Comoros (COMOROS SOLAR ENERGY INTEGRATION PLATFORM). 18 MW of fuel oil-fired DEGs will be operational by the end of 2021.

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

As for landslides, the risk of power plants other than Bandamadji is not high. It is important to avoid construction in high-risk areas as much as possible and to use appropriate civil engineering design when necessary.

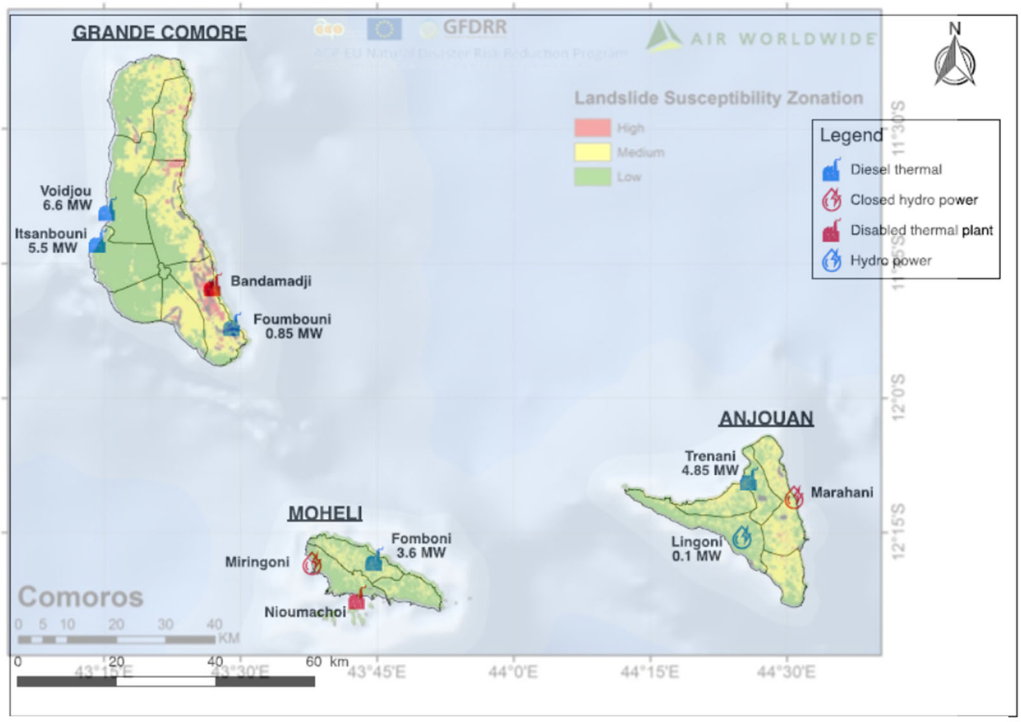


Figure 3–325 Comoros power plant location and landslide risk map

Source: Prepared by the study team based on Comoros' energy review for promoting renewable energy sources (2021, PIMENT Laboratory)

(3) Water and Sanitation

1） Overview of Relevant Organizations and Legal systems

The General Directorate of Energy, Mines and Water (Direction General de l’Energie, des Mines et de l’Eau, “DGEME”) of the Ministry of Production, Environment, Energy, Industry and Handicrafts (Ministere de la Production, de l’Environnement, de l’Energie, de l’Inductrie et de l’Artisanat) is responsible for the water and sanitation sector in the Comoros. DGEME is also responsible for water resources management.

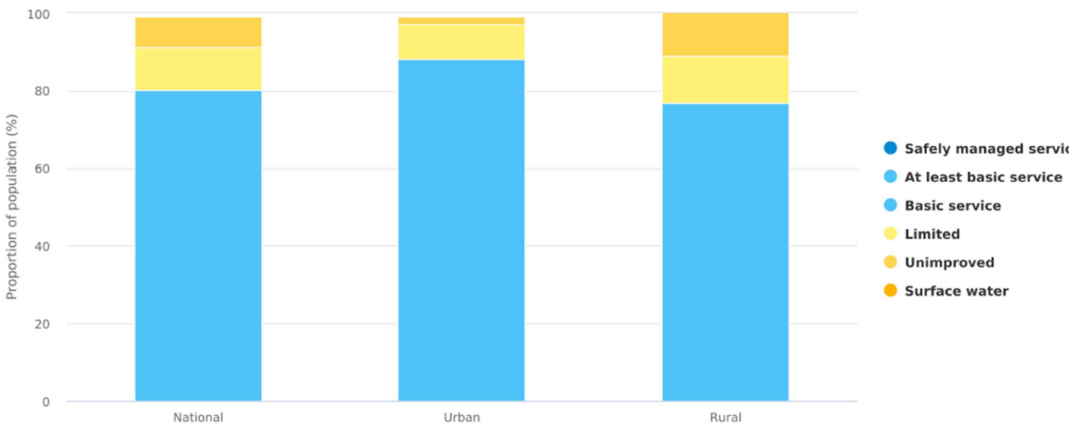
According to the World Bank, the Comorian government is in the process of reforming the water and sewage sector. (World Bank. 2020. Comoros Urbanization Review.)

In Comoros, the water supply service is run by SONEDE (the National Company in charge of the Exploitation and Distribution of Water in the Comoros (EN); la Société Nationale Chargée de l'Exploitation et la Distribution des Eaux aux Comores (FR)), a state-owned company.

In addition to the existing water law (Code de l'eau), the water and sanitation law (Code de l'eau et de l'assainissement) was enacted in 2019.

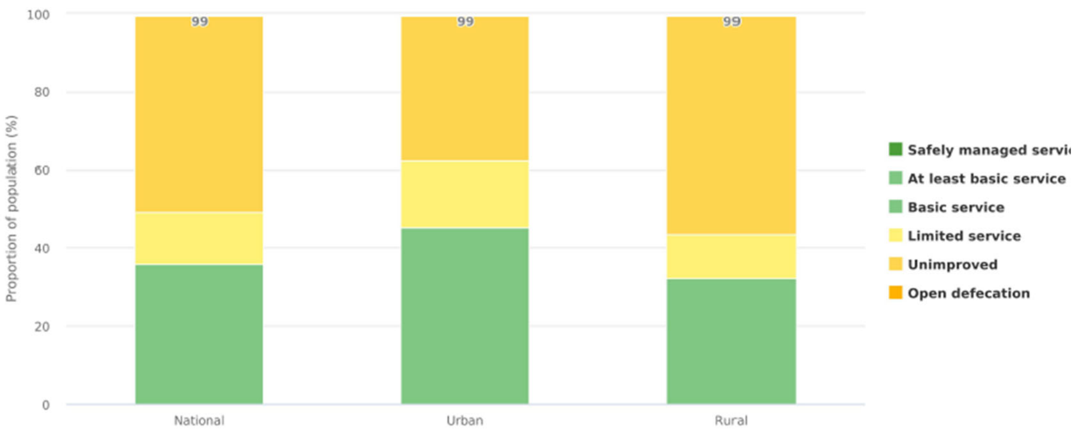
2） Overview of Related Plans and Development Status

According to a UN Water summary, the proportion of the population with access to basic water in the Comoros generally exceeded 90% in 2017, but few people have access to safe water. (Figure 3–326) The proportion of the population with access to basic sanitation facilities was over 30% (nationally) in 2017. (Figure 3–327) In both indicators, the situation is worse in rural areas than in urban areas.



Data provider: WHO, UNICEF

Figure 3–326 Percentage of population using water supply services in the Comoros by level of service and region.



Data provider: WHO, UNICEF

Figure 3–327 Percentage of population using sanitation services in the Comoros by level of service and region

Source: UN Water. 2021. Comoros.

The Comorian government's strategies for water and sewerage include the following.

- Growth and Poverty Reduction Strategy 2010-2014 (Stratégie de Croissance et de Réduction de la Pauvreté 2010-2014, “SCRP”)
- Drinking Water Supply and Sanitation Strategy 2013-2030 (Stratégie d’Alimentation en Eau Potable et d’Assainissement, “AEPA”)
- Comoros Emerging Plan 2030

There are three sources of drinking water in the Comoros: surface water, groundwater and rainwater harvesting. There are water supply systems in Ngazidja, Anjouan and à Mohéli. Other several cities and town have water supply systems sourced from groundwater developed with supports of UNICEF, WB, and NGOs. According to SCRP, in 2004, 30.6% of household water supply came from public taps, 24.2% from rainwater harvesting tanks, and 15% from private water supply. Detailed water supply coverage and facility information was not available in the desktop survey.

SCRP identified a lack of planning capacity for water supply, a lack of financial resources to renew facilities, and health challenges with rainwater harvesting tanks. The improvement objectives include the development of a master plan, strengthening of the organisation, standardisation and mandatory treatment of drinking water, improvement of drinking water, transmission and distribution infrastructure, and implementation of instrumentation monitoring for stable operation.

Although there are sewerage systems in the larger cities of the Comoros, they were built as long ago as 1878 and have not been updated. In addition, most of the population has no access to sewage systems. The drainage system is not functioning, with most wastewater flowing naturally, percolating into the ground or entering the rainwater drainage system. Adequate sanitation is also a challenge. SCRP has set the improvement of sewage and sanitation as a goal, with the development of a master plan and the provision of sanitation facilities.

The Comoros government has set a target of increasing access to drinking water to 95% and access to sanitation to 95% by 2025. (Vice President in charge of the Ministry of Territory Development, of Infrastructures, Urbanization and Housing of the Union of Comoros. HABITAT III Country Report. 2015)

In 2009, JICA conducted the “Preparatory Survey for the Human Security Program” in order to study the support policy for the resumption of bilateral assistance to the Comoros, which had been suspended due to political instability, and conducted surveys in the fields of fisheries and agriculture, health, and climate change countermeasures. In the health sector, it was pointed out that rainwater harvesting tanks, which serve as a source of water for the population, contribute to malaria outbreaks, but the project was not able to formulate a case for drinking water because malaria mortality rates are not as high as in neighbouring countries.

The following support has been provided by international donors.

- Rural Water Supply and Sanitation Project in Southern Areas (Hadoudja Drinking Water Supply and Sanitation Project, “PAEPA”, AfDB, 2017)
- Access to drinking water was increased from 10% (2009) to 37.5% (2015) and access to

sanitation from 7% (2009) to 20% (2015) by building new and rehabilitating water and sanitation facilities, examining the organisational and financial framework for the water and sanitation sector, strengthening planning capacity, stimulating the activities of sector stakeholders and providing a model for collaboration with donors in other sectors.

- Urgent support against Cyclone Kenneth (UNICEF, 2019)
- Emergency response including deliver of drinking water, hygiene kits, generators for water supply pumps.

3) Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

As an island nation located in the Indian Ocean, Comoros is vulnerable to cyclones.

During Cyclone Kenneth in April 2019, SONEDE's pumping station ceased to function and flooding caused a large number of residential rain water harvesting tanks to leak. (UNICEF. May 2019. Comoros Humanitarian Situation Report.) According to the Comoros Government, the damage caused by Kenneth to the water and sanitation sector was estimated at US$21.1 million. (Union des Comores. June 2019. Damage Assessment and Recovery and Reconstruction Plan.)

Water pumping facilities were also damaged in the 2012 floods.

Aging sewerage systems, limited service coverage and waste disposal problems have resulted in poor sanitation and poor drainage during heavy rains.

4) Consideration of Disaster Risk Reduction Measures

In addition to the urgent need to improve the access rate to sanitation, support for the rehabilitation of sewerage and drainages could be considered from the perspective of reducing the risk of flooding associated with heavy rains and cyclones, but the financial size of the Comoros makes it difficult to implement grant aid.

(4) Telecommunications

1) Overview of Relevant Organizations and Legal systems

The ministry responsible for the telecommunications sector in Comoros is the Ministry of Posts, Telecommunications and Digital Economy (Ministère des Postes, des Télécommunications et de l'Economie Numérique, chargé de l'Information), and the telecommunications regulator is ANRTIC (Autorité Nationale de Régulation des Technologies de l'Information et de la Communication).

Figure 3–328 ANRTIC office

Source: ANRTIC

2) Overview of Related Plans and Development Status

Until recently, the Comoros telecommunications sector market was dominated by the state-owned Comoros Telecom (CT). By 2014, at least two private operators tried to penetrate the telecommunication sector but had failed. Specifically, a private operator that attempted to enter the market in 1994 failed to pay its license fees and had its license revoked. In 2013, a plan to privatize the state-owned enterprise CT failed when it was refused by Comoros Parliament due to potential job losses. A telecom law was passed in 2014 and a second private telecom operator, Telma Comoros, was authorized in 2015, partially liberalizing the ISP market. But even after that, CT refused to share its network infrastructure with Telma Comoros, forced its subscribers to use international calls, used its political influence to pressure the regulator ANRTIC to raise prices to match those of CT, and to force customs to pay duties and fees on equipment that was exempted under the terms of its license. So the business plan of Telma Comoros had many issues.

Due to the lack of domestic ICT infrastructure, Comoros was isolated and not connected to regional networks and markets. Like many Small Island Developing States (SIDS), the Comoros has a small economy that does not allow for economies of scale, and has faced major challenges in connectivity. The Comoros ICT Development Index (IDI) evaluated by ITU is the lowest in the African region, and mobile broadband services in Comoros are among the most expensive in Africa, with typical call baskets of 500 MB and 1 GB amounting to 14.5 percent and 18.2 percent of GNI per capita, respectively (ITU, June 2017).

Because of such background, the broadband Internet connection rate is low in Comoros. As of 2019, the percentage of the population with access to the Internet remains at about 8%. Fixed-line subscriptions peaked around 2010 and then declined and shifted to mobile service, which also peaked in 2019 and began to decline.

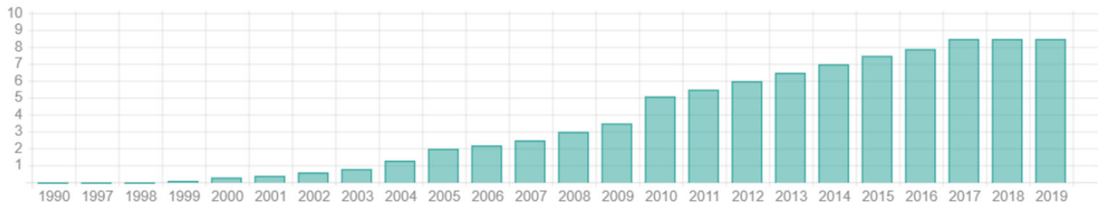


Figure 3–329　Percentage of the population with Internet access, 1990-2019

Source: WorldData.info[104]

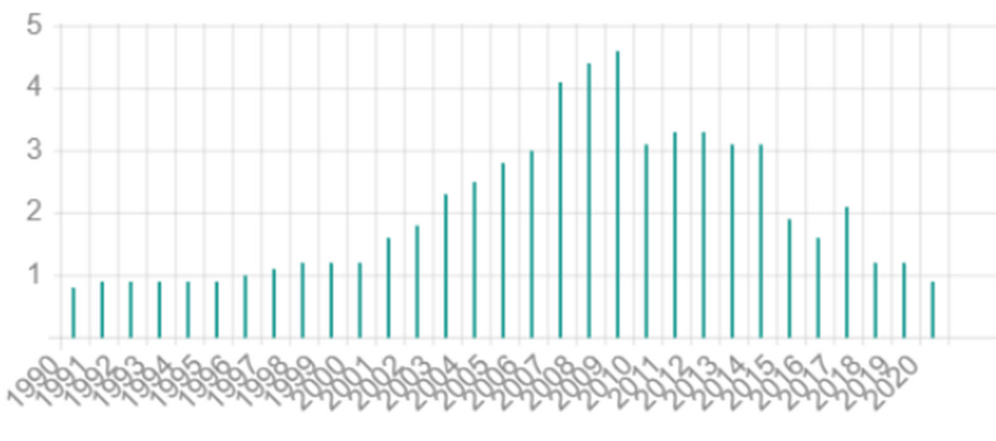


Figure 3–330　Fixed-line Subscriber Population Ratio

Source: WorldData.info

[104]www.worlddata.info/africa/

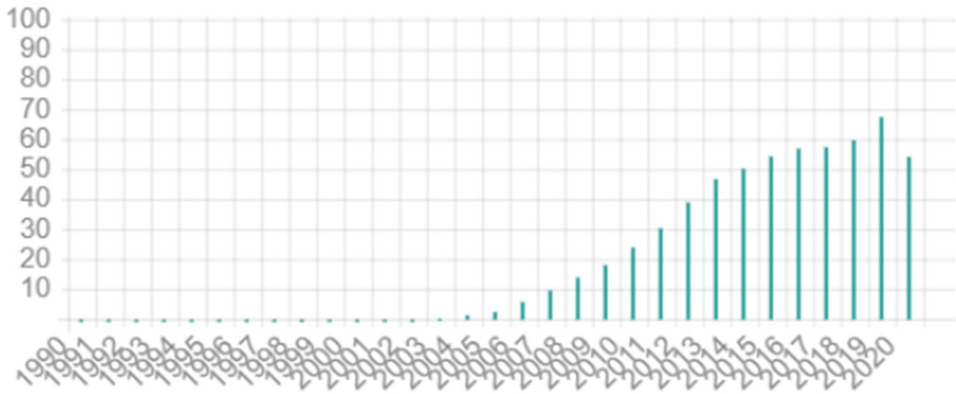


Figure 3–331 Percentage of mobile line subscriber population

Source: WorldData.info

Table 3–241 Key indicators for the Comoros' telecommunications sector

(ITU estimates, 2017)

Indicator	(Federal Islamic Republic of the) Comoros	Africa average	World average
Fixed-telephone sub. per 100 inhab.	2.1	0.9	13.0
Mobile-cellular sub. per 100 inhab.	54.9	74.4	103.6
Active mobile-broadband sub. per 100 inhab.	37.8	24.8	61.9
3G coverage (% of population)	89.8	62.7	87.9
LTE/WiMAX coverage (% of population)	73.0	28.4	76.3
Individuals using the Internet (%)	8.5	22.1	48.6
Households with a computer (%)	9.2	8.9	47.1
households with a computer (%)	5.6	19.4	54.7
International bandwidth per Internet user (kbit/s)	17.4	11.2	76.6
Fixed-broadband sub. per 100 inhab.	0.2	0.6	13.6

Source: ITU

Table 3–242 Number of Communication Line Users and Population Ratio in Comoros (2020)

	Total number (subscribers)	Population ratio (%)
Broadband users	912	0.1
fixed-line subscriber	7,573	0.87
Mobile subscribers	472,815	54.37

Source: WorldData.info

In order to improve the situation of the telecommunication sector in Comoros, since 2013 the WB Group has been supporting Comoros' efforts to improve the telecommunication sector. WB, under the 4th Phase of the Regional Communications Infrastructure Program (RCIP-4), a project launched in late 2013. A total of US$22 million was raised from IDA and deployed in Comoros. This had three objectives in the Comoros' telecommunications sector: (1) to promote competition, (2) to support the participation of private companies, and (3) to reform laws and regulations. IFC, the private unit of WB Group, was invited by the government of Comoros to facilitate another privatization of CT in 2016, but the CT privatization process was rejected by the Comoros parliament, which feared the impact of potential redundancies ahead of the presidential election. This was due to the fact that CT is the largest employing business in Comoros with more than 2,000 employees, and many residents receive subsidized income directly or indirectly from the CT (e.g., commission income from selling or transferring cell phones on their behalf). After failing to privatize CT, the IFC built a new PPP framework instead of fully privatizing CT. This is a business scheme to transfer CT's submarine fiber optic network assets (EASSy and FLY-LION3, two international submarine cables and an inter-island network) to Comores Cables, a new company jointly owned by CT, Telma Comoros and the government of Comoros. The business scheme is to get connection service fee for the broadband services from mobile operators and ISPs. FLY-LION3 is a new submarine cable that will connect Mayotte and Madagascar and will interconnect with two existing international undersea cables (EASSy and LION-2). In addition, the IFC lent Telma Comoros €13 million to finance the development of its domestic network. On the other hand, CT has lost market share and it has resulted in unsustainable levels of headcount and debt, but with the change in CT management team in February 2018, CT is now looking forward to restructuring. CT also launched 4G mobile service in July 2018.

The third pillar, following the promotion of competition and private sector participation, was the reform and efficiency of legal regulations. About 15% of the funds from RCIP-4 was allocated to improve efficiency of the work of ANRTIC, the telecom sector regulator. Specifically, it included the enactment of new telecommunications legislation, the issuance of licenses to the three operators in the country, liberalization of the ISP sector, and support for frequency allocation. Until 2014, the role of ANRTIC was formal because CT dominated the telecom market, but in the new competitive environment after 2014, ANRTIC is expected to play an important role in ensuring a fair competitive market. RCIP-4 provided training and technical assistance to enable ANRTIC to take on this new role.

The budget allocation for RCIP-4 is described in detail below. The budget size of RCIP-4, which came into effect in November 2013, was initially US$22 million and consisted of three components, as shown in the table below.

Table 3–243 Project Components of RCIP-4

Component	Objective	Budget size	Main work
1	Enabling Environment	3.3 million US dollars	Promoting further regional market integration, sector liberalization and legal and regulatory reforms. Assisting the government with the submarine cable FLY-LION 3, including environmental studies, feasibility studies and demand analysis.
2	Connectivity	US$17 million	2.1. Financing Comoros's membership and participation in the FLY-LION 3 cable consortium; 2.2. Providing demand stimulation through the advance purchase of capacity for target beneficiaries; 2.3. Additional measures to stimulate demand: promoting the creation of new Internet Service Providers (ISPs) and establishing an Internet Exchange Point (IXP).
3	Project management	US$1.5 million, plus US$0.2m in contingency funds	Supporting project management, including coordination, training, equipment, procurement, financial management, audit monitoring and evaluation, etc.

Source: WB[105]

The WB Group uses an indicator called DLI (Disbursement Linked Indicator) to quantitatively understand the effect of investment. The main DLIs adopted in RCIP-4 are listed in the table below.

Table 3–244 Major DLIs adopted in RCIP-4

Component	Index Name	DLI (Actual as of 2019)	DLI (Target for 2020)
Common	Total number of Internet subscriptions (Number)	5,416.00	300,000.00
	Mobile internet subscriptions (Number)	0.00	295,000.00
	Population (Number)	735,375.00	800,000.00
	Fixed-line internet subscriptions (Number)	5,416.00	16,300.00
	Total number of mobile subscriptions (per 100 inhabitants) (Number)	27.39	72.75
	Fixed mainlines (Number)	23,600.00	18,000.00
	Mobile subscriptions (Number)	216,438.00	582,000.00
	Direct project beneficiaries (Number)	0.00	0.00
	Female beneficiaries (Percentage)	50.00	50.00
Compo 1 (Enabling environment)	Number of licensed ISPs (Number)	1	4
Compo2 (Connectivity and demand stimulation)	Broadband Internet Subscriptions (Number)	150.00	300,000.00
	Fixed-line broadband subscribers (Number)	150.00	16,530.00
	Mobile broadband subscribers (Number)	0.00	49,500.00
	Fixed and mobile broadband subscriptions per 100 inhabitants (Number)	0.02	37.70

[105] https://www.gtai.de/resource/blob/30748/125b0be4173031787db4e195eacc0915/pro201810085001-data.pdf

Component	Index Name	DLI (Actual as of 2019)	DLI (Target for 2020)
	Broadband subscribers as a percentage of total ICT subscriptions (%)	0.04	50.00
	Number of E-Systems connected to an interoperable Government-administered digital platform (Number)	0.00	3.00
	Number of female beneficiaries of the co-working space (Number)	0.00	100.00
	Number of crowdsourced reports from citizens on quality of service for telecommunication services (Number)	0.00	4.00

Source: WB[106]

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

As described in 2) Market Overview, Comoros, being an island nation, relies mostly on submarine cables for its communications. In January 2022, an underwater volcanic explosion off the coast of Tonga shut down Tonga's international communications for 12 days. It is believed that this was due to the damage to the submarine cable at least twice, caused by tsunamis and landslides on the seabed following the explosion of an underwater volcano, and also because the power supply from the landing station on the Tongan side stopped. In the case of the Comoros, the landing stations for both EASSy and FLY-LION3 are located in Moroni. The landing station itself is not at high risk of landslides due to flooding, etc. However, as in Tonga, there is a risk of damage to the submarine cable due to earthquakes or submarine volcanic activity. However, unlike weather disasters, the frequency of volcanoes and earthquakes is small, making it difficult to address this risk.

106 https://www.gtai.de/resource/blob/30748/125b0be4173031787db4e195eacc0915/pro201810085001-data.pdf

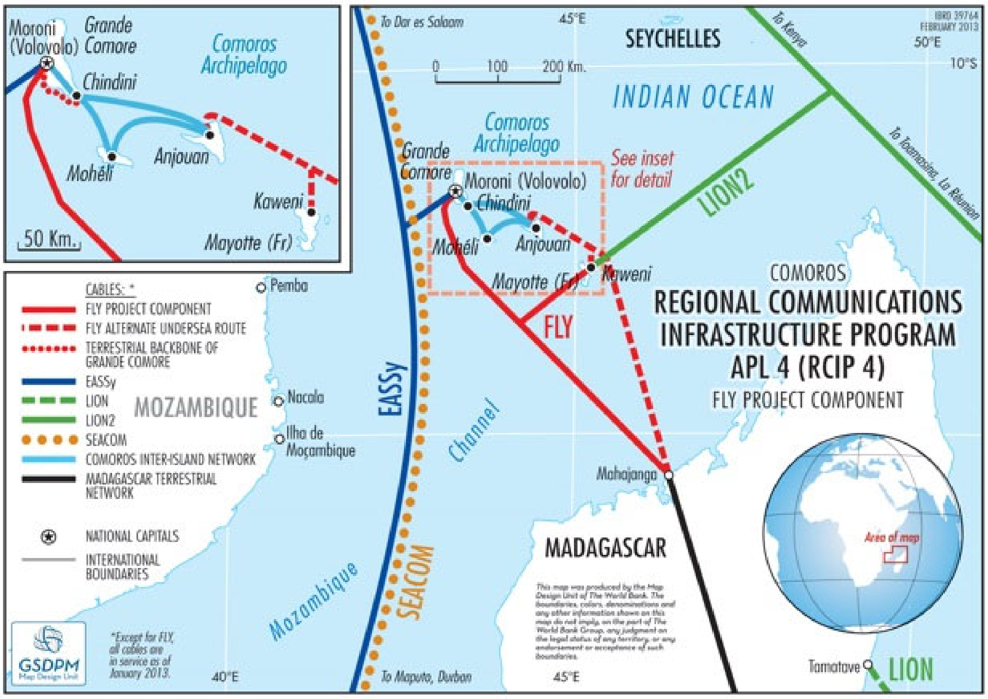


Figure 3–332 Connection diagram of FLY-LION3 and existing submarine cable[107]

Source: GSDPM

4) Consideration of Disaster Risk Reduction Measures

In order to cope with the blockage of international communication due to the damage of submarine optical cables as described in 3), it is desirable to secure the minimum satellite communication lines as backup lines. In fact, in the case of Tonga, after the submarine cable was damaged, the government of Tonage signed a 15-year contract with a satellite telecommunication service provider (Kacific) to maintain satellite telecommunication. A lesson and learns from Tonga is needed to determine how much bandwidth (speed) should be prepared for backup satellite telecommunication channels.

[107]https://alais.org/improving-international-connectivity-in-comoros/
https://blogs.worldbank.org/digital-development/how-wdr16-policy-framework-applied-union-comoros

(5) Agriculture

In the Comoros, the agricultural sector accounts for 34.4 % (2019) of the working population, with agriculture, forestry and fisheries accounting for 33.10 % (2019) of total GDP and 38.7 % (2013) of exports. Most of the people engaged in agriculture are engaged in subsistence farming of about 1.1 ha. The country supplies 59% of its own food demands. The main agricultural products are staple foods such as banana, cassava, taro, sweet potatoes and fruits, vegetables such as onions and aubergines, and coconut. Vanilla, cloves, coffee and ylang-ylang are also produced as cash crops.

The country has 131,000 ha of arable land, which is 70.3% of the total land area. Much of its agricultural production is rain-fed, which makes it vulnerable to climate change.

1） Overview of Relevant Organizations and Legal systems

a) Related organizations

i) Ministry of Agriculture, Fisheries, Environment, Tourism and Handicrafts / Ministre de l’Agriculture, de la Pêche, de l’Environnement, du Tourisme et de l’Artisanat (MAPETA)

MAPETA has been established as a body to develop and promote plan and policies related to agriculture, fisheries, environment, tourism and handicrafts.

ii) National Research Institute for Agriculture, Fisheries and Environment / l’Institut national de la recherche pour l’agriculture, la pêche et l’environnement (INRAPE)

INRAPE exists under the authority of MEAPE and is responsible for designing and implementing research programmes and studies on agriculture, fisheries and the environment; plant, animal and forestry production and its food processing; the conservation and improvement of the natural resources involved in each production; and the promotion and implementation of research and experiments on agricultural land and their socio-economic environment.

b) Legal system

There are no laws or regulations in the agriculture sector relevant to this study.

2） Overview of Related Plans and Development Status

a) Related plans

There are no plans such as agricultural master plans in the Comoros, but there are national development plans related to agriculture, nutrition and food security as summarised below.

Table 3–245 Development plans related to agriculture, nutrition and food security

Plan	Overview
Accelerated Growth and Sustainable Development Strategy / Stratégie de Croissance Accelerée et de Développement Durable 2015-2019 (SCA2D)	One of the objectives is to promote agricultural production and to reduce hunger, food insecurity and malnutrition. Four priority areas have been identified for the implementation of agricultural sector policies: a) sustainability of production conditions; b) strengthening of value chains; c) institutional development; and d) strengthening of relevant agencies and organisations supporting the agricultural sector. The disaster management sector aims to strengthen the capacity for rapid response and management of natural disasters, relief and civil protection, and appropriate water management capacity (at national and local levels) to reduce the risks to water resources posed by climate change.
Plan for Implementation, Monitoring and Evaluation of the National Nutrition and Food Policy / Plan de Mise en Œuvre & de Suivi et Évaluation de la Politique Nationale de Nutrition et d'Alimentation 2014-2019	One of the operational objectives for “Strategic Axis 1: Improving household food security” is to "increase agricultural productivity and production in rural and peri-urban areas by 6-10%" by 2019. To achieve this target, activities to strengthen technical capacities in food crop conservation and to enhance cultivation techniques to increase productivity are proposed. The operational objectives for “Strategic Axis 4: Emergency Preparedness and Nutrition” are to a) reduce the impact of food crises and emergencies, and b) strengthen capacity for rapid assessment of nutritional status after disasters and emergencies.
National Action Plan to Combat Desertification in the Comoros / Plan d’Action National pour la Lutte Contre la Désertification aux Comores (PAN/LCD)	In response to threats and crises affecting agriculture, nutrition and food security, the following activities are planned: a) develop management plans for key watersheds; b) reforest springs and riverbanks; c) improve and strengthen national frameworks for combating desertification and land degradation; d) build systems for collecting and disseminating information on agricultural land changes; e) strengthen technical and scientific capacity and knowledge on desertification and land degradation; e) strengthening technical and scientific capacity and knowledge on desertification and land degradation; and f) supporting the development of systems for monitoring climate change and early warning of climate events.
National Food and Nutrition Policy / Politique Nationale de Nutrition et d'Alimentation	Strategic Programme 5 sets out emergency preparedness and nutrition responses. Specifically, it includes strengthening the capacity to prevent and manage food crises and emergencies; establishing a national fund for humanitarian action and the restoration of productive capacities and means in the event of natural disasters and climate change; and strengthening the emergency response on islands to assess emergencies for early warning and response and to organise emergency relief.
National Action Programme for Climate Change Adaptation / Programme d’Action	Within the framework of PANA, projects are planned to establish a bank for drought-adapted seeds and varieties, train professionals, increase food production by reducing harvest losses and improve access to food for vulnerable groups. Projects are also envisaged to

National d'Adaptation aux changements climatiques (PANA)	improve degraded soils and prevent soil erosion, thereby increasing the area of useful agricultural land and limiting agricultural encroachment on forests, and to establish a national climate risk monitoring and early warning system.

b) Development Status

i) Japan's Assistance Policy

Japan has adopted a basic policy of promoting human security and economic and social development for the Comoros. The main initiatives in the agricultural sector are to support agricultural development to improve food self-sufficiency, and to support development in the fisheries sector to improve livelihoods and nutrition through the use of fisheries resources, in order to achieve economic independence. Support will also be provided in the areas of disaster management and biodiversity.

In recent years, the main support from Japan in the agricultural sector related to this study has been the annual support for improving food security (grant aid "food aid"), which has been provided since 2008.

ii) Assistance by related donors and private sectors

Recent support and trend of relevant donors are summarised below.

Table 3–246 Assistance by related donors and private sectors

Project/Donor	Summary	Duration / Cost
Integrated Development and Competitiveness Project / WB	Promote the development of micro, small and medium enterprises (MSMEs) and related value chain actors in agriculture, tourism and relevant sectors.	2019 - 2024 US$ 25.00 million
Family Farming Productivity and Resilience Support Project / IFAD	Support on climate-smart family farming practices, market linkages and income generation to increase agricultural production and climate resilience of 35,000 vulnerable small holder farmers and support income increase and their food and nutrition security.	2017 - 2022 US$ 17.75 million

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Damages to the agricultural sector in the recent disasters are as follows.

Table 3–247 Damage and loss to the agricultural sector

Year	Area	Outline
Apr. 2019 Tropical cyclone Kenneth	Anjouan Island, Grande Comoros Island, Moheli Island	・ Total affected Crops: Approx. 80% of crops were destroyed, causing food shortages and staple food prices to rise (Flood damage)
Apr. 2012 Flood+Land slide	Moloni Island	・ Damage to agricultural land and infrastructure ・ Total affected Crops: landslides and rockslides caused by heavy rain damaged crops (up to 70% in Anjouan) ・ Total affected Livestock: 473 head of cattle, 740 small ruminants and 4,740 chickens

According to the Recovery Plan for the flood in 2012, the heavy rains brought by the cyclone caused rivers to overflow and the resulting mudslides destroyed agricultural land. The disaster further aggravated already weakened food production systems. It is characterised by the lack of agricultural inputs (seeds, tools, etc.), lack of extension services, accelerated soil erosion due to traditional farming without crop rotation, tillage and organic inputs, poor storage facilities, lack of rural finance and credit, and poor water management and infrastructure.

4） Consideration of Disaster Risk Reduction Measures

Based on the damage from the previous rainfall and cyclones, it is considered that flood control measures (river embankment, river channel excavation, etc.) and landslide prevention measures (installation of retaining walls, surface water removal works, etc.) are effective to protect agricultural land. As information on the Comoros was only collected through a desktop survey, it is necessary to identify issues and confirm local needs related to disaster prevention based on the details of the damage (causes of the disaster, areas, etc.) in order to consider specific disaster prevention measures.

(6) River Management and Coastal Management

1） Overview of Relevant Organizations and Legal Systems

In the Comoros, the Ministry of Energy, Agriculture, Fisheries and Environment (MEAFE) can be named as the body responsible for river management. MEAFE is the ministry responsible for integrated river management. MEAFE is also the ministry responsible for the Green Climate Fund, a fund related to climate change, and has implemented projects using the fund.

2） Overview of Related Plans and Development Status

A related plan is the National Adaptation Plan of Action (NAPA), which has been formulated in the framework of climate change. In the context of climate change, the plan contains Action Plans on adaptation measures for the agricultural and water resources sectors, and the NAPA has organized measures to deal with the main crises in the Comoros, such as loss of water resources, drought, water shortages and damage caused by meteorological phenomena.

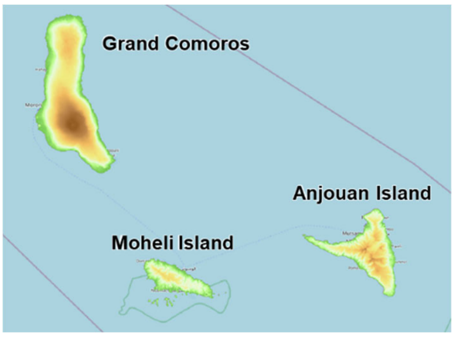
Other plans related to river management could not be identified through the desktop research.

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

a) Topographic and climatic conditions in the Comoros

The Comoros is an island nation consisting of three main islands: Grand Comoro, Anjouan and Mohéli. As there is no data available on the Internet for observatories in the Comoros, the average monthly rainfall on the French Mayotte located in the south-east is shown.

- Average monthly rainfall shows heavy rainfall in the period November-April and little rainfall in the period May-October.
- The average annual total rainfall is around 1,200 mm, which is slightly less than the annual total of 1,600 mm in Tokyo. The Comoros is also on the route of cyclones, and heavy rainfall between December and March, when most cyclones occur, is a characteristic of the region.



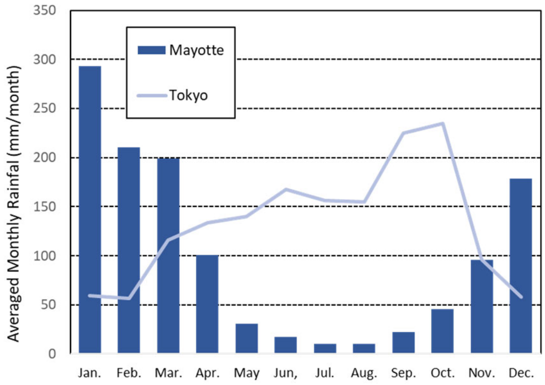


Figure 3–333 Average rainfall in the Comoros

Source: Japan Meteorological Agency website

Regarding the damage caused by cyclones, the country was hit once in the 1950s, five times in the 1980s, once in the 1990s, once in the 2000s and once between 2010 and 2015, which is relatively fewer than Madagascar, which was hit 59 times between 1950 and 2015, and Mauritius, which was hit 31 times.

In addition to this, floods, not caused by cyclones, have affected the country a total of around seven times between 1970 and 2015.

Regarding flooding, in 2012, when a total of 1,783 mm of rain fell over a five-day period, flooding occurred, as shown in the figure below.

Figure 3–334 During the floods in 2012

Source: Southwest Indian Ocean Risk Assessment Financing Initiative (SWIO-RAFI): Component 1 - Hazard

b) Status of donor support

The program in the Comoro is aimed at addressing water scarcity in a changing climate, with support from UNDP through the Green Climate Fund. "Ensuring climate resilient water supplies in the Comoros Islands" is being implemented. The MEAFE is the responsible ministry and aims to reduce the impact on drinking water and irrigation water associated with extreme climatic events, including droughts and floods.

There are three objectives as Outputs of the program. The three objectives are: to use climate-related information in water supply planning and management, to promote water resources management, including weather forecasting and early warning, and to develop a resilient water supply infrastructure. The main focus is on measures to secure water resources, but also includes flood forecasting and early warning, and flood resilient water supply infrastructure.

c) Status of Hazard Map Maintenance

The status of the development of hazard maps in the Comoros could not be confirmed. As described in the Disaster Risk Analysis section of this report, a Disaster Risk Profile has been developed by the GFDRR, of which the World Bank is the secretariat, which has examined areas with a high potential for floods from the 100-year probability flood.

Hazard maps show the flooded areas of the capital, Moroni, as well as the second largest city, Moutsamoudou on Anjouan.

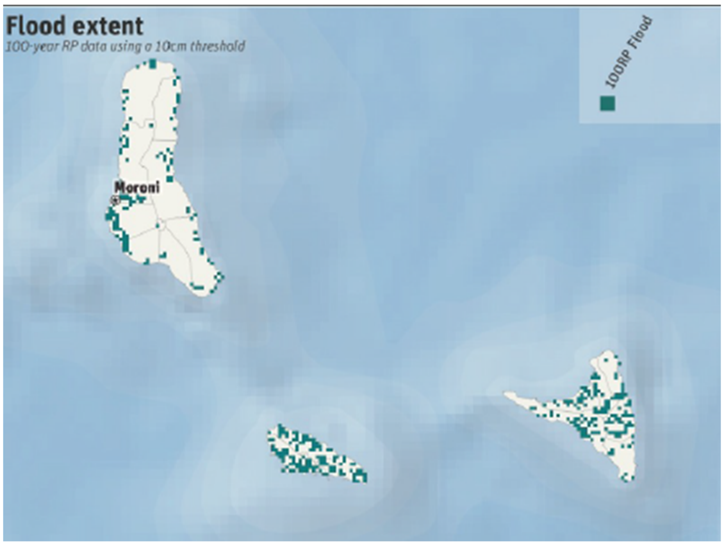


Figure 3–335 Flooded area due to 100-year probability rainfall in the Comoros

Source: GFDRR

4) Consideration of Disaster Risk Reduction Measures

In the Comoros, we attempted to collect information through a desktop research. Although we were able to confirm the support provided by donors, we were not able to confirm the implementation of specific measures.

For concrete measures to be considered, it is necessary to understand the current situation, including field surveys, and to consult and coordinate with other institutions.

3.7 Seychelles

3.7.1 Disaster Risk Profile

(1) Qualitative Evaluation of Hazard Distribution

1) Situation of Hazard Distribution in Madagascar

The hazard data described in "2.1.2 How to identify overview of disaster risk" was visualized in GIS to identify the profile of hazard as shown in the figure below.

- Seychelles is an island nation located at the south of the equator and not a cyclone prone area, although cyclones have passed through the area. For this reason, the hazard from strong wind and Storm Surge is not high. Meanwhile, the area was affected by a cyclone landfall in 2016, which is a low frequency but have a potentially to cause severe damage.
- Although there are no flooded areas in the global model flood analysis, previous JICA research has identified river flooding in small rivers near Victoria, and a detailed analysis is required to understand the risks associated with flooding in these rivers.

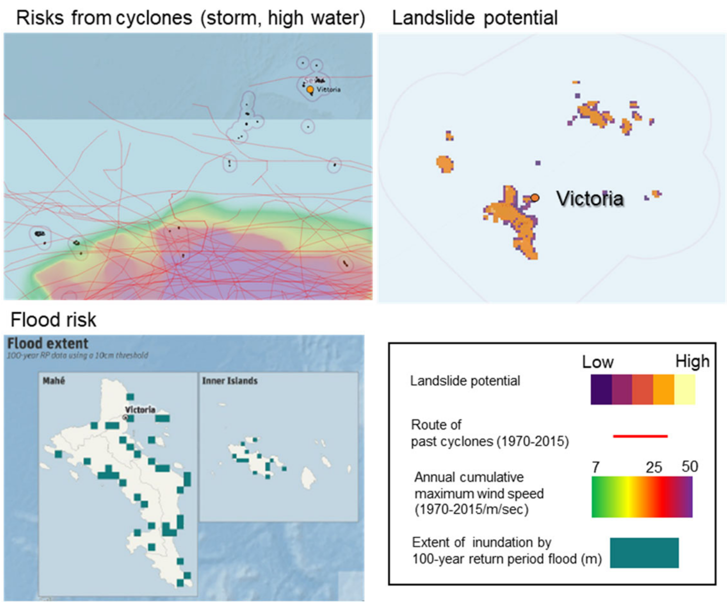


Figure 3–336 Hazard distribution in Seychelles

Source: Each data source is listed in Chapter 2, Open Street Map (background map)

2） Situation of Hazard Distribution in Major Cities of Madagascar

Situation of hazard distribution in each major city was identified according to the criteria shown in "2.1.2 Basic Idea and Methodology to Identify Disaster Risk Profile ". The population of major cities was confirmed based on UN-Habitat and World Population Review, and the major cities with large population sizes were sorted out.

The only city with a population of more than 10,000 people is the capital city of Victoria.

The table below shows the distribution of hazards in each city. and the figure to show the distribution of each hazard as a basis for qualitative judgment.

Table 3–248 Hazard Status in Major Cities in Seychelles

City name	Population size (thousand person)	Hazard Status			
		Floods	Cyclones	Storm Surge	Landslides
Victoria	22	✓✓	✓	✓	✓✓

Source: JICA Study Team

a) Victoria

Victoria is the capital city located in the Mahe Island and the level of hazard was analysed based on the distribution of each hazard.

Flood hazard was evaluated as "✓✓" based on the analysis conducted by GFDRR (Figure bellow (1)). Storm surge hazard and Hazard of the strong wind was evaluated as "✓" since although inundation area is not distributed but it is located in an area affected by Cyclone. Landslide hazard was evaluated as "✓✓" since area with high landslide potential score over the medium level is distributed in the city. (Figure bellow (2)).

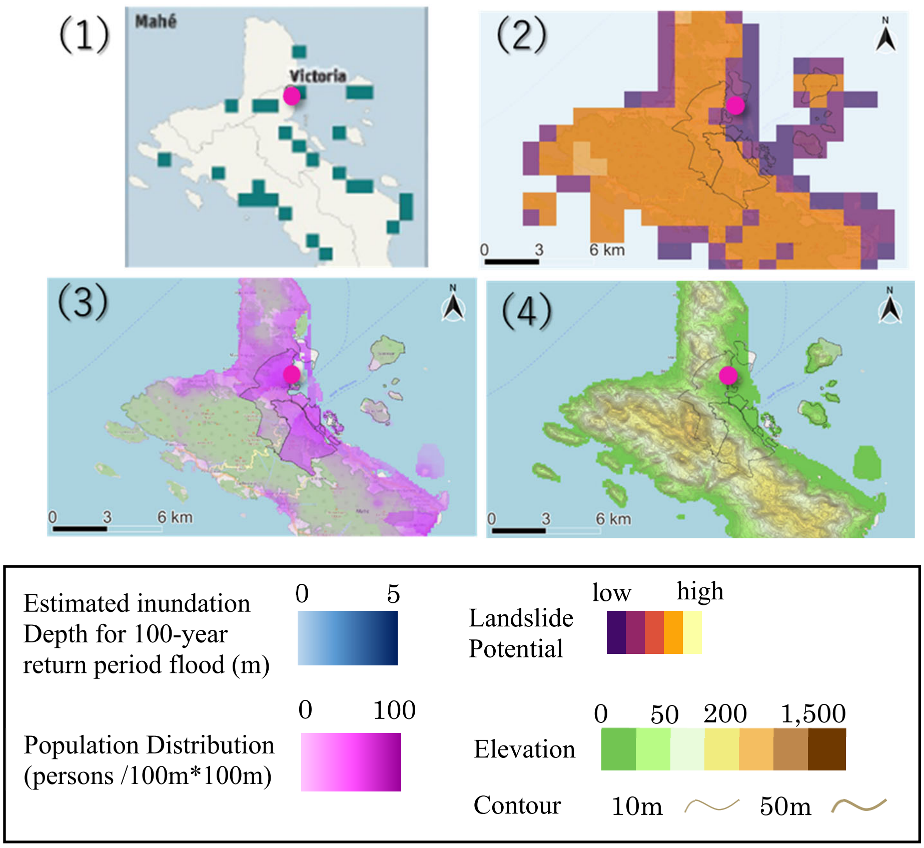


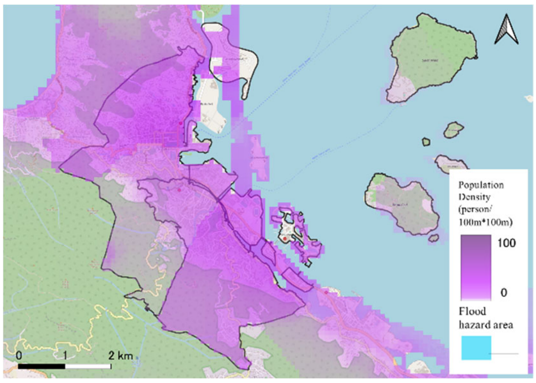
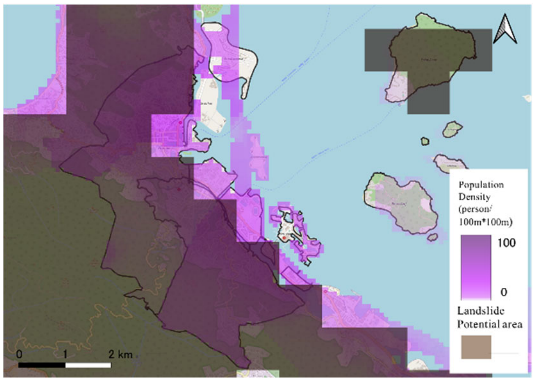
Figure 3–337 Situation of Hazard Distribution in Victoria

Source: JICA Study Team

(2) Estimation of Potential Economic Loss due to Disasters

A more detailed assessment of disaster risk was carried out for Victoria. For GDP per capita, the World Bank's published figures for 2020 were used.

Table 3–249 Distribution of Hazard and Population in Victoria, Seychelles

Cyclone routes and population distribution	Landslide and population distribution
	

Source: JICA Study Team

Table 3–250 Distribution of Hazard and Population in Victoria, Seychelles

Hazard	Target city	Victoria
Flood	Damaged area (km^2)	0
	Damage area ratio (%)	0%
	Population affected ('0000 persons)	0.0
	Estimated damage (million USD)	**0**
Landslide	Damaged area (km^2)	16
	Damage area ratio (%)	74%
	Population affected ('0000 persons)	1.8
	Estimated damage (million USD)	**9**

* GDP per Capita (Current USD / person) used the data from WB
the value in the year 2020 which is (10,764.4 USD / person) was used

Source: JICA Study Team

In Victoria, the hazards of floods and cyclones are not significant, but the hazard distribution of landslides is wide, resulting in high economic loss potential due to landslides.

On the other hand, it is difficult to understand localized floods by analysing the assumed inundation area using a global model. Therefore, detailed analysis is necessary to understand the economic loss potential of flash floods and mudslides that occur on steep slopes and along rivers. Since these events are localized, it is important to prioritize countermeasures through detailed analysis of the location of important facilities in high hazard areas.

(3) Damage and Loss Disaggregated by Sector

1） GFDRR Disaster Risk Profile

Damage estimates for cyclone and flood disasters in Seychelles have been reviewed, categorized into buildings (residential), commercial and industrial, public facilities and infrastructure. Damage estimates are calculated for each sector on a 10-year probability scale, a 100-year probability scale, and a 250-year probability scale. Furthermore, based on these probability scale damage estimates, Average Annual Loss (AAL) is calculated.

Table 3–251 Sectoral Damage Estimates in Seychelles in GFDRR Disaster Risk Profiles

Disaster type		Cyclones	Flood
Conditions for analysis		Estimated annual damage	Estimated annual damage
Building (residence)	Amount of damage (Thousand USD)	200	1,500
Commercial and industrial	Amount of damage (Thousand USD)	150	1,000
Public facilities	Amount of damage (Thousand USD)	20	150
Infrastructure	Amount of damage (Thousand USD)	3	4

Source: Summarized by the JICA Study Team from GFDRR Disaster Risk Profile (Seychelles)

In the GFDRR disaster risk profile the distribution of disaster risks by province is visualized by disaster type and by sector as follows:

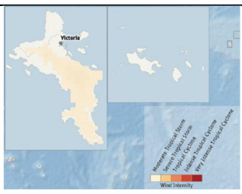
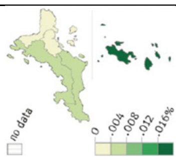
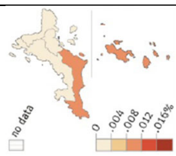
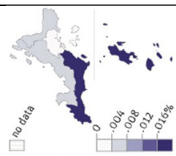
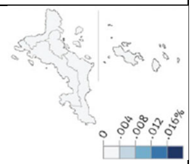
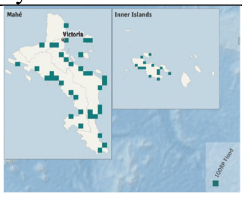
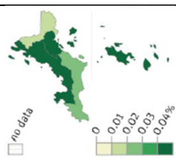
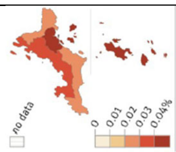
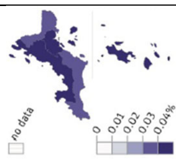
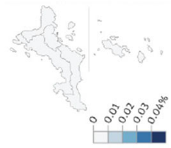
	Hazard distribution	Residential buildings	Commercial and Industrial	Public facilities	Infrastructure
Cyclones	 *Wind speed of 70 km/h or higher and Storm Surge of 30 cm or higher due to a 100-year probability cyclone	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)
Floods	 *Flooded area due to100-year probability flood	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)	 *National ratio of estimated annual damage (%)

Figure 3–338 Distribution of Disaster Risk by Type and Sector

Source: Compiled by the research team from GFDRR Disaster Risk Profile (Seychelles)

Regarding damage by sector, the amount of damage in commercial and industrial sectors is comparable to the amount of damage to houses, so the importance of disaster measures for commercial and industrial facilities is also high. In particular, as described in the subsequent analysis of the PDNA, the impact of the disaster on tourism in Seychelles has been observed, and it is also important to reduce the impact of the disaster on tourism.

The regional distribution of disaster risk is higher in the Inner Islands, 30 km north-east of Mahe, where Victoria is located. On Victoria Island, the risk of cyclones in the east of the island and floods in the west of the island and Victoria is high.

Seychelles is not located in a cyclone prone area and has suffered relatively little damage compared to other island countries. However, as Seychelles has experienced cyclone landfalls, it is necessary to consider disaster preparedness and the impact of cyclones on Seychelles' main industry, tourism.

2) Sectoral damage summarized in PDNAs

In the Seychelles, PDNAs have been prepared for two disasters, the 2013 flood and the 2016 cyclone, and the amount of damage are organized in the table below. The amount of damage to agriculture, industry and commerce, tourism, houses and transport infrastructure is significant. It is characterized by a particularly large impact on the tourism sector. In addition, damage to the transportation infrastructure is greater than damage to houses.

Although the Seychelles is less frequently affected by cyclones than other countries, it is clear that tourism is severely affected by cyclone.

Table 3–252 Damage to each sector by PDNA in Seychelles (million USD)

Sector		2016 (Cyclones)	2013 (Flood)	Total
Industry	Agriculture	0.1	1.4	1.5
	Fishery	0.0	0.0	0.0
	Industrial, commercial, and other damage	0.4	0.8	1.1
	Sightseeing	1.1	0.0	1.1
Social assets	Houses	0.7	1.2	1.9
	Education	0.0	0.3	0.3
	Hygiene	0.0	0.6	0.6
	Other	0.0	0.0	0.0
Infrastructure	Traffic	0.2	2.9	3.1
	Electricity and communications	0.2	0.0	0.2
	Water and sewage	0.1	0.1	0.2
	Other	0.0	0.1	0.1

Source: PDNA

3) Disaster Damage and Loss Statistics

The disaster damage and loss statistics for Seychelles, for the disasters covered (floods, cyclones, Storm Surge and Landslide), aggregate the number of deaths, damage to houses, economic losses, education and health facilities, agricultural land and road damage results for the 592 events between 1980 and 2014, as shown in the table below.

The number of deaths in Seychelles between 1980 and 2014 was five, suggesting that the country has a relatively low disaster risk. However, there has been some damage to education and health facilities and houses, and measures are needed to prepare for the cyclone landfalls.

Table 3–253 Actual Damage by Sector according to Disaster Damage Statistics in Seychelles

Targeted disaster types	Floods, Cyclones, Landslide
Target year	1980-2014
Number of disaster events	592
Number of deaths	5
Total destruction of houses (buildings)	11
Partial damage to houses (buildings)	2,501
Economic loss (USD)	274,752
Economic loss (local currency)	53,279,720
Educational Facilities	6
Public health facility	3
Agricultural land (ha)	6
Road (m)	221

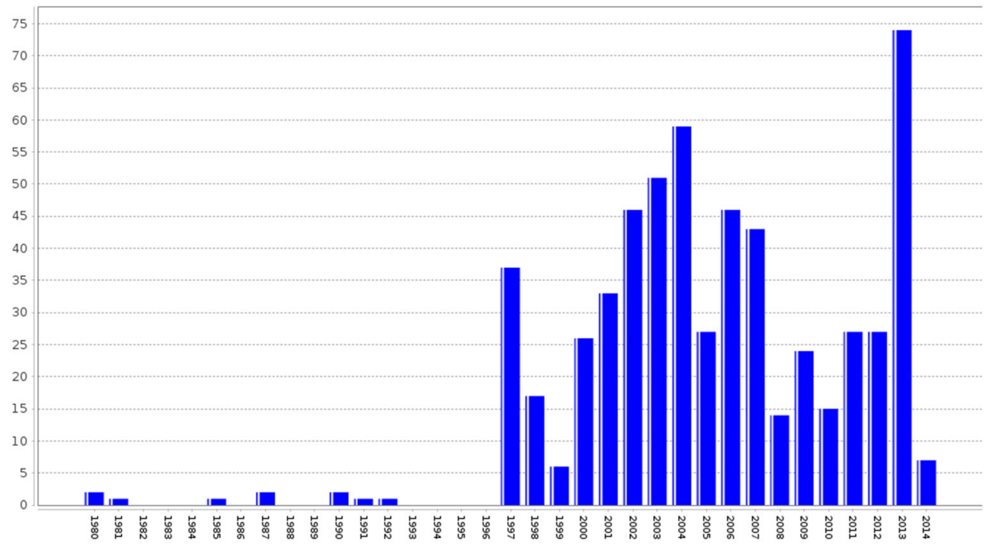
Source: Data collected from DesInventar and summarized by JICA Study Team

In addition, the annual trends of the number of disaster events and the number of damaged houses (destroyed + partial damaged) were confirmed to analyse the trend of damage.

The number of disaster events shows an increasing trend. In terms of the number of houses damaged do not show a increasing trend the value is highest in year 2013.

In Seychelles, due to the climatic conditions and geographical location, it is not a region where small-scale disasters such as floods and landslides occur on a regular basis, and no increasing trend of disaster damage could be confirmed. On the other hand, there have been large-scale disasters such as the 2013 floods and the 2016 cyclone that required the preparation of a PDNA and external assistance. Therefore, in preparation for low-frequency disasters, measures are expected to be taken to regulate locations in areas with high potential for large-scale landslides and flooding, and to protect critical facilities with pinpoint accuracy, such as disaster countermeasures for critical infrastructure.

Recently (after around 2000), due to the improvement of capacity to collect disaster damage and loss data including small-scale disasters, it is difficult to compare the previous and past statistics on the same basis. On the other hand, DesInventar has summarized information on large-scale disasters from the past, so it is possible to identify the rough trends. In DesInventar, information collected after 2005 will be used to evaluate the achievement of the indicators for the global target of the Sendai Framework for Disaster Risk Reduction, so it is expected that the information will be summarized on a uniform basis. Therefore, it is important to check the trend of the statistics continuously in order to understand the damage trend.



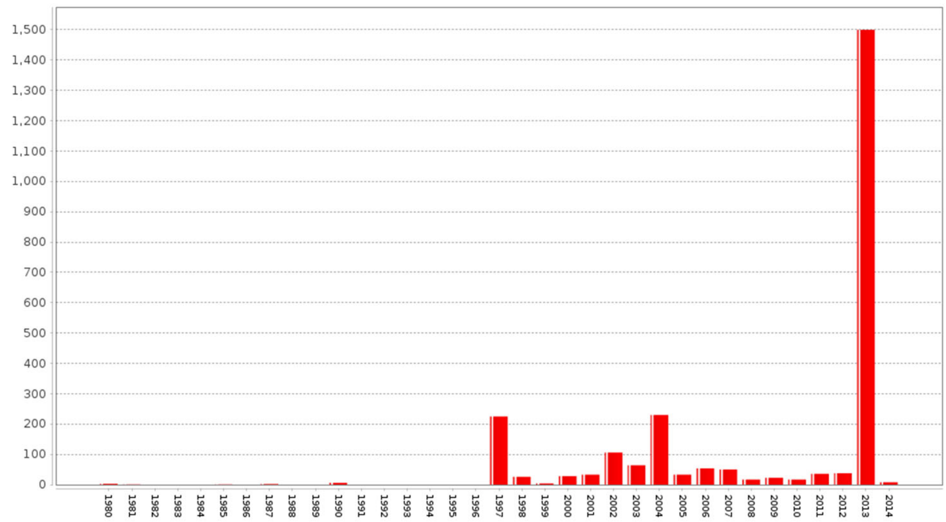


Figure 3–339 Trend of Disaster damage and loss in Seychelles from 1898 to 2018

(Above: Annual Disaster Event, Bellow: Annual damaged houses (destroyed+partial damaged))

Source: DesInventar

3.7.2 Climate Change

(1) Observed and Projected Climate Change

It is hot and humid throughout the year with an average temperature of 26.9°C and humidity of 80% in Seychelles. The average annual precipitation on Mahe Island is about 2,400 mm along the coast, while along the mountainous areas, the average precipitation is higher (about 3,600 mm). It also shows less average precipitation along the northern and southern ends of the island. The average annual precipitation on Bird Island and Dennis Island in the northeast is about 2,000 mm and 1,800 mm, respectively, which is double that of Aldabra Island (about 1,000 mm) and Assumption Island (about 900 mm) in the southwest. from May to October, the southeast trade winds produce a relatively cool and the climate is relatively cool and dry in most areas from May to October. Most of the islands are located outside the cyclone belt and are not directly affected by cyclones. However, when a tropical cyclone occurs in the southwestern Indian Ocean, it can cause strong winds, flash floods, and severe thunderstorms due to its feeder bands. The most significant impacts on socioeconomic activities are annual variations linked to changes in the global circulation, such as the El Niño Southern Oscillation (ENSO) and La Niña Southern Oscillation, which when they occur cause severe water shortages and affect all sectors of the economy, including agriculture.

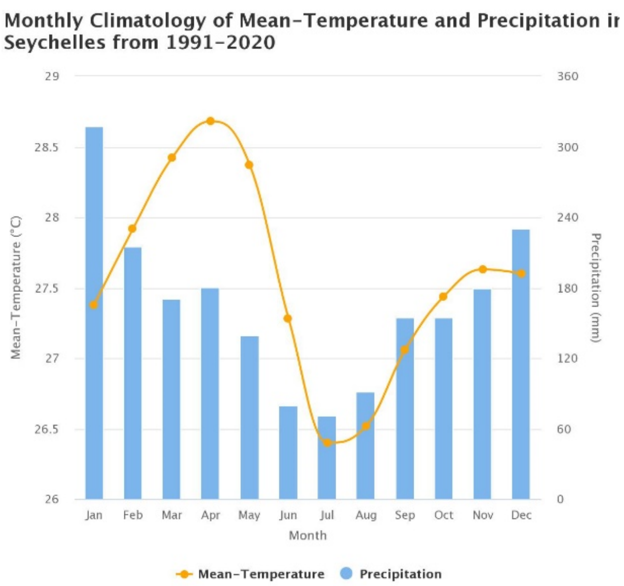


Figure 3–340 Monthly mean temperature and precipitation（1991-2020）

Source：Climate Change Knowledge portal site, WB

It is observed that the average temperature has increased by nearly 1.5°C between 1901 and 2020.

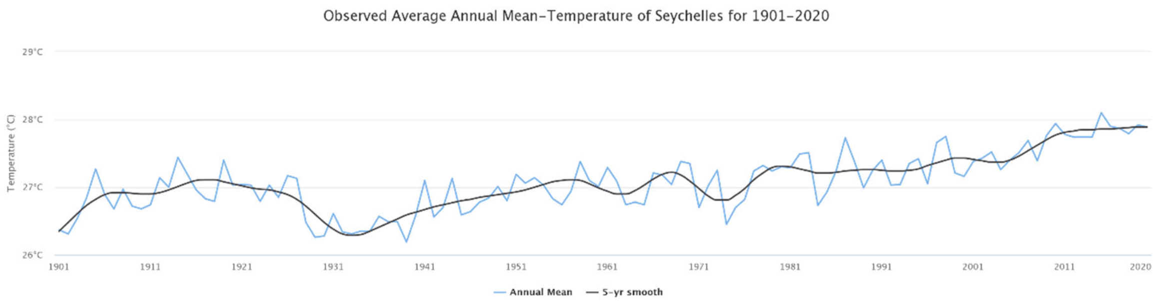


Figure 3–341 Observed average annual mean temperature for 1901-2020

Source: Climate Change Knowledge portal site, WB

In terms of precipitation, there has been a significant increase in the dry season (three times as much as in the wet season), which has become wetter than the period from 1972 to 1990. As a result, there is now an increasing concern about extreme rainfall and resulting flooding.

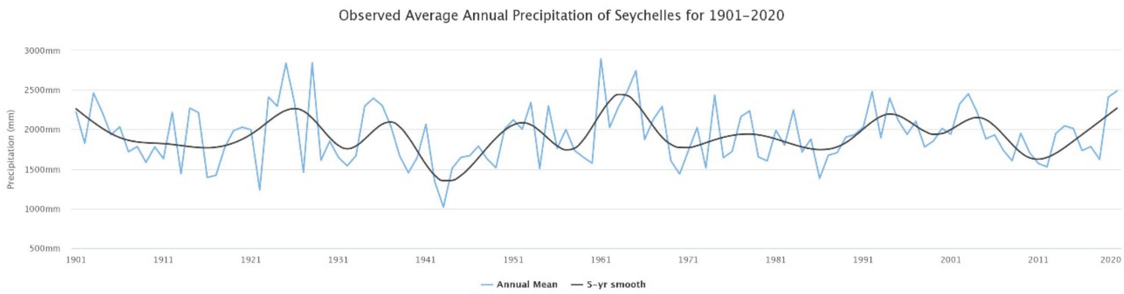


Figure 3–342 Observed average annual precipitation for 1901-2020

Source: Climate Change Knowledge portal site, WB

Among the future projections of climate change, regarding temperature increase, both Mahe Island and Aldabra Atoll are projected to have a high possibility of temperature increase of about +3.0°C. The range of temperature increase is predicted to be +0.4-0.7°C, 0.9-1.4°C, and 1.8-2.9°C in 2025, 2050, and 2100, respectively. In terms of precipitation, there is a high possibility that precipitation in the dry season will decrease, with a projected decrease of -12.7 % in 2025 and -36.3 % in 2100. On the other hand, precipitation during the rainy season is projected to increase by +5.9 % in 2025, +9.3 % in 2050, and +12.4 % in 2100.

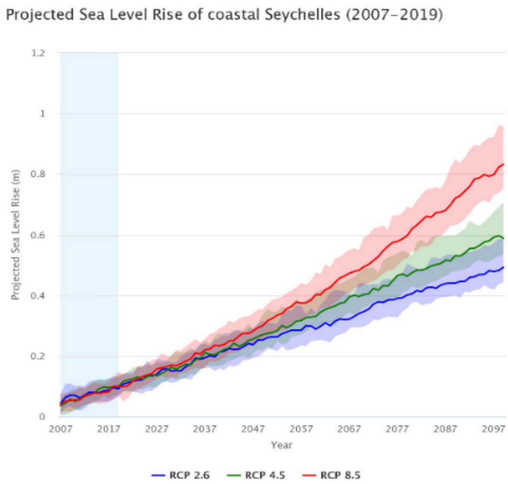


Figure 3–343 Prediction of sea level rise

Source: Climate Change Knowledge portal site, WB

Sea level rise has also already been observed; in May 2007, a storm surge flooded 50 meters inland from the coastline, causing major damage to roads and public infrastructure. Sea level rise is projected to be in the range of 0.4 to 0.9 meters by the end of this century[108]. Due to the high vulnerability of the Seychelles to these climate change hazards, the following sectors are expected to be affected.

Table 3–254 Impacts of climate change

Sector	Impacts
Agriculture	- Changes in rainfall patterns (torrential rains and droughts), damage to crops caused by windstorms and torrential rains - Impact of rising temperatures on livestock and crops - Landslides in mountainous areas - Saltwater intrusion in coastal lowlands - Invasion of salt water in coastal lowlands - Impacts on transportation and storage of imported food products (price hikes)
Fishery	- Impacts on tuna and fishery assets due to changes in ocean temperature and ocean acidification - Short-term impacts on fisheries and aquaculture, including increased risk of disease, parasites, and harmful algal blooms (increasing in severity after 2030)
Coastal area	- Increased inundation and erosion due to loss of coral reefs and breakwater capability - Impacts on coastal infrastructure, fishery and tourism sectors (especially erosion of coral reefs, dune vegetation and beaches)
Health	- More hot days, heavy rains, flooding and landslides, and increased risk of lightning strikes - Increased incidence of diseases such as dengue fever and yellow fever

[108] Climate Change Knowledge portal site, WB

Sector	Impacts
Transportation and infrastructure	- Road damage due to coastal erosion and flooding in lowland areas - Landslides and rockfalls due to heavy rainfall in the highlands - Impacts on water supply, movement of tourists and employees, port operations, import and export of goods and services, fishing boat operations, and inter-island transportation
Disaster Risk management	- Severe flooding and landslides caused by Cyclone Ferren in January 2013. - Heavy rains destroyed existing drainage systems and retaining walls, resulting in flooding, landslides and rock falls. Severe damage was caused to houses, public facilities, roads, bridges, drainage systems, water and sanitation facilities, crops, and farms. - The total damage is estimated at SR104 million (US$8.4 million), equivalent to 0.77% of the country's gross domestic product (GDP). - Infrastructure damage in Farquhar Atoll caused by Cyclone Fantara in 2016. The damage is estimated at US$7.5 million.
Tourism	- Susceptible to flooding and extreme weather events, beach quality degraded by shoreline erosion - Deeply dependent on vulnerable critical infrastructure and protection of the natural environment, the impact is significant.
Biodiversity	-Susceptible to changes in temperature and seawater temperature, changes in precipitation, drought, forest fires, and invasion of alien species

Source: Seychelles' Updated Nationally Determined Contribution

In fact, in May 2007, a very high tide level caused a flood of as much as 50 meters against inland areas, causing damage to roads and public infrastructure. Abnormal rainfall has also caused significant losses to crops. Torrential rains during the El Niño in 1997-98 and the La Niña in 1998-00 caused widespread flooding and significant losses. The fisheries industry alone accounted for 45% of the total loss, followed by agriculture and tourism, which were reported to have been severely damaged. In addition, in January 2013, Pointe Au Sel in the southeast of the island had 184mm of rainfall in 24 hours, and damage to transportation infrastructure and houses due to landslides and falling rocks was reported.

(2) Policies and Strategy for Climate Change

1) National level

Climate change efforts in Seychelles are currently being undertaken by the Climate Change and Energy Ministry of Agriculture, Climate Change and Environment. In addition, the Seychelles National Climate Change Committee (NCCC), established in 1992, has been responsible for the overall coordination of the development and implementation of the national climate program. Currently, the NCCC is integrated into the Global Climate Change Alliance + Steering Committee. The following are some of the climate change-related plans that have been developed within these organizational structures.

Table 3–255 Current status of relevant policies and strategy

Category	Status
National Communication	Initial National Communication, submitted to UNFCCC in 2000 Second National Communication, submitted to UNFCCC in 2011
NDC	INDC, submitted to UNFCCC in 2015 Updated NDC, submitted to UNFCCC in 2021
National Adaptation Programmes of Action (NAPA)	Not submitted
National Adaptatin Plan (NAP)	Not submitted
National plan, policy	Seychelles National Climate Change Strategy 2009 Seychelles Sustainable Development Strategy (2012-2020) Conservation and Climate Adaptation Trust of Seychelles Act 2015 Seychelles Biodiversity Strategy and Action Plan (2015-2020) Seychelles Blue Economy Strategic Policy Framework and Roadmap2018 Seychelles National Climate Change Policy 2020

The following climate change-related plans that have been developed recently provide directions for adaptation to climate change.

Seychelles Climate Change Policy 2020

This report is for evaluates and summarizes of the various climate change initiatives that have been undertaken to date. The overall goal is to promote a coordinated, proactive, effective and coherent response to the global, geographic and regional challenges and opportunities posed by climate change. Among its specific goals are the following.

1. Promoting understanding of climate change and its impact on Seychelles
2. Strengthening capacity and social empowerment at all levels to adequately respond to climate change
3. Mainstreaming and integrating climate change considerations into policies in all sectors and at all levels.
4. Achieving transition to a low-carbon economy.
5. Implementing measures to adapt to the impacts of climate change, increase resilience and minimize vulnerability.
6. Contributing to international negotiations on climate change

Climate change adaptation has also been included in the updated version of the NDC submitted in July 2021. It declares that by 2030, the country will continue to integrate climate change considerations into the plans and strategies of all key sectors through the following priority actions.

- Prioritizing nature-based solutions to protect coastal ecosystems from climate change impacts such as storm surges, flooding and erosion, using the Coastal Management Plan as a guideline for implementation of nature-based solutions;
- Adopting an integrated Ridge-to-Reef approach to coastal management that brings together the Seychelles Marine Spatial Plan, the Coastal Management Plan, the Blue Economy Roadmap, the National Biodiversity Strategy and Action Plan and other ongoing initiatives to guide development in sectors such as fisheries and aquaculture, tourism, agriculture, waste management, water resources, biodiversity conservation and urban development;
- Developing a Port Development Master Plan, which also caters for growth and includes a climate adaptation strategy;
- Improving the management of freshwater resources, implementing the existing Water Resource Management Strategies as part of the Seychelles Water Supply Development Plan, and implementing new strategies to reuse water;
- Developing and implementing a climate change strategy for the tourism sector, incorporating long-term sustainable planning and management of tourism infrastructure, and coastal management, in partnership with the private sector;
- Updating and continuing with the implementation of the Seychelles National Agriculture Investment Plan and promoting climate smart agriculture including water efficient irrigation, rainwater harvesting and expansion of climate adapted crops and livestock;
- Developing and implementing effective, sustainable and license-based fisheries management plans, integrating climate change adaptation, to ensure sustainable use of resources and avoid overexploitation;
- Strengthening sustainable land-use planning and management and effective implementation of integrated sustainable development practices, and;
- Implementing the National Integrated Emergency Management Plan.

Seychelles' climate change adaptation measures are based on the following commitments and targets, which focus on the conservation of the country's blue economy and blue carbon ecosystem.

- Seychelles intends for coastal planning and infrastructure to be regulated at the national and local level to prioritize the consideration of “blue” Nature-based Solutions (NbS) for climate resilience.
- Seychelles will protect its blue carbon ecosystems, i.e., at least 50% of its seagrass and mangrove ecosystems by 2025, and 100% of seagrass and mangrove ecosystems by 2030;
- Seychelles will establish a long-term monitoring programme for seagrass and mangrove ecosystems by 2025 and include the GHG sink of Seychelles’ blue carbon ecosystems within

the National Greenhouse Gas Inventory by 2025;

- Seychelles commits to the implementation of its adopted Marine Spatial Plan and the effective management of the 30% marine protected areas within the Seychelles' Exclusive Economic Zone

2） Regional level

Information on climate change adaptation impact assessments and adaptation measures in rural areas have not been found.

(3) Supports from Other Donors

The 8 supporting partners such as World Bank, EU, UNDP, IRENA, GIZ, TNC, Pew Charitable Trust and SeyCCAT, assisting Seychelles technically and financially to raise their ambitions by updating mitigation and adaptation targets and broadening the scope of our NDCs to cover a greater part of the economy.

Table 3–256 Support from donors (as of 2021)

Donor	Sector	Project name
World bank	coastal erosion, flooding, tidal variations and cyclones	Seychelles' Coastal Management Plan (CMP) 2019-2024 Outline: Several NGOs are implementing coral restoration projects in multiple sites21 and a six-year Adaptation Fund project recently commenced aims to restore 2.5 ha of coral reefs and build capacity in this field
GCF	Coastal	Ridge to Reef project Outline: the project is currently being implemented by the Government of Seychelles with partners from civil society, integrating strategies to protect, manage and restore terrestrial, coastal and marine ecosystems.

Source: Seychelles' Updated Nationally Determined Contribution, 2021

3.7.3 National and Urban Development

(1) National Axis and Strategic Cities

The Seychelles are divided into 25 local administrative divisions, with 22 on Mahe Island, which including one in a remote island. In addition, there are two districts on Praslin Island, and one district combining La Digue Island and the Inner Islands. The Outer Islands are one local administrative division as a whole. Only Victoria, the national capital, is classified as a city. (Urban area population 26,000 (2014))

Since it is a group of remote islands, domestic transportation is mainly by air and ships. Domestic flights run from Seychelles International Airport, located in the eastern part of Mahe Island, to Praslin Island. By sea, regular operation from Victoria Harbor to each island in the country make it possible to move between the islands.

(2) Cross-border Infrastructure

International traffic and logistics are by air and sea, and the base facilities are Seychelles International Airport and Victoria Harbor, both located in Mae Island.

(3) Location of Important Industries

Seychelles' main industry is the beach resorts known as the "Pearl of the Indian Ocean". These resorts are scattered not only on Mae Island, but also on remote islands such as Praslin Island. Resorts on Mae Island are located far from urban areas such as Victoria,

The major industry following the tourism is fishing and fish processing. The fishing products are fish and shellfish, mainly shrimp and tuna, and contributing to earning of foreign currency through exports. The fishery processing is canned tuna, which accounts for the majority of total exports. The landing of fish products is mostly on the Victoria fishing port. With the increase in the number and size of fishing vessels used, and the increase in demand for ice, a new fishing port construction and an upgrade of the existing fishing port were implemented in 2008 with JICA support.

As for agriculture, it exports copra and coconut, which are the raw materials for soap, but their scale is very limited.

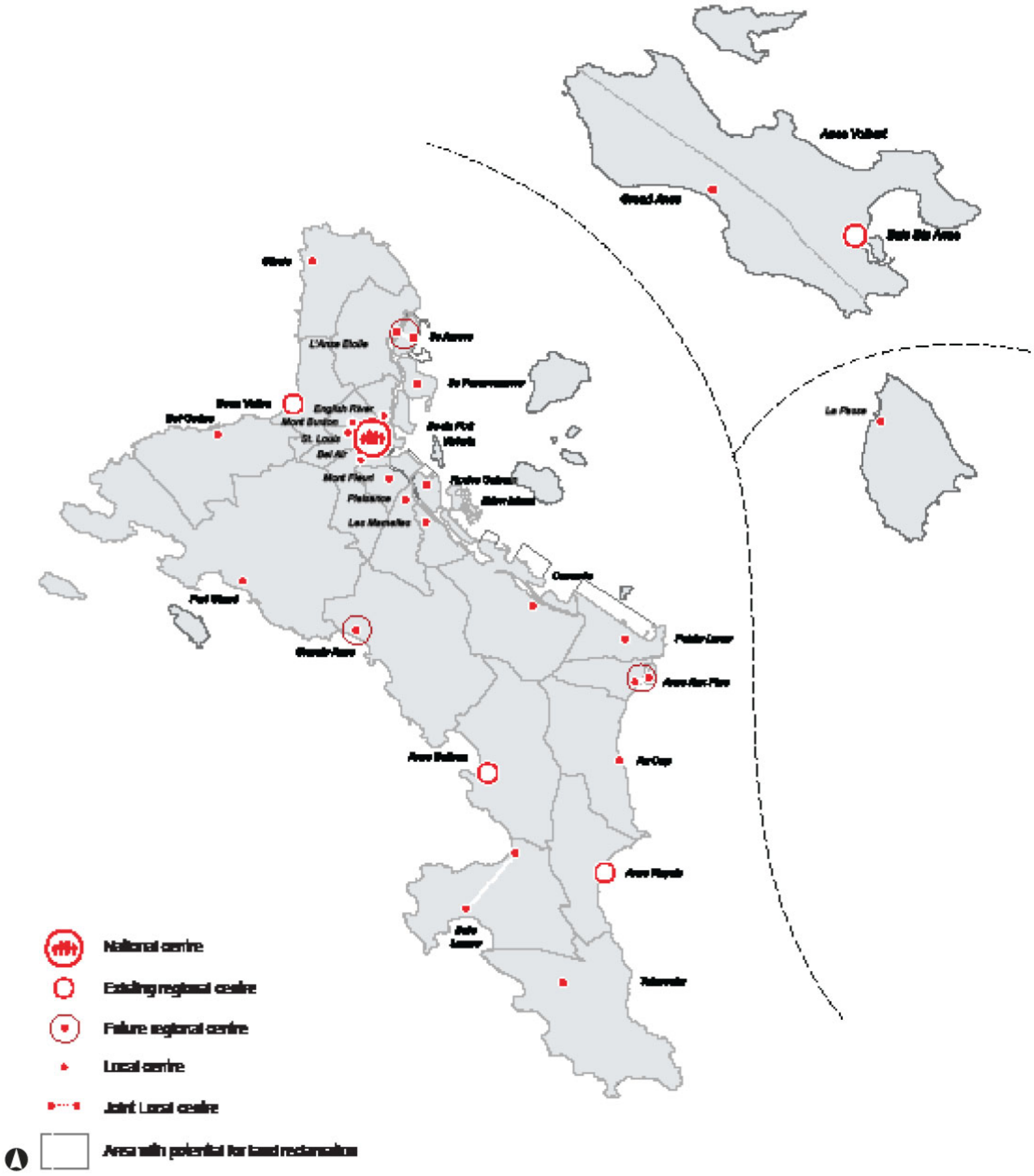


Figure 3–344 Distribution of Major Facilities and Settlements

Source：Seychelles Strategic and Land Use Plan 2040

(4) Urban Development System

a) Land / housing

The residential land in Seychelles is allocated by the government, and the policy is to systematically allocate it according to the size of the household. Land other than housing (agriculture, commerce, etc.) is basically leased. Land for landscape use for tourism can be sold or leased by the government, if it is not suitable for housing. （STATE LAND POLICY[109])

b) Spatial planning / city planning

The Seychelles Planning Authority has jurisdiction over the physical plan and is also the competent authority for land development [110].

City planning is stipulated by the Town and Country Planning Act Cap 237, which states that land use and development plans should be established, regulations should be implemented, sustainable development should be created, and these should be realized together with the general public. Development guidance (planning consultation) is included as authority for that purpose.

c) Seychelles Strategic and Land Use Plan 2040

The Seychelles Strategic and Land Use Plan 2040 plan was approved in September 2015. Although it is a national land use plan, it includes a land use strategy for Mae Island and a detailed plan for Victoria. It describes economic strategies, population forecasts, housing demand forecasts, and land use associated with growth scenarios. Along with the National Development Strategy and the Seychelles Sustainable Development Strategy, it is positioned as the third pillar in policy making, and is referred to by each ministry and agency, including the Seychelles Planning Authority, when these institutions make policy decisions.

[109] http://www.luh.gov.sc/default.aspx?PageId=34
[110] http://www.spa.gov.sc/about-us

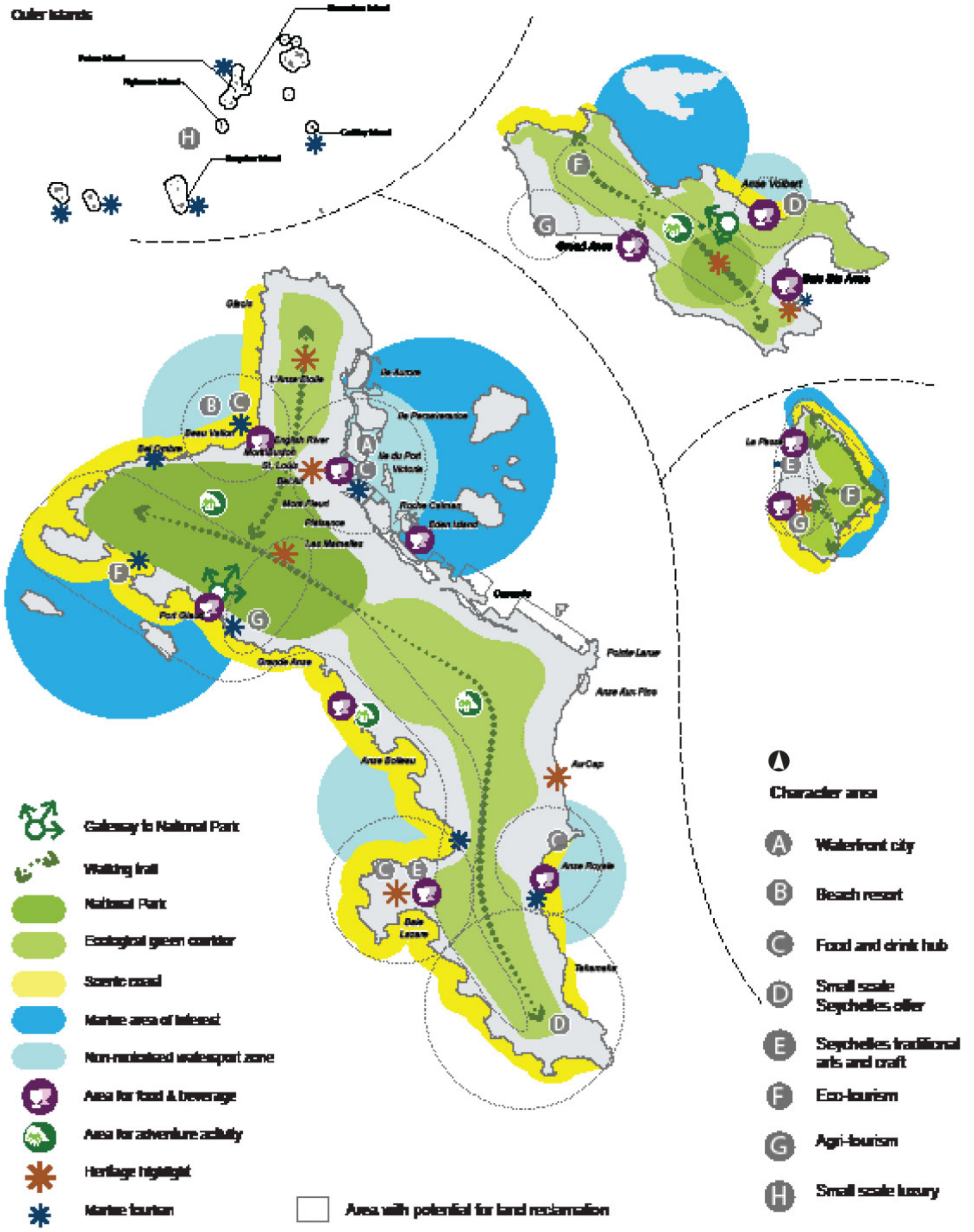


Figure 3–345 Land Use Strategy

Source: Seychelles Strategic and Land Use Plan 2040

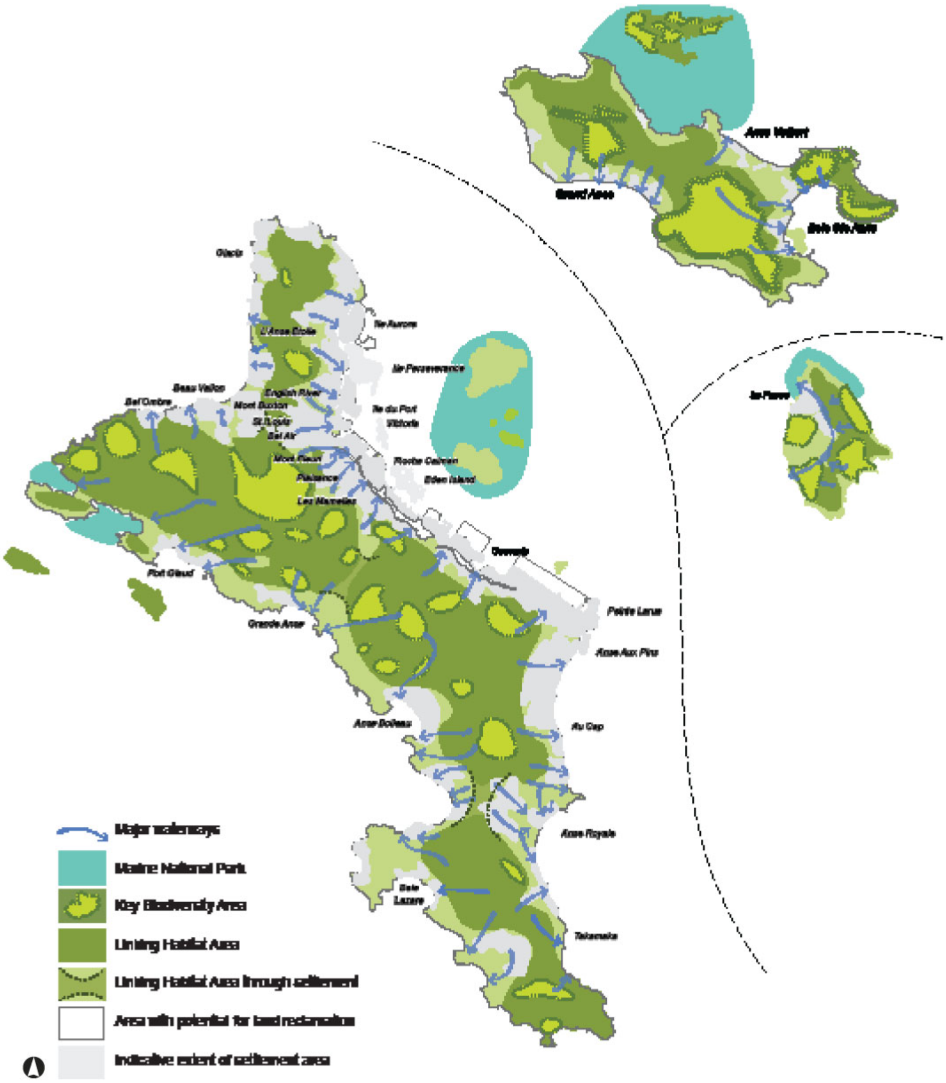


Figure 3–346 Land Use Plan

Source: Seychelles Strategic and Land Use Plan 2040

3.7.4 Disaster Management Plan and Implementation Structure

In Seychelles, a new Disaster Management Act and Disaster Management Policy were enacted in 2014, which provide a comprehensive framework for disaster management. The law is subject to revision every four years. In line with the disaster management law, the National Multi-Hazard Risk Communication Alert and Waning System and the National Disaster Risk Management Fund have been established for multi-hazard risks.

DRDM (Division of Risk and Disaster Management) has been founded as the government agency responsible for disaster management. Under the disaster management law, the Division of Risk and Disaster Management has the duty to develop mechanisms and other means to effectively promote disaster measures in cooperation with relevant agencies. In 2019, the National Integrated Emergency Management Plan (NIEMP) 2019-2024 was formulated under the lead of the Division of Risk and Disaster Management with support from the World Bank and other agencies. The NIEMP describes the roles and processes to be followed by the relevant organizations in order to respond to disasters in a coordinated manner. The figure shows the disaster management system in this plan. However, it was not possible to identify any plans that focus on promoting the development of disaster prevention infrastructure or risk reduction measures prior to disasters, and it is assumed that these plans have not been formulated.

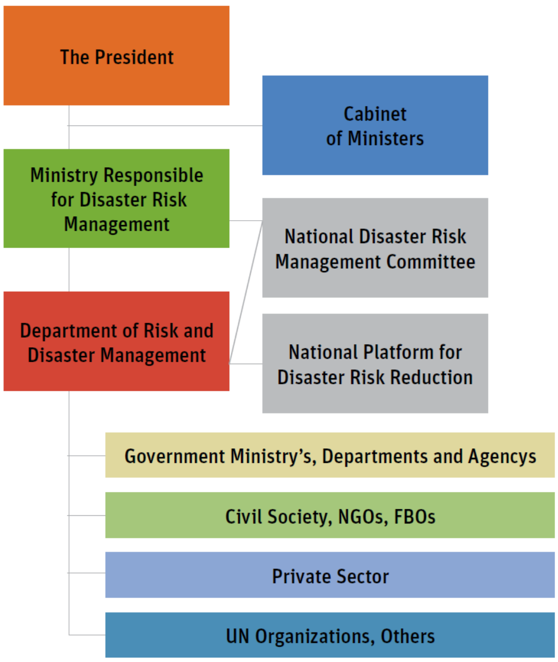


Figure 347 Disaster Response System in Seychelles

Source: National Integrated Emergency Management Plan.

3.7.5 Trends in Donor Support

(1) Overview of Donor Support

According to the data of the International Cooperation Bureau of the Ministry of Foreign Affairs of Japan on Official Development Assistance (ODA) by country for the period 2000-2017, trends in donor assistance to Seychelles show that European Union (EU) institutions, such as the European Commission and the European Investment Bank, are the largest donors among international organizations, while France is the largest donor among major donors.

Table 3–257 Top five donor economic cooperation achievements (in millions of dollars)

Achievements in economic cooperation with international organizations		**Economic cooperation performance of major donors**	
EU Institutions	87.1	France	82.5
GEF	23.43	Japan	43.2
BADEA	13.66	The United Kingdom	10.2
UNTA	7.63	Australia	6.2
WHO	3.93	Belgium	3.8

Source: Compiled by the research team from the Official Development Assistance Country Data Collection (2000-2017), International Cooperation Bureau, Ministry of Foreign Affairs of Japan

According to the main areas of support by donor as shown in COUNTRY STRATEGY PAPER (CSP) 2021-2025 of African Development Bank, it can be seen that support for infrastructure, transportation, and energy are the most common areas by sector.

Table 3–258 Main areas of support by donor

	SECTORS															
Development partner	Macro economic framework	Private sector/ Financial sectors	Infrastructure /Transport/ Energy	Trade	Agriculture/ Rural Development & food Security	Health	Education	Environment	Tourism	Water& Sanitation	Petroleum	Public Sector/ Governance	Judicial& Legal Reform	Capacity/Inst Building (Inc M&E)	Security& Stability	Fisheries/blue economy
AfDB	√		√							√						√
Australia																
BADEA			√			√	√			√				√		
OFID			√			√	√									
IMF	√															
European Commission				√			√	√				√		√		√
France																
Commonwealth Secretariat																
FED(EC)																
IFAD					√											
UK																
France																
India			√			√	√									
Italy																
Japan														√		√
Portugal																
Spain																
Taiwan, China			√				√									
UAE			√				√		√							
UNDP							√	√						√		
UNEP																
UNICEF																
United States																
WFP																
WHO						√										
World Bank	√											√		√		√
EIB			√													
AFD			√													
Kuwait Fund							√									
Saudi Fund			√													
IMO			√													

Source: AfDB COUNTRY STRATEGY PAPER (CSP) 2021-2025

(2) Trends in Aid from World Bank (WB)

COUNTRY PARTNERSHIP FRAMEWORK (CPF) 2018-2023, which sets out the WB's aid policy, aims to rebuild the core economy of fisheries and tourism to increase sustainability and inclusiveness, and to strengthen the management and resilience of natural resources, in line with the Seychelles government's Blue Economy Program. The two key areas of focus are "sustainable growth for shared prosperity" to rebuild the core sectors of the economy - tourism and fisheries - to provide opportunities for job creation, and "promoting inclusion and public sector performance" to allocate significant investments in social assistance to human capital investments, especially for the bottom 40 percent.

Since Seychelles is made up of small islands with a population of less than 100,000, and is highly vulnerable to economic shocks and natural disasters, the WB has indicated its intention to provide assistance. As for the disaster risk reduction sector, one of the goals in "Sustainable Growth for Shared Prosperity" is to "strengthen management capacity and vulnerability to natural disasters." The goals focus on improving the country's ability to mitigate the increasing risks it is facing and will increasingly face from climate change related to flooding in coastal areas and vulnerability of marine resources. In particular, a cautious approach to improving the resilience of coastal areas, combined with securing tourism-related revenues, is needed, and the immediate priority is to close the knowledge gap. The comprehensive master plan for coastal erosion management includes a judicious combination of engineering work and nature-based solutions, and several pilots are already underway.

The Seychelles government has been proactive in preparing for natural disasters by securing contingency funds and making significant investments, but challenges include limited capacity to accurately identify and quantify risks and limited incorporation of disaster risks and resilience to climate change in spatial planning and investments. While the Seychelles' climate adaptation strategy is relatively well developed and outlines investment priorities, the analysis suggests that more detailed risk assessments, coastal management plans, and specific investments are needed, particularly in the areas of flooding and coastal resilience, which are important to the tourism industry. The existing Catastrophe Deferred Drawdown Option (Cat DDO) Development Policy Loan (DPL) strengthens the government's DRM policy and reform agenda and enhances its ability to respond to disasters efficiently.

As the government of Seychelles has been actively formulating disaster risk reduction plans and implemented related initiatives, the WB has provided support in the form of supplementing these plans and initiatives, and plans to continue supporting the formulation of these plans in the future. Specifically, it will support needs and gaps research on coastal flooding threats, investment in adaptation measures using new climate finance architectures, including various environmental and climate-related trust funds such as the Global Environment Facility (GEF) and the Green Climate Fund (GCF), and the improvement of climate change-resilient waste infrastructure and green technologies.

Table 3–259 WB's disaster response / DRR related projects

Project Name	Project Objective	Financier	Approval Year
Seychelles First Fiscal Sustainability and Climate Resilience Development Policy Financing	To support the government’s effort to: (i) strengthen medium-term fiscal sustainability; (ii) build resilience and (iii) develop the digital economy.	International Bank For Reconstruction And Development	2022
Disaster Risk Management Development Policy Loan with CAT DDO	To strengthen the Government of Seychelles Disaster Risk Management policy and reform agenda and enhance its capacity to efficiently respond to disasters.	International Bank For Reconstruction And Development	2014

(3) Trends in Aid from the African Development Bank (AfDB)

The main objective of the COUNTRY STRATEGY PAPER (CSP) 2021-2025, which sets out the AfDB's aid policy, is to support structural transformation and increase the country's economic resilience, with a single priority area of "fostering resilience to promote economic and environmental sustainability.”

The PAPER states that it will support interventions to address infrastructure deficiencies in the areas of energy, sanitation and solid waste management in Seychelles. It also aims to unleash the potential for business growth and address environmental risks. It will consider and develop strategies to support private sector growth in key sectors such as tourism, fisheries, and high-tech manufacturing, increase productivity, strengthen connections to global value chains, in order to participate in regional trade.

The government of Seychelles has formulated a disaster risk management master plan to work on disaster impact prediction and population protection planning, and the AfDB is exploring opportunities to intervene in the area of climate change through technical assistance projects. Specifically, it is considering supporting capacity building initiatives focused on climate change adaptation to address constraints such as the government’s ability to develop and implement specific adaptation measures, the availability of adequate human resources, and the financial capacity to implement and maintain proposed adaptation measures. Therefore, the AfDB aims to support MEECC to obtain technical assistance from the ClimDev Fund to build scientific capacity, and to realize the development of scientific capacity on meteorological station networks, data collection and interpretation, and climate information services to support early warning and disaster preparedness. It also says that it could help Seychelles mobilize international climate control finance to implement mitigation and adaptation measures.

Table 3–260 AfDB's disaster response / DRR related projects

Project Name	**Project Objective**	**Financier**	**Approval Year**
Emergency Assistance to Address Damages and Losses Caused by the January 2013 Cyclone Felleng	To contribute to a return to normalcy in the affected areas through urgent minor repairs and rehabilitation of school infrastructure and replacement of damaged or lost school equipment, as well as provision of medical supplies and agriculture inputs and equipment.	Special Relief Funds	2013
Emergency Assistance to December 2004 Tsunami victims	To contribute to normalization through urgent minor repairs to road infrastructure and schools, as well as the purchase of replacement fishing equipment.	Special Relief Funds	2005

3.7.6 Selection of Key Cities

Based on a comprehensive review of the general situation of disaster risks, climate change, land development, and urban development in Seychelles, as well as the trend of donor support, we have decided to focus on Victoria (Mahé Island), the capital of Seychelles, as a key city area for this study, and to focus on issues related to disaster risk reduction and the possibility of support projects at the city level. The study will focus particularly on these key areas, but the study of potential support projects will not be limited to these areas, but will be conducted flexibly as appropriate based on the situation in each sector, local needs, and issues related to regional disaster risk reduction.

3.7.7 Information Collection and Analysis for Cooperation in the Field of Disaster Risk Reduction in Each Sector

(1) Transportation

Seychelles is an island nation consisting of 115 islands in the Indian Ocean. The capital, Victoria, is located on the main island of Mahé. The main islands, such as Mahé, have a steep slope from the mountains in the center to the coast, so the only flat areas are the narrow areas along the coastline. Therefore, various infrastructures, including roads, ports and airport infrastructures, as well as residential and commercial buildings, are mainly located along the coasts. These will be directly affected by sea level rise due to climate change. Although the road network and road surface are in good condition, measures for aging and demand are needed, and ports and airports need to be strengthened and expanded.

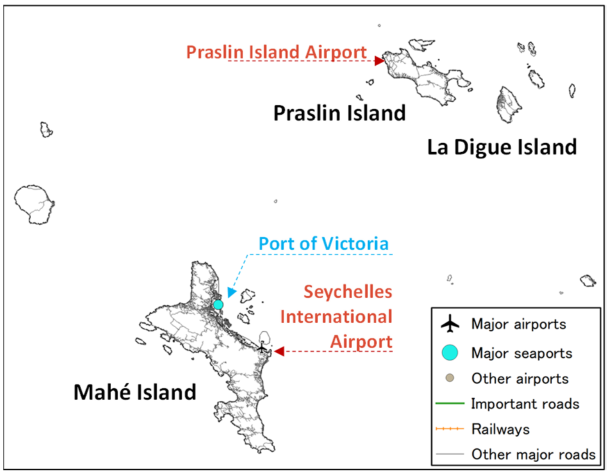


Figure 3–348 The three main islands of Seychelles and their major transportation infrastructures

Source: JICA Study Team

1) Overview of Relevant Organizations and Legal systems

The ministry responsible for transportation in Seychelles, including roads, is the Department of Transport (DoT). Government agencies responsible for each subsector of transportation are under the DoT. Table 3–261 shows the main related organizations, including those that manage or operate each subsector. The location of the transportation infrastructures on Mahé, the main island, is shown in Figure 3–349. There is no rail service in Seychelles.

Table 3–261 Key Institutions in the Transportation Sector in Seychelles

Subsector	Key Institutions
—	Department of Transport, DoT
Road	Seychelles Land Transport Authority, SLTA
	Road Transport Commission, RTC
	Seychelles Public Transit Corporation, SPTC
Port	Seychelles Ports Authority, SPA
Airport	Seychelles Civil Aviation Authority, SCAA

Source: JICA Study Team

Figure 3–349 Transportation infrastructures on Mahé Island, Seychelles

Source: JICA Study Team

The Seychelles Land Transport Authority (SLTA), under the DoT, is in charge of road development, maintenance and management, and operation of road structures, including bridges, culverts, retaining walls, drainage facilities and pedestrian bridges. The Road Transport Commission (RTC) regulates, controls, and manages road traffic, while the Seychelles Public Transit Corporation (SPTC) is responsible for public transportation services (public buses).

According to the AfDB data (Seychelles Infrastructure Action Plan, AfDB, May 2015), roads in Seychelles are divided into four types: Primary, Secondary, Feeder and Estate Roads. The total road length is 508 km, of which 250 km are Primary Roads, 150 km are Secondary Roads, and about 100 km are Feeder Roads. 96% of the roads are paved. Most of these roads are located on Mahé Island. The road network in Mahé Island has been rated for its high connectivity. On the other hand, traffic accidents are also on the rise due to the increase in the number of automobiles. Outside of Victoria, there are few separated roads for pedestrians and vehicles, which raises concerns about the safety of pedestrians.

a) Port

The government organization under the DoT with jurisdiction over maritime affairs and ports is the Seychelles Ports Authority (SPA). SPA is also responsible for the operation of the Port of Victoria, as well as the passenger terminals at the Ports of Mahe, Praslin, and La Digue.

The largest port in Seychelles is the Port of Victoria. In 2011, the Port of Victoria handled over 6 million tons of cargo in a year. Most of that cargo is for exports of canned tuna. The number of vessels arriving at the Port of Victoria has been on a downward trend since peaking at 1,340 in 2006 and was slightly more than 800 in 2011 (see Figure 3–350). This is due in part to the decline in fishing vessels, reefer ships, cruise ships, and yachts caused by pirates appearing in the waters of Eastern Africa, but also to the decline in container ships.

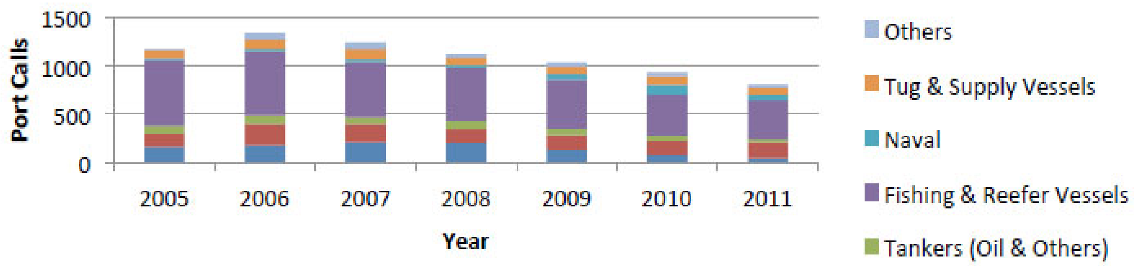


Figure 3–350 Number of vessels arriving at the Port of Victoria, Seychelles
Source: Seychelles Infrastructure Action Plan, AfDB, May 2015.

The Port of Victoria has an annual container handling capacity of 25,000 TEUs. From 2008 to 2011, the volume of containers handled increased from about 15,000 TEUs to 20,000 TEUs (see Figure 3–351). According to the AfDB data (Seychelles Infrastructure Action Plan, AfDB, May 2015), the volume of containers handled is expected to reach its maximum capacity in the next five years.

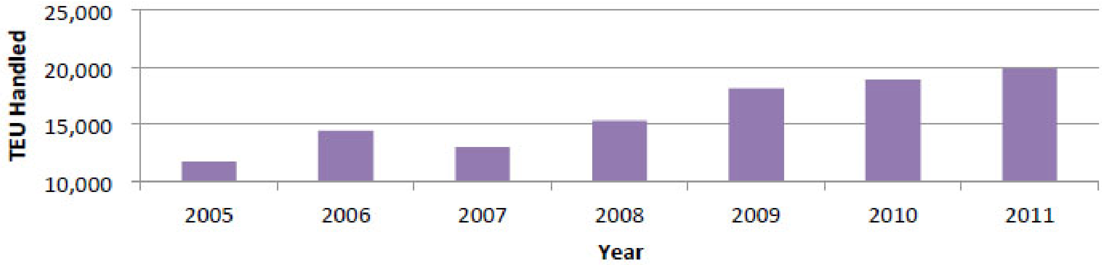


Figure 3–351 The volume of containers handled at the Port of Victoria, Seychelles

(Total of import, export and transshipment)

Source: Seychelles Infrastructure Action Plan, AfDB, May 2015.

b) Airport

The government organization under the DOT responsible for operations and policies related to civil aviation is the Seychelles Civil Aviation Authority (SCAA). SCAA also operates the Seychelles International Airport and is also responsible for the operation of the airfield on Praslin Island. Other airfields are operated by Islands Development Company (IDC) or resort companies.

Due to the geographical limitation, most airfields are difficult to expand. The only international airport is the Seychelles International Airport, and only small planes can take off and land at the other airfields, making it difficult to serve international flights. The Seychelles International Airport has a runway of 2,987 meters. Currently, there is only one runway, but a second runway is needed. The reason for this is not only to increase the transportation capacity of the airport, but also, more importantly, to continue operating the airport even during emergencies, as it takes time to process accidents, etc. when the runway is out of service due to them. Under the airport development plan, which was updated in 2009, development activities are scheduled in two phases. The annual passenger and cargo traffic of the Seychelles International Airport and the main contents of the Airport Master Plan are shown in and Table 3–263, respectively.

Table 3–262 Passenger and cargo traffic at the Seychelles International Airport

	2007	2008	2009	2010	2011	2012
Aircraft Movements	3,582	3,382	3,751	4,800	4,470	4,843
International Passengers ('000)	437	424	415	458	495	517
Domestic Passengers ('000)	274	234	169	182	186	118
International Freight (tons)	8,300	6,204	5,630	6,886	6,918	5,943

Source: Seychelles Infrastructure Action Plan, AfDB, May 2015

Table 3–263 Summary of the Airport Master Plan for the Seychelles International Airport

Parameter	Planning Horizon	
	Phase 1 Year 2022	Phase 2 Year 2037
International Terminal		
Annual Passenger Capacity	1,500,000	3,600,000
Peak Hour Passengers	980	1,800
Aircraft Parking Stand Requirements	5	10
Domestic Terminal		
Annual Passenger Capacity	500,000	900,000
Peak Hour Passengers	210	400
Aircraft Parking Stand Requirements	6	10
Total Annual Passenger Capacity	2,000,000	4,500,000

Source: Airport Master Plan Review Study – 2009

Source: Seychelles Infrastructure Action Plan, AfDB, May 2015.

2) Overview of Related Plans and Development Status

According to the AfDB data (Seychelles Infrastructure Action Plan, AfDB, May 2015), the DoT does not have a transportation master plan. Most transportation infrastructure planning are coordinated and determined by the 27 municipalities every year without any kind of quantitative evaluation. The following is a list of projects proposed in this AfDB data for the development of transportation infrastructures.

Table 3–264 Recommended projects related to transportation infrastructures in Seychelles and project costs

Agency	Item/Project	Indicative Cost
DoT (Generally)	Technical Assistance (TA) in Traffic and Highway Engineering including preparation of Transportation Master Plan with Integrated Transit Study and setting up Asset Management Program	$6.35 Million
Land Transport (SLTA)	New Asphalt Plant in Mahé	$300,000
Land Transport (SLTA)	Non-Motorized Traffic Planning and Implementation of a Skeletal Network (10-20 km)	$10.0 Million
Land Transport (SLTA)	• Capital and Traffic Management Improvements within Victoria,: • Signalization (Traffic Lights) • Extending Bus Lay-Byes • New Roundabout at Airport • Francis Rachel St –new partial lane • 5th June Ave New lane	$2.15Million
Land Transport (SLTA)	Waterfront Bypass - At Grade and overpass Le Chantier Roundabout: This is a GoS-funded initiative with the objective of addressing traffic volume concerns around Victoria especially during the peak periods	$10.0 Million
Land Transport (SLTA)	Road Link Between Mt Fleuri Rd and Bois de Rose	$1.5Million
Land Transport (SLTA)	Road Link Stevenson Delhomme and Bel Air	$1.0Million
Public Transit (SPTC)	Bus Replacement Program	$7.7 Million
Public Transit (SPTC)	Bus Equipment Replacement & Upgrade	$1.6 Million
Public Transit (SPTC)	Depot Improvements–Barbarons/Ile du Port	$1.7 Million
Public Transit (SPTC)	New Bus Depot at Praslin	$750,000
Aviation – Short Term	Seychelles International Airport Terminal Rehabilitation and Refurbishment	$15 Million
Aviation – Long Term	Building Second runway on reclaimed land	$150-200 Million
Aviation – General	Security Improvements: Surveillance, screening and monitoring to ensure safety and compliance with ICAO standards and practices.	$3 Million
Marine Transport (Ports)	Victoria Port Expansion including Quay extension and dredging	$90 Million (70 Million Euros)

Source: Seychelles Infrastructure Action Plan, AfDB, May 2015.

Table 3–265 Priorities of recommended projects related to transportation infrastructures in Seychelles

Project	Fisheries Sector	Tourism Sector	Offshore Petroleum Sector	Structural Transformation	Quality of Life	Sustainable growth	Inclusive growth	Regional integration	FIRR>0	Total Score	Rank
Victoria Port Expansion including Quay extension and dredging	3	2	3	1	3	1	1	3	1	18	1
Bus Replacement Program	1	2	0	2	2	2	2	0	2	13	2
Non--Motorized Traffic Planning and Implementation of a Skeletal Network	0	2	0	1	2	3	1	0	x	9	3
Depot Improvements	1	2	0	1	2	1	0	1	x	8	4
New Asphalt Plant in Mahé	2	2	0	1	1	1	1	0	x	8	4
Seychelles International Airport Terminal Rehabilitation and Refurbishment	1	3	0	1	0	0	0	3	0	8	4
Bus Equipment Upgrade	1	2	0	1	1	1	1	0	x	7	6
Various Capital Imp -- Congestion	1	2	0	1	1	1	0	0	x	6	8
Victoria Bus Terminal Improvements	1	2	0	1	1	1	0	0	x	6	8
Building Second runway involving land reclamation	1	2	0	0	0	0	0	3	x	6	8
Mt Fleuri Road Link	1	2	0	1	1	0	0	0	x	5	10
Stevenson Bel Air Rd Link	1	2	0	1	1	0	0	0	x	5	10
Victoria Bypass Project	1	2	0	1	1	0	0	0	x	5	10
New Bus Depot at Praslin	1	2	0	0	0	1	0	0	x	4	13
Security Improvements Projects	1	3	0	0	0	0	0	0	x	4	13

Source: Seychelles Infrastructure Action Plan, AfDB, May 2015.

Table 3–266 Phase plans for recommended projects related to transportation infrastructures in Seychelles

Project	Potential Phasing		
	Short Term (0-5 years)	Medium Term (5-10 years)	Long Term (10+ years)
Bus Replacement Program	✓		
Victoria Port Expansion including quay extension and dredging	✓	✓	
Non-Motorized Traffic Planning and Implementation of a Skeletal Network (10-20 km)	✓		
New Asphalt Plant in Mahé	✓		
Bus Equipment Upgrades	✓		
Depot Improvements		✓	
Victoria Bus Terminal Improvements		✓	
New Bus Depot at Praslin		✓	
New Asphalt Plant in Mahé	✓		
Various Capital Imp*		✓	
Victoria Bypass Project*		✓	
Mt Fleuri Road Link*		✓	
Stevenson Bel Air Rd Link*		✓	
Airport Security Improvements Projects		✓	
Seychelles International Airport Terminal Rehabilitation and Refurbishment		✓	
Building second runway involving reclaimed land			✓

**The TMP recommended projects could include some of these projects*

Source: Seychelles Infrastructure Action Plan, AfDB, May 2015.

3) Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Key facilities on Mahé Island include the Seychelles International Airport, the Port of Victoria, the Province Highway, the coast road, and the roads crossing Mahé Island. The Port of Victoria and the coast road, as well as the Seychelles International Airport located on the coast, are at risk of storm surge, coastal erosion, and flood, while the roads crossing Mahé Island pass through a mountainous area and may be at risk of landslides.

Figure 3–352　Critical transportation infrastructures on Mahé Island, Seychelles

Source: JICA Study Team

4)　Consideration of Disaster Risk Reduction Measures

Due to the difficulty in surveying the current status and usage conditions of critical transportation infrastructures, the occurrence of disasters, and local needs related to disaster risk reduction, it was not possible to conduct a study on priority disaster risk reduction measures.

(2) Power

1) Overview of Relevant Organizations and Legal systems

The Ministry of Environment and Energy (MEECC) is responsible for energy policy and legislation in Seychelles, and the Seychelles Energy Commission (SEC), a subordinate body of MEECC, is effectively responsible for energy policy and legislation in Seychelles. Article 3 of the Energy Act stipulates that the government shall formulate energy policy on the advice of MEECC and SEC, and that MEECC shall be in a position to give instructions to SEC on policy and other matters. On the other hand, Article 6, which defines the duties of the SEC, stipulates that the SEC shall formulate energy plans and implement energy policies.

The SEC also oversees (plans, regulates, and manages) development planning and operations in the power sector. In terms of specific power transmission and distribution operations, Mahe, Praslin, La Digue and the surrounding islands are managed by the Public Utilities Corporation (PUC), while other islands are managed by the Island Development Company (IDC). For other islands, and the National Park Authority for some national park islands.

At present, most of the electricity is derived from oil, and 76% of the electricity project cost is for fuel. The power development plan including renewable energy is being prepared with IAEA support, while the PUC is preparing a master plan on its own. In addition, the MP for the introduction of hybrid power generation without battery (2016) was implemented with JICA support. In order to expand the use of renewable energy, the introduction of FIT is under consideration. The current scale of renewable energy is 1.2MW for PV and 6MW for wind.

In addition, 9 MW of hydropower, 4 MW of small hydropower, and 12 MW of PV have been added as INDCs to meet the Paris Agreement (Energy Profile Seychelles World Bank 2015).

2) Overview of Related Plans and Development Status

Electricity supply on Mahe Island is largely from fuel oil diesel generation. The island's loop system is well developed and Saudi Arabia is expected to support additional development. This island also has a high degree of completion of the loop system.

In addition, although the data is as of 2015, the peak demand on Mahe Island is about 50 MW, while the installed capacity is 77 MW, indicating that Mahe Island has sufficient reserve capacity. On the other hand, there is room for improvement in the understanding of overall load and grid conditions and economic operation.

In 2013-14, Praslin Island was experiencing power shortages, and rotating blackouts were implemented, new connections were denied, and new hotel operators were encouraged to own their own power (Seychelles_-_Infrustructure_Action_Plan_Report 2015 afdb). At the time, there was a peak demand of 7.4 MW, whereas the safe capacity, taking into account reliability and other factors, was 4.4 MW. In addition, IPPs do not exist in Seychelles, although they were provided for in the 2012 Electricity Law. This is believed to be due to the fact that the system is still incomplete, and its reform is being carried out with World Bank support.

The current installed capacity is 77 MW on Mahe Island and 16 MW on Praslin and La Digue Islands, with diesel power generation except for 3.5 MW of PV and 6 MW of wind power (A Strategic Approach towards 100% Renewable Energy in Seychelles Seychelles). Mahe's power quality is high and outage times are short. A study is underway to achieve 100% renewable energy on Mahe Island. 50 MW of wind, 125 MW of PV, 5,000 tons of biodiesel, and GWh of pumped storage are needed to achieve this goal.

This will require an investment of 390 MMUSD by 2035, while the country is under IMF supervision due to ballooning public debt and cannot issue additional public bonds. The government plans to raise electricity prices in 2013-22 to improve its balance of payments.

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

In the January 2013 floods, there was no damage to the high voltage system on the main island, and only some of the low voltage system was damaged by falling trees (A Strategic Approach towards 100% Renewable Energy in Seychelles).

In August 1997, heavy rains and flooding caused landslides and inundation of power transmission and distribution networks and substations (UNITED NATIONS DEVELOPMENT PROGRAMME Disaster risk profile of the Republic of Seychelles). By August 19, the high voltage system had been restored, but it took some time to restore the low voltage system.

In addition, from the power transmission system diagram of Mahe and Praslin islands, it can be seen that the system has been looped, which indicates that the system is highly resistant to failures.

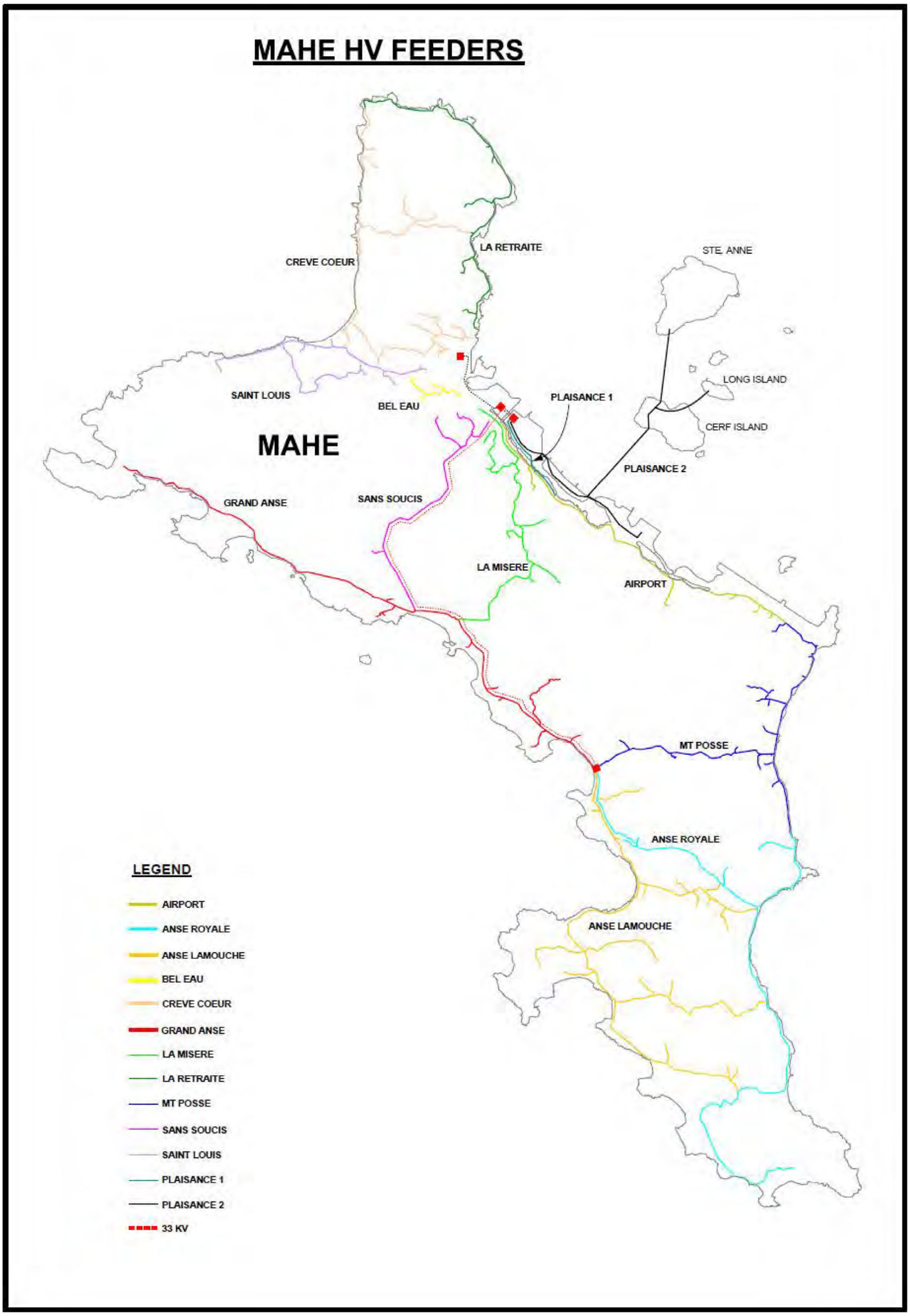


Figure 3–353 Mahe Island power transmission system diagram

Source: From the Master Plan Development Project for Microgrids on Remote Islands in Seychelles (2017, JICA)

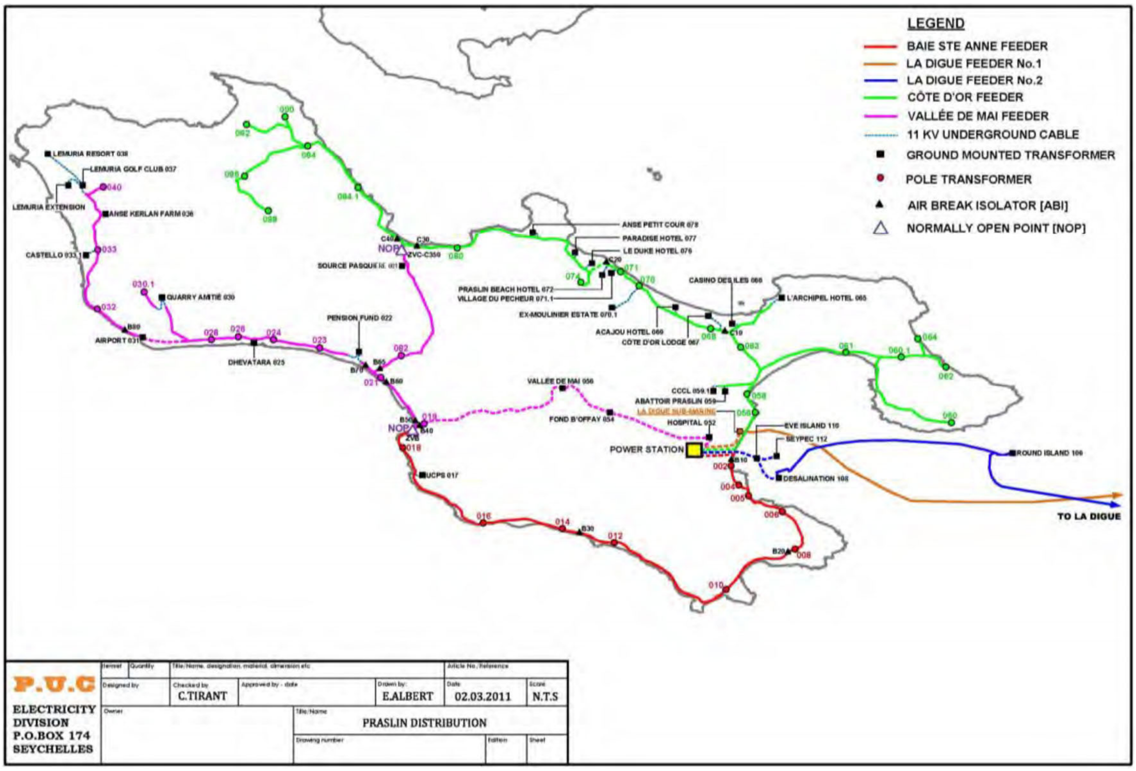


Figure 3–354 Power transmission diagram of Praslin Island

Source: From the Master Plan Development Project for Microgrids on Remote Islands in Seychelles (2017, JICA)

4) Consideration of Disaster Risk Reduction Measures

In Seychelles, as mentioned above, the current policy is to increase the percentage of renewable electricity to 15% by 2030 in order to reduce the cost of electricity supply and improve sustainability, and the Ministry of Energy alone is planning to increase the percentage of renewable electricity to 100% by 2030. However, in reality, more than 90% of electricity is derived from diesel, and in addition to the financial difficulties, the small scale of the grid is hindering the introduction of variable renewable electricity such as solar power (according to a JICA survey, the limit is 10MW on Mahe Island and 2MW on Praslin Island, assuming no storage batteries are used).

To address this issue, we propose the introduction of a hybrid power generation system consisting of photovoltaic power generation, storage batteries, and engine generators to achieve a stable power supply while introducing renewable energy regardless of grid constraints. Improving the stability of the power supply is important for improving the functions of government and industry, and for maintaining these functions in the event of a disaster. Research that should be conducted first includes the following items.

- Survey of important public sectors and companies in the metropolitan area that require a stable electricity supply
- Needs assessment in the tourism sector and industrial parks
- Study on the possibility of increasing the ratio of renewable energy by adding hybrid systems to existing diesel power generation facilities
- Technical and economic feasibility study in cooperation with Japanese heavy industry manufacturers

The past JICA study (Seychelles Remote Island Microgrid Development Master Plan Project) was based on the premise of not using storage batteries, so the amount of solar power that could be introduced was limited, but the system of the Japanese heavy industry manufacturer includes storage batteries and is superior in stabilizing the fluctuating output of solar power. As for the solar modules to be used, not only those made in China, but also those made in Korea and the U.S. are possible (they do not have to be made in China in order to function).

In addition, in cooperation with Japanese heavy industry manufacturers, we can provide remote operation and maintenance support, and if necessary, we can include capacity building for business owners.

(3) Water and Sanitation

1) Overview of Relevant Organizations and Legal systems

The state-owned Public Utility Corporation (PUC) is responsible for water and sewerage services in Seychelles.

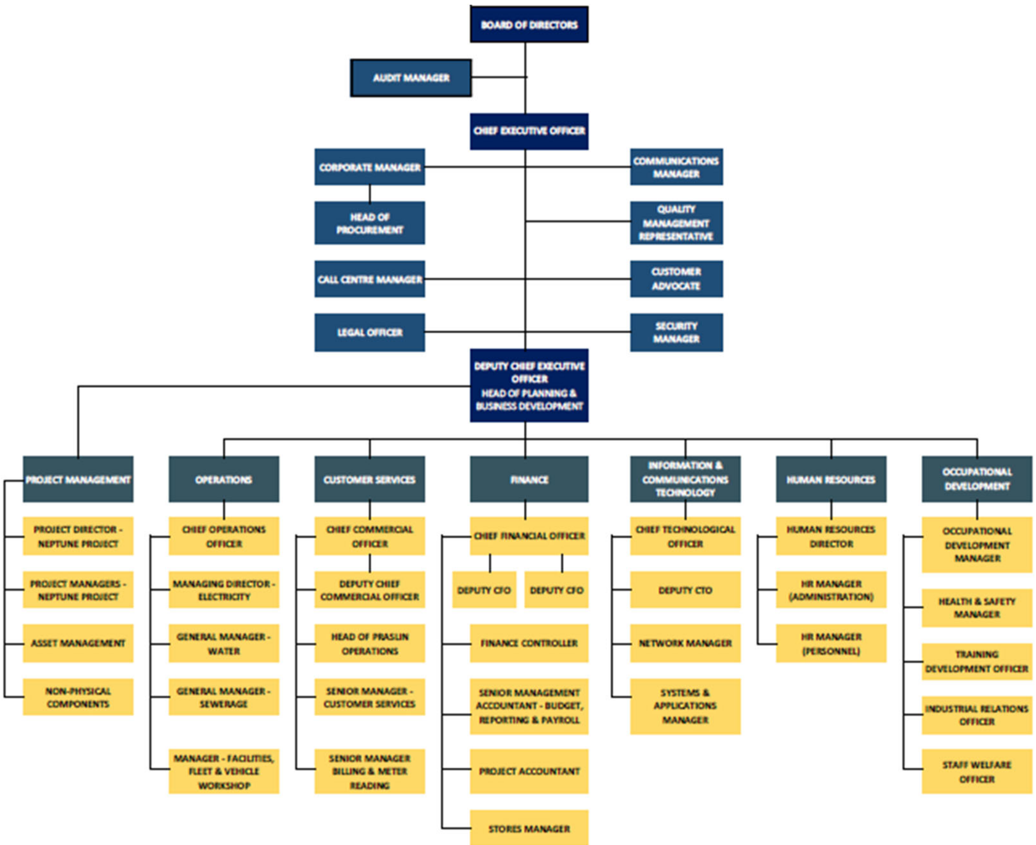


Figure 3–355 Organization of Public Utility Corporation

Source: PUC. 2020. Annual Report.

Water and sanitation legislation includes the Water Supply (Abstraction Licence) Regulations 1984 (S.I. 48 of 1984).

National plans and strategies relating to the sector are as following.

- National Water Policy
- National Integrated Water Resource Management (IWRM) Plan
- Sanitation Master Plan

2） Overview of Related Plans and Development Status

UN Water's summary shows that the proportion of the population with access to basic water in Seychelles will exceed 95% by 2019. The proportion of the population with access to basic sanitation has reached almost 100% as of 2019.

Of this number, 34,737 are water supply subscribers and 5,795 are sewerage subscribers. The number of sewerage users is only about 20% of the total population of about 80,000. (PUC. 2020. Annual Report)

77% of the water supply comes from surface water, including the La Gogue and Rochon dams, but there are also desalination plants in operation. There are 23 water treatment plants with a total pipeline length of 700 km. There are four sewage treatment plants (Providence, Beau Vallon, Pointe Larue and Anse Aux Pins).

Improving the NRW rate is a major challenge: in 2020, the unaccounted for water (UFW) rate was 24.62% on Mahe Island and 37.44% on Praslin Island.

Water security, including management stability and source security, is also a challenge: in 2020, the spread of COVID-19 led to a sharp drop in tourism, which in turn reduced water demand, and the desalination plant struggled to reach its minimum operating capacity.

Low sewerage penetration is also a challenge. The PUC is working to improve this in line with its Sanitation Master Plan, and is also constructing a new septic system called La Digue. The PUC is also working on a new septic system called La Digue.

The priority projects planned by the PUC for 2021 are as follows.

	Project Description	Project Cost
WATER PROJECTS	Raising of La Gogue Dam by 6 metres -including additional works to be undertaken on the right abutment & South Saddle	SCR 287 million
	Refurbishment of water treatment plants -Hermitage & Cascade	SCR 80 million
	Water Transfer from Anse Major & Mare Aux Cochons	SCR 42 million
	Replacement of non-performing pipeline to reduce non-revenue water	SCR 20 million

	Project Description	Project Cost
SEWERAGE PROJECTS	Sewerage System for La Digue	SCR 220 million
	Rehabilitation of existing sewerage system in Greater Victoria:	
	❖ Providence sewerage treatment plant, pump stations and force mains	SCR 152 million
	❖ Pipeline replacement in Victoria to address infiltration	SCR 40 million
	Central Pump Station	SCR 12 million
	Network extension in Beau Vallon area -Ex Kashouggy Estate	SCR 5.3 million

Figure 3–356 Priority projects planned by the PUC for 2021

Source: PUC. 2020. Annual Report.

JICA didn’t provide any assistance in the water and sanitation sector so far.

The following assistance has been provided by other international donors.

- Resource efficiency program for the Seychelles water sector (REPSWS) (EIB and AFD, 2014-2016)

Energy efficiency in water supply, future water demand and security of supply, implementation of water pressure improvements on the main islands.

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Seychelles is an island nation located in the Indian Ocean and is vulnerable to cyclones and consequent flooding. With inadequate sewerage systems, the drainage system may not be functioning adequately.

However, efforts to reduce flood risk are already underway: JICA carried out a baseline study in 2014 as part of the Coastal Erosion and Flood Management Project, and the Ministry of Environment and Energy has implemented the river channel rehabilitation proposed in the study. This and other risk reduction projects are also being promoted by the Seychelles Government.

4） Consideration of Disaster Risk Reduction Measures

While the water supply system is well developed, the sewerage system is inadequate and needs to be promoted from the perspective of flood damage reduction. On the other hand, it is unlikely that the PUC will need support in the field of water and sanitation in the future, as its capacity to implement projects is high.

(4) Telecommunication

1） Overview of Relevant Organizations and Legal systems

The basic law for the telecommunications and ICT sector in Seychelles is the Broadcasting and Telecommunication Act, Act 2 of 2000 (Broadcasting Act), but the official version of the Seychelles law is not available on the Internet, but only in hard copy from the Ministry of Justice of the country. The law stipulates the issuance of licenses to telecommunications carriers, regulation of the content of communications, regulation of the misuse of communications, and radio frequency assignment.

The authority supervising Telecommunications and ICT sector in Seychelles is the Department of Information Communications Technology (DICT). The main roles of the DICT are as follows

[1] Develop laws, regulations, and policies related to telecommunications and related services

[2] Enforcement of laws, regulations, and policies related to telecommunications and related services

[3] Develop and maintain software applications that support the delivery of government services

[4] Implementation, management, and maintenance of government ICT infrastructure

[5] Coordinate collaboration with various government departments/ministries to address specific ICT needs and requirements

[6] Establishing the role of ICT in different sectors/ministries and helping to enact these roles

[7] Planning and management of wireless communication resources (domain names, frequencies, numbers, etc.)

The DICT consists of two major divisions, the Communications Division and the Information Technology (IT) Division, and according to the Ministry's website, the organizational structure is as shown in the figure below. The communication department (right side of the figure) is responsible for [1] and [2], while the IT department (left side of the figure) is responsible for [3], [4], [5], [6], and [7].

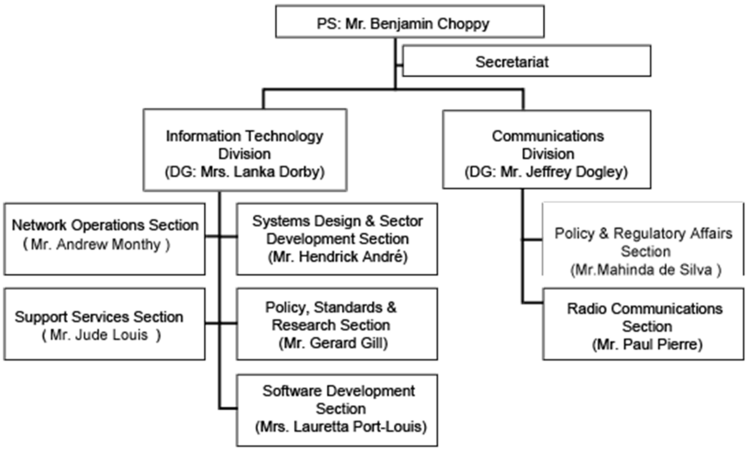


Figure 3–357　Organizational chart of DICT

Source: DICT website.[111]

According to the statistics published by DICT, the number of broadband subscribers in the country, both mobile and fixed, has grown significantly.

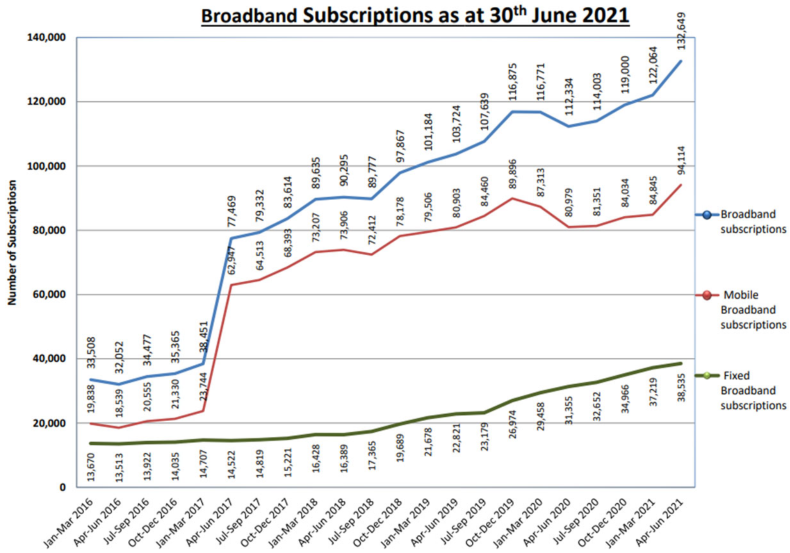


Figure 3–358　Number of broadband subscribers in Seychelles (as of 30 Jun 2021)

Source: DICT website.[112]

[111] https://www.ict.gov.sc/homecnt/deptorg.aspx
[112] https://www.ict.gov.sc/documents/2021/MEMO_ICT_SECTOR_PERFORMANCE_DATA_30_JUNE_2021.pdf

2） Overview of Related Plans and Development Status

Seychelles, with its thriving tourism industry and high per capita income, has a high rate of broadband Internet access. As of 2020, the percentage of the population with access to the Internet has reached about 79%.

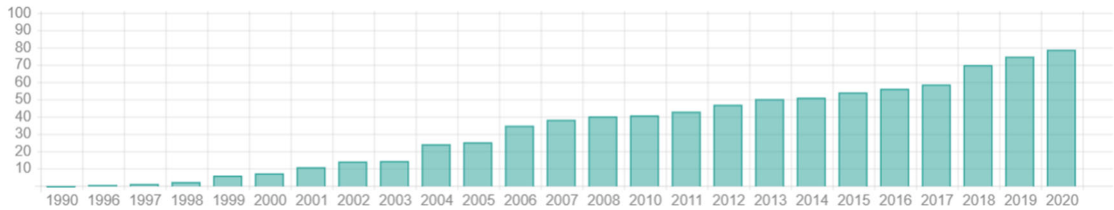


Figure 3–359 Percentage of population with access to the Internet (1990-2019)[113]

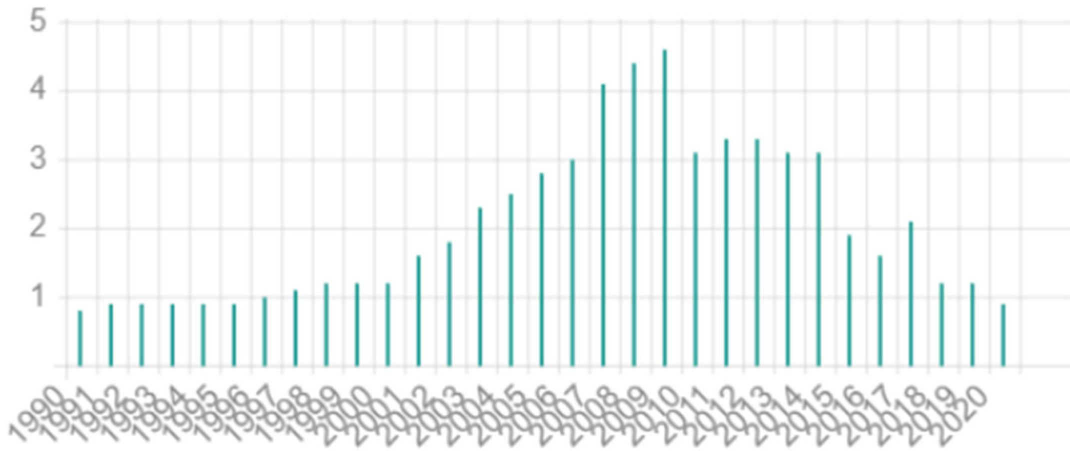


Figure 3–360 Fixed line subscriber population ratio

Source: WorldData.info

[113] https://www.worlddata.info/africa/seychelles/telecommunication.php

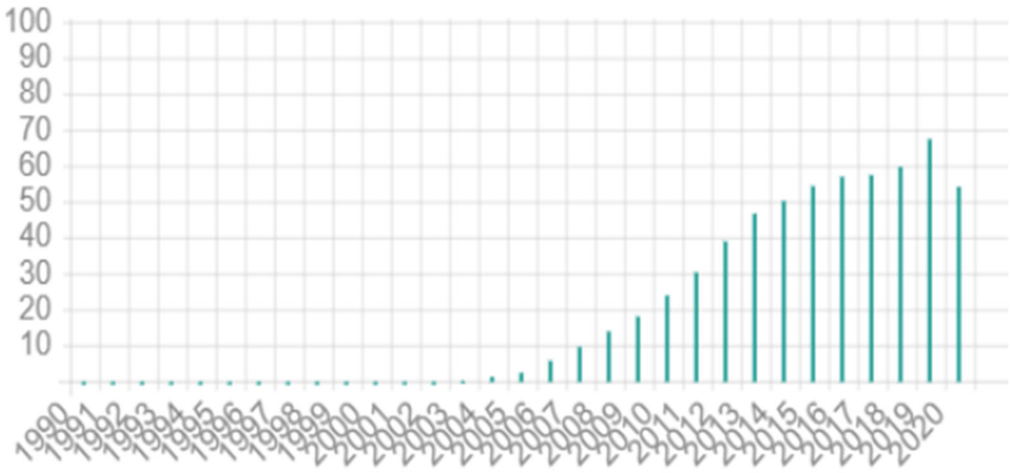


Figure 3–361 MobileLine subscriber population ratio

Source: WorldData.info

Table 3–267 Key indicators for the Seychelles telecommunications sector

(ITU estimates, 2017)

Indicator	Seychelles	Africa average	World average
Fixed-telephone sub. per 100 inhab.	2.1	0.9	13.0
Mobile-cellular sub. per 100 inhab.	54.9	74.4	103.6
Active mobile-broadband sub. per 100 inhab.	37.8	24.8	61.9
3G coverage (% of population)	89.8	62.7	87.9
LTE/WiMAX coverage (% of population)	73.0	28.4	76.3
Individuals using the Internet (%)	8.5	22.1	48.6
Households with a computer (%)	9.2	8.9	47.1
households with a computer (%)	5.6	19.4	54.7
International bandwidth per Internet user (kbit/s)	17.4	11.2	76.6
Fixed-broadband sub. per 100 inhab.	0.2	0.6	13.6

Source: ITU

Table 3–268 Number of Telecommunication Line Users and Percentage of Population in Seychelles (2020)

	Total number (subscribers)	Population ratio (%)
Internet user	77,785	79.0
Broadband users	34,966	35.5
fixed-line subscriber	18,882	19.2
Mobile subscribers	183,498	186.4

Source: WorldData.info

According to the DICT, the basic plan and strategy for the country's telecommunications and ICT sector is as follows

[1] Modernize and update the national ICT policy and strategic plan

[2] Work closely with stakeholders to make ICT hardware and software more affordable

[3] Increase the residential penetration of computers and Internet access

[4] Collaborate with ICT service providers to continue investing in their infrastructure and introducing affordable and innovative services

[5] Promote improved universal access to basic ICT service and ensure that tariffs are competitively priced

[6] Promote and facilitate the deployment of e-commerce in Seychelles

[7] To connect all government departments to the Electronic Government Network (EGN) in order to allow for secure integration of the various information systems of government

[8] To computerize the core processes of Government Departments with appropriate information systems

[9] To make available Government Services (E-Services) available online on the Internet, where appropriate, for access by businesses and the public

[10] Modernize the ICT legislative framework to bring it in line with established and developed ICT markets.

In particular, with regard to [5] (improving universal access to basic ICT services), it is explicitly stated that the government will work with stakeholders to extend the coverage of services such as cable TV, hotspots, public telephones, and wireless and ADSL Internet access to Praslin and La Digue islands other than Mahe. It was clearly stated.

Seychelles is the third country in Africa, after South Africa and Madagascar, where Cable and Wireless (Seychelles) started offering 5G services in July 2020. The radios and other communication equipment were procured from Huawei Technologies of China. As of January 2022, the service area includes the capital city Victoria, Roche Caiman, Perseverance, Beau Vallon Beach Promenade, Eden Island, and Seychelles International Airport (SEZ).[114]

[114]Cable and Wireless (Seychelles) was a subsidiary of Liberty Latin America in the United States, but Liberty Latin America has adopted a policy of concentrating on its business in Central America and the Caribbean. However, Liberty Latin America has adopted a policy of concentrating on its business in Central America and the Caribbean, and Cable and Wireless (Seychelles), which had been Liberty Latin America's only mobile business outside Central America and the Caribbean, has been sold to a consortium in Seychelles and is no longer part of Liberty Latin America.

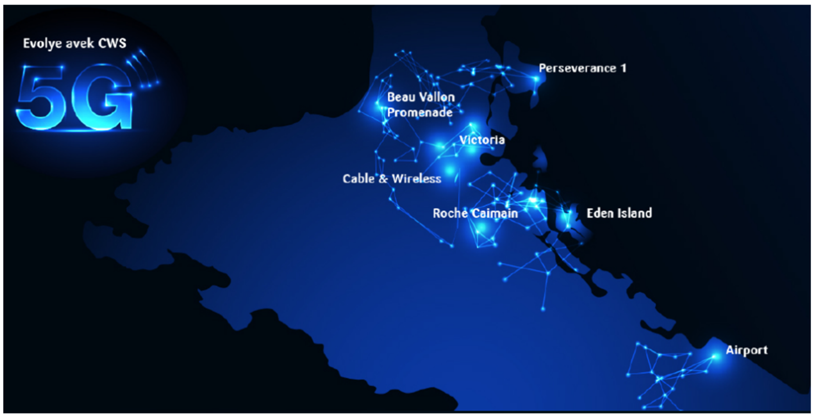


Figure 3–362　5G Coverage Area in Seychelles
Source: Cable and Wireless (Seychelles) website.115

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

In February 2011, the EU-Africa ITF (EU-Africa Infrastructure Trust Fund) decided to set aside €4 million for a project to install a submarine optical cable called SEAS (Seychelles to East Africa Submarine Cable) to connect Seychelles to EASSy, which runs along the east coast of Africa. SEAS is a 1,930 km long submarine optical cable connecting Victoria, the capital of Mahe Island in Seychelles, to Dar Es Salaam in Tanzania. Out of the total project cost of €27 million, 40% was financed by equity and 60% by debt. The long-term debt was financed half by the European Investment Bank and half by the AfDB, while the stock shares were acquired by the Seychelles government, Cable and Wireless Seychelles, and Airtel. SEAS was completed and operated in May 2012. The transmission capacity of SEAS is 20Gbps at the start of operation, but can be expanded to 320Gbps by adding more equipment.

[115] https://cwseychelles.com/5G

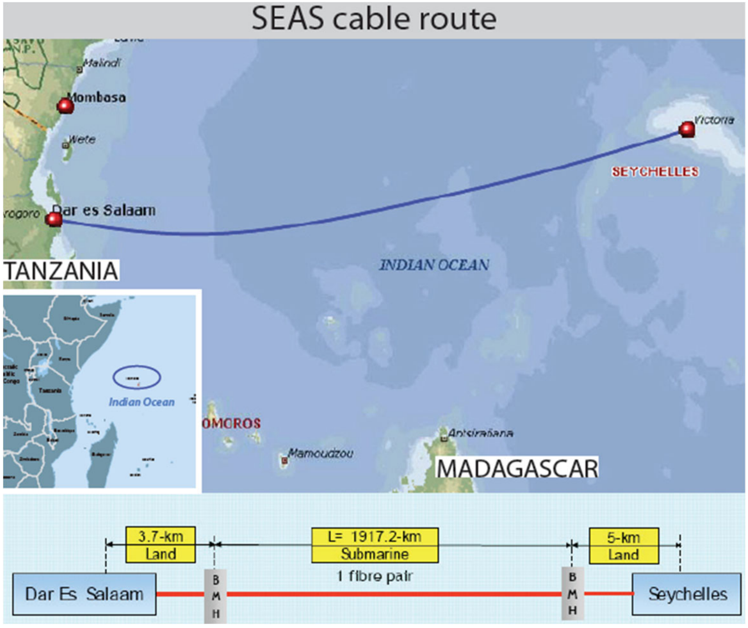


Figure 3–363 SEAS (Seychelles to East Africa Submarine Cable) cable route diagram

Source: EU-Africa ITF Secretariat

The second submarine cable for Seychelles is PEACE (Pakistan East Africa Connecting Europe). PCCW Global, the international business arm of Hong Kong-based telecommunications service provider HKT, and PEACE Cable International Network Co, Limited have agreed to extend the PEACE submarine cable system as PEACE South. PEACE South is scheduled to land at Perseverance, an artificial island on the northeast coast of Mahé Island, Seychelles, in July 2021. The PEACE project will be implemented by Seychelles Cable System Company at a cost of US$20 million.

4) Consideration of Disaster Risk Reduction Measures

Like the Comoros, Seychelles is an island country, and the lifeline of its international telecommunications network is two submarine fiber optic cables, SEAS and PEACE South. From the perspective of disaster prevention, the landing stations to be set up on Beau Vallon Beach for SEAS and on the man-made island of Perseverance for PEACE South need to be prepared for storm surges due to rising sea levels, but since both are operated and managed by private companies, support by JICA is unlikely.

In order to cope with the blockage of international communication due to the damage of submarine optical cables as described in 3), it is desirable to secure some satellite communication lines as backup lines. A technical study is needed to determine how much bandwidth (speed) should be prepared for satellite communication channels.

(5) Agriculture

In Seychelles, the agricultural sector accounts for 1.1 % (2020) of the working population, 2.3 % (2019) of total GDP and 54.3 % (2018) of exports. The majority of exports are of seafood and processed seafood products. The majority of those engaged in agriculture are subsistence farmers with less than 2 ha. The country imports much of its food, including its staple food, which is rice, which accounts for 80% of its food demand. This is increasing year by year. The high cost of agricultural production, restrictions on agricultural land, inappropriate land allocation, limited resources and climatic influences mean that domestic demand is not being fully met.

The total area of arable land is 1,550 ha, or 3.4% of the country's total land area. Much of the agricultural production is rain-fed, but the irrigation potential is estimated at about 1,000 ha, with 260 ha of farmland currently irrigated.

1） Overview of Relevant Organizations and Legal systems

a) Related organizations

i) Ministry of Fisheries and Agriculture (MFA)

MFA plays the role for increasing the availability of locally produced food to meet national food security and nutrition needs, and in reducing risk and vulnerability when factors that limit access to global food markets occur. It also simulates and guides investments to build and maintain the local food production base as part of a strategic food supply and availability system in accordance with the National Food and Nutrition Security Policy.

ii) Seychelles Agricultural Agency (SAA)

SAA was established in 2009 to strengthen national food and nutrition security and to promote modernisation and development of the agricultural sector. SAA implements agricultural programmes and projects, manages irrigation facilities, provides agricultural extension services, conducts crop and livestock research, manages farmland, provides agricultural insurance, collects irrigation water charges, and sells agricultural inputs to farmers.

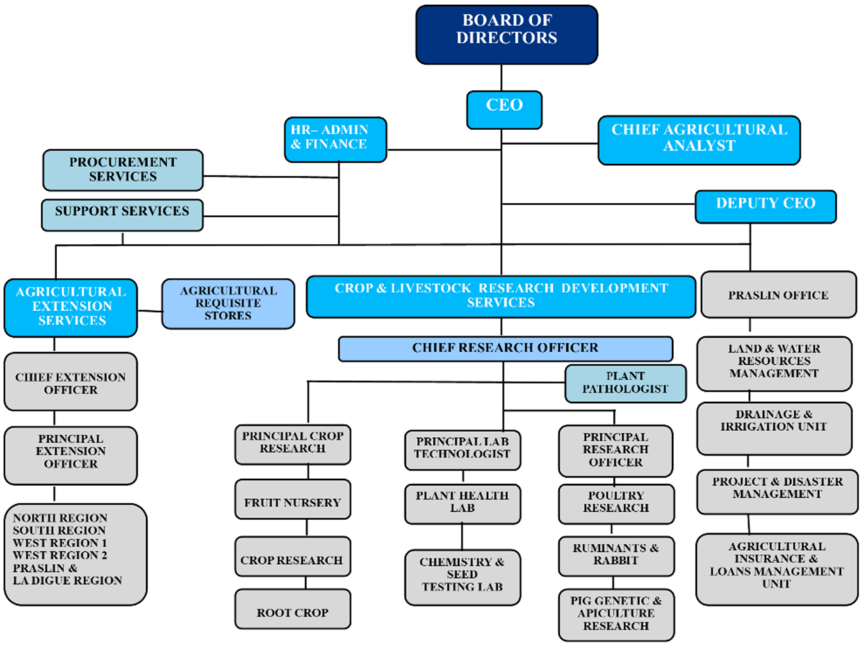


Figure 3–364 SAA Organization chart

Source：SAA HP

iii) Seychelles Meteorological Authority (SMA)

The seasonal forecasts and climate information provided by SMA enable farmers to make decisions on when to plant (Climate Smart Agriculture in Seychelles, FAO, 2019). SMA has also released an official mobile app that provides forecasts and observations on weather, climate and natural disasters.

iv) Agriculture Disaster Committee (ADC)

The ADC was set up to record and verify the damage to farms and other agricultural facilities and infrastructure during the direct hit and flooding of Tropical Storm Felleng in 2013.The ADC was made up of representatives from SAA's departments of agricultural extension services, farmland management, statistics, agricultural research and development, livestock development and veterinary services, and the Department of Environment (Drainage Department).

b) Legal systems

In 2009, the Seychelles Agricultural Agency Act was enacted, establishing the SAA as a legal entity and setting out its powers and functions; it provides for the establishment of an Agricultural Development Fund by the SAA.

2) Overview of Related Plans and Development Status

a) Related plans

i) National Food and Nutrition Security Policy (NFNSP)

The NFNSP was developed in 2013 with the aim of coordinating and strengthening national capacities to achieve food and nutrition security objectives and targets. The overall goal is to guarantee the right to safe, healthy and adequate food at all times and to satisfy the nutritional needs for optimal health for all persons living in Seychelles.Specifically it aims to; i. To ensure food security for all Seychellois through efficient and effective agricultural production, sustainable fisheries and balanced by importation of healthy and nutritious food; ii. To improve and optimize the nutritional status, health and wellbeing of all Seychellois; and iii. Strengthen and align institutional resilience and capacity to effectively and appropriately respond to changes and shocks in food and nutrition security needs including an adequate and responsive knowledge and science base.

The Government of Seychelles recognises that increasing disaster preparedness is a key element in promoting sustainable development, given the constraints and vulnerabilities of a small, isolated island nation, and will revise its food security management plan to take into account stockpiling, storage, global and regional threats and strategic regional alliances (Southern African Development Community (SADC) and Common Market for Eastern and Southern Africa (COMESA). The country did not have a national food reserve and trading companies strategically stockpiled only certain foods. It was also planned to set up an agricultural insurance scheme with insurance companies to compensate agricultural producers for losses caused by disasters. At present, the SAA provides agricultural insurance. In order to reduce the vulnerability of farmers to drought and climate change there is need to put in place effective coping mechanisms through; a) Enhanced use of the early warning information in agricultural systems through dissemination of weather/drought information; and b) Increased role of science and technology in helping livestock agriculture adapt to climate change, and in better understanding of the causes and impacts of climate change. It is stated that the policy will be reviewed every five years, but no additional information has been obtained.

ii) Seychelles National Agricultural Investment Plan (SNAIP) 2015-2020

The SNAIP is a framework that aims to harmonise, integrate and accelerate the implementation of national agricultural and food security and nutrition-related policies and strategies. The development goal is to produce enough food to meet national food security and nutrition needs and to reduce risks and vulnerabilities in the event of local and external factors that limit or obstruct access to global food markets. To achieve this goal, five programmes have been established: i) conservation and sustainable use of agricultural land and water; ii) crop and livestock productivity, commercialisation and diversification; iii) sustainable fisheries management and development of fisheries and marine food; iv) food security and nutrition; and v) human and institutional capacity building.

iii) SAA Policy 2020

The SAA Strategy 2020 is a strategy that will help SAA in implementing the SNAIP to lead the implementation of agricultural programmes and strategic projects that support to strengthen the national food security, increase the contribution of agriculture to GDP and other socio-economic indicators, and promote the development and modernisation of the agricultural sector. The SAA's areas of focus are: i) promoting the development of priority crops and livestock commodity value chains; ii) protecting and conserving farmland and water; iii) building institutional capacity; and iv) increasing influence in regional networks.

According to SAA's analysis of factors affecting the agricultural sector, the coastal plateau has poor drainage infrastructure and occasional flooding of farmland. On the other hand, on the mountain side, serious soil erosion occurs on hilly farmland, and there is lack of investment in anti-erosion measures and emphasis on best practices. Therefore, in 2017, a project to improve drainage systems was implemented to mitigate flooding occurring on farms in Praslin and Mahé (Anse Boileau). Other irrigation system improvement projects were also implemented to enhance the storage and distribution of irrigation water in key agricultural areas to boost agricultural production during droughts.

b) Development status

i) Japan’s Assistance Polic

As Seychelles has one of the highest GNI per capita among African countries, development assistance from Japan is limited. In recent years, assistance in the areas of fisheries and climate change were provided.

ii) Assistance by related donors and private sectors

Recent support and trend of relevant donors are summarised below.

Table 3–269 Assistance by related donors and private sectors

Project/Donor	Summary	Duration/Cost
Country Programme Framework (CPF) / FAO	Technical assistance programs were provided in three priority areas; 1) support the development of a legislative, investment and policy environment to enhance food security and nutrition; 2) productivity enhancement through sustainable production and management of natural resources that mitigate the effects of climate change, and the introduction of agroforestry; and 3) support to create and strengthen more inclusive and efficient agribusiness and agro-food chains.	2014 – 2017 US$ 1.3 million
Agriculture Sector and Marine Aquaculture Development Study / AfDB	The project was aimed at to goals; (i) the formulation of appropriate strategies for the implementation of agricultural policies and the preparation of viable agricultural development projects for funding; and (ii) the formulation of marine aquaculture development policies and strategies and the preparation of a development plan to guide and regulate the development and management of marine aquaculture in Seychelles.	2013 – 2019 US$ 3.74 million

3) Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

Damages to the agricultural sector in the recent disasters are as follows.

Table 3–270　Damage and loss to the agricultural sector

Year	Area	Outline
Jan. 2013 Tropical cyclone Felleng	Southeast cost of Mahé Island, Praslin Island, La Digue Island,	・ Total cost of damage: US$ 776,543 (agricultural materials, rice terraces, irrigation facilities, irrigation drainage) ・ Total cost of loss: US$ 650,357 (crops, seedlings) ・ Total recovery and reconstruction cost: US$ 1,427,060 (compensation for crop losses, drainage measures, infrastructure development)

Source: Seychelles Damage, Loss, and Needs Assessment (DaLA) 2013 Floods, the Government of Seychelles

During the flood in 2013, accumulation of rainwater from mountainous areas on coastal farmland, erosion of hilly farmland due to rainwater runoff, landslides and mudslides occurred. DaLA identified the following issues for consideration.

- Need for proper infrastructure such as drainage, roads etc., for flood risk reduction.
- Lack of enumerators to collect information in the event of a disaster.
- Need for training on information collection and analysis.
- Lack of transport and fuel for staff to collect data and visit farms due to lack of budgets.
- Need to consider low interest credit facility for farmers. This would enable farmers to improve investments in infrastructure such as irrigation and shade houses
- Lunches and overtime are not provided as they are not budgeted.

Based on the damage and SAA Strategy 2020, the challenges are poor drainage infrastructure along the coast and severe soil erosion on hilly agricultural land.

4) Consideration of Disaster Risk Reduction Measures

As countermeasures to the above mentioned issues, drainage systems and afforestation for soil erosion control have already been implemented. As the information on Seychelles was collected only through desktop survey, it is necessary to check the issues related to the measures being taken and the local needs related to disaster management in order to consider specific disaster management measures.

(6) River Management and Coastal management

1) Overview of Relevant Organizations and Legal systems

In Seychelles, the Ministry of Environment and Energy is also responsible for river management, and the National Meteorological Service and Coastal Adaptation and Management Division, which belong to the Climate Adaptation Information Department within the Environment Division of the Ministry of Environment and Energy, are in charge.

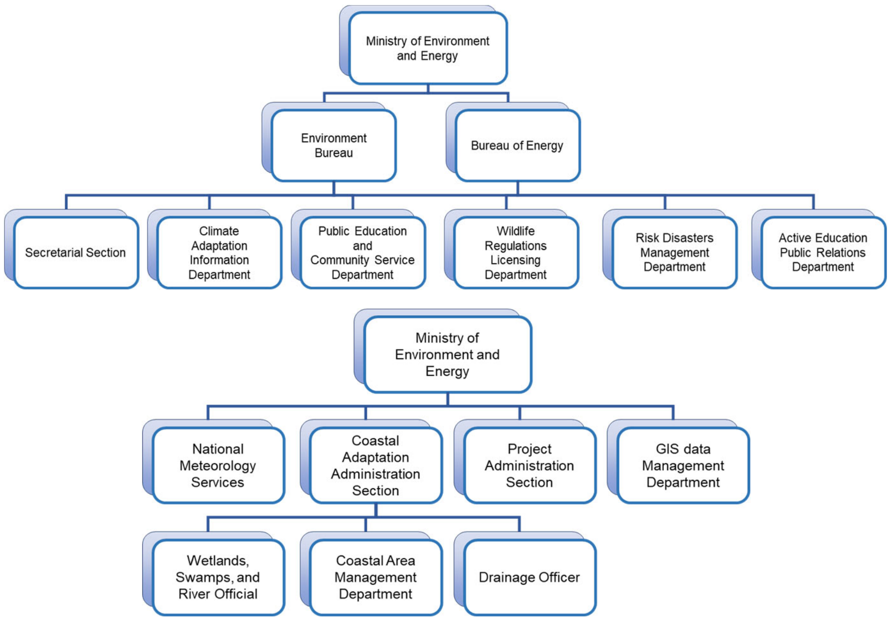


Figure 3–365 Organizational structure related to river management in Seychelles

Source: Seychelles Coastal Erosion and Flood Management Project Report

In particular, the Wetlands, Marshes and Rivers Unit of the Coastal Adaptation and Management Division is in charge of river conservation, protection and management, as well as public education on flood management, while the Flood and Drainage Unit is responsible for the design, construction and monitoring of drainage networks, as well as the collection of sluice gate and watershed data, and the reduction of vulnerability to flood risks at the national level.

2) Overview of Related Plans and Development Status

The main related plans for river management in Seychelles are the Seychelles Sustainable Development Strategy 2012-2020 and the Seychelles National Climate Change Strategy.

Table 3–271 Descriptions of river and coastal management in related plans

Plan	Descriptions related to river management
Seychelles Sustainable Development Strategy 2012-2020	The strategy's vision is to achieve a knowledge-based, innovative approach, as well as a balance between the social and economic needs of present and future generations through the integrated conservation of natural capital, in order to realize sustainable development that ensures an improved quality of life, including the natural environment. The strategy targets the following five areas for river management. - Development of systems for integrated social development and sustainable use of resources - Formulation of long-term national development and land use management policies for sustainable land use - Probability of effective complete coastal zone management - Strengthening of climate change mitigation measures - Establishment of an effective environmental information management system to enhance management and development of long-term social education environment for environmental sustainability
Seychelles National Climate Change Strategy	The strategy aims to minimize the impacts of climate change through coordinated and proactive actions at various societal levels against climate change, and specific action plans have been developed. The action plans related to river management are as follows. - Extend the rainfall monitoring network as a means of forecasting and design - Assess potential coastal hazard areas, vulnerabilities, and appropriate protection levels for the districts. - Develop a legally binding coastal land use plan. - Establish basic design guidelines for coastal drainage, coastal protection facilities, roads, and other public facilities development projects that take into account climate change. - Develop and implement effective adaptation measures and tools, including community-level coastal restoration and conservation measures, at pilot scale. - Integrate and adapt leadership training on climate change, coastal security and conservation.

Source: Seychelles Sustainable Development Strategy, 2012-2020 and Seychelles National Climate Change Committee: Seychelles National Climate Change Strategy, 2009

3） Analysis of Key Facilities and Issues for Cooperation in the Field of DRR

a) Topographic and climatic conditions in Seychelles

Seychelles is an island nation consisting of 115 islands, the most important of which is Mahe Island, with its 905-meter-high Morne Seychellois. The climate is always mild, with heavy rainfall from January to February. It is dry and cool from May to September. The average rainfall map at an observation point (Seychelles International Airport) available on the Internet is shown below. From this, we can see the following.

- In terms of average rainfall, rainfall is relatively heavy from November to February, and relatively light from March to October, but rainfall is observed throughout the year.
- The average annual total rainfall is 2,402.7 mm, which is higher than the annual rainfall of 1,600 mm in Tokyo.

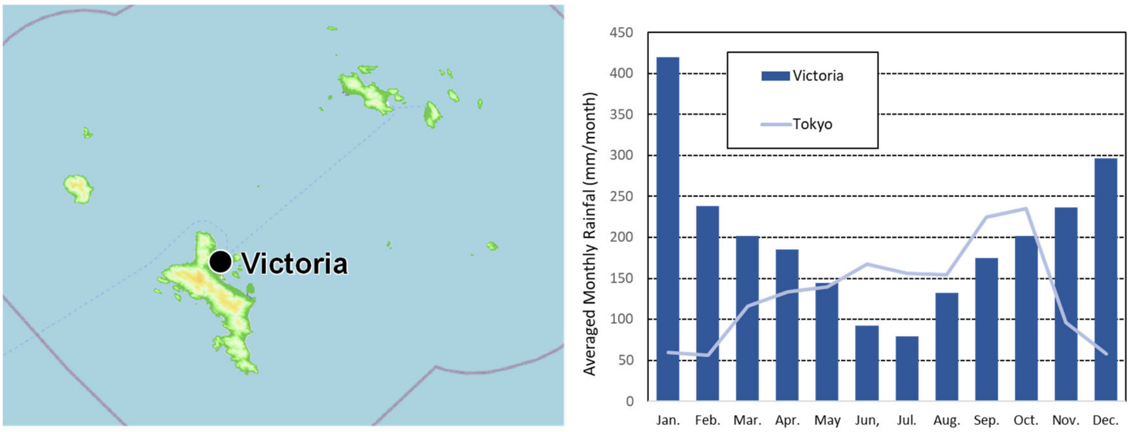


Figure 3–366 Average rainfall in Seychelles

Source: Japan Meteorological Agency website

b) Overview of rivers in Seychelles

In Seychelles, flood damage has been observed along small rivers in the island of Mahé, but a detailed analysis of the rivers around the capital city of Victoria has been conducted, as it is particularly important to take measures in the capital city. Several small rivers run through Victoria, and some of them have been flooded.

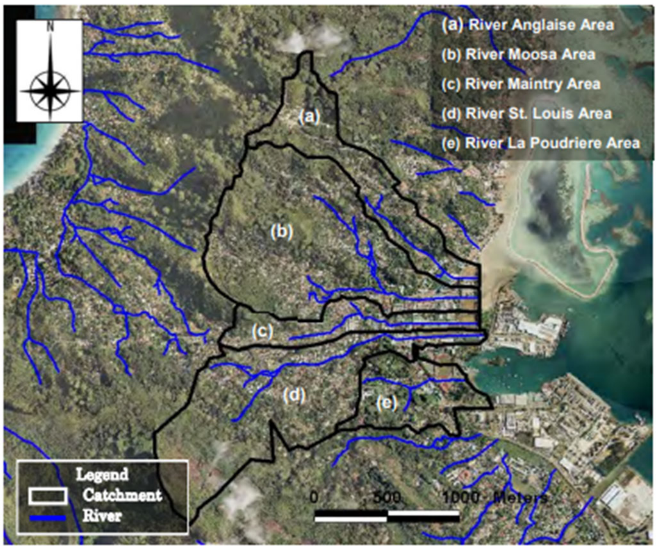


Figure 3–367 Location map of rivers around Victoria, Mahé Island
Source: Seychelles Coastal Erosion and Flood Management Project Report

c) Flood damage in the past

In Seychelles, information on flooding disasters is limited, so the disaster history will be based on the results of interviews conducted by JICA in the past. As a note, in addition to floods and landslides, destruction of roads and houses were also observed. The majority of the affected areas are on Mahe Island, and it can be seen that flooding has occurred in various districts within Mahe Island.

Table 3–272 Flood damages in Seychelles from 1989 to 2006

Date	Area	Location	Description
31st July 1989	Mahe	Anse Aux Pins, Pointe Larue	flooding
28th January 1990	Mahe	Belonie, La Louise, Beau Vallon	flooding / landslide
18th-19th February 1990	Mahe	Victoria Town, Anse Etoile, Pointe Larue, Mont Fleuri and Bel Eau	flooding / overflow / damage to houses
18th-22nd May 1990	Mahe	Mont Buxton, Port Glaud, Les Mamelles, Anse aux Pins	flooding / landslide/ damage to houses
16th February 1993	Mahe	Victoria, Albert Street	flooding
18th February 1993	La Digue	La Passe, Anse Reunion	flooding/mud/damage to drainage and road
10th-13th Jan. 1997	Mahe	Mont Fleuri, Roche Caiman, Foret Noire, Bel Air	flooding/landslide
9th-12th Feb 1997	Mahe	Foret noire, Plaisance. Mont Fleuri	flooding/landslide
13th-17th August 1997	Mahe La Digue	Victoria Town, Beau Vallon, Pointe Conan, Takamaka	flooding / overflow / collapsed roads, 5 killed, 1237 affected.
5th Nov. 1997	Praslin	Grand Anse, Baie Ste Anne	flooding
29th-30th December 2004	Mahe	Northern regions of Mahe, Victoria Town, Beau Vallon	flooding / inundated houses / damage to public infrastructure
8th-12th June 2005	Mahe	Grand Anse, Anse Boileau, Port Glaud, Anse Royale, Le Niol	flooding / landslide / falling of trees
4th-5th January 2006	Mahe	North Mahe, Pointe Conan, Beau Vallon and Mont Buxton.	flooding / landslide / collapsed roads

Source: JICA Seychelles Coastal Erosion and Flood Management Project Report

4) Consideration of Disaster Risk Reduction Measures

In the past JICA studies, the following measures were identified as priority measures for river and coastal management. Since these priority measures are being implemented sequentially, it is necessary to consider additional measures to be implemented based on the implementation status of these priority measures.

- Development of a coastal conservation plan for the priority coasts (North East Point in the northeast of Mahe Island, Baie Lazare in the southwest, Anse Kelan in the west of Praslin Island, and La Passe in the west of La Digue Island)
- River channel improvement of the five target rivers in Victoria (Anglesey, Mosa, Maintray, Saint-Louis and La Podolie)
- River channel improvement in priority areas on Mahe Island (Pointe Larue, Anse-aux-Pins, Au Cap, Anse Royal)

3.8 South Africa

3.8.1 DRR Education

(1) Background of disasters in Southern African region

Based on the "Disasters in Africa: 20 Year Review (2000–2019)"[116] survey conducted by the Centre for Research on the Epidemiology of Disasters (hereinafter CRED) and USAID, the natural disaster damages in the South Africa tend to be underestimated due to the relatively small impacts compared with Asian or North American cases. However, disasters especially in African and Southern African regions are equally with significant impacts when taking the poverty level and population size into consideration (CRED, 2019). According to the report from CRED and USAID, Disaster in Africa: in the Review (2000 - 2019), the countries that were much more affected than others in the last 20 years are Southern Africa including Kenya, Mozambique and South Africa. The reports indicates that the most prominent events leading to disastrous impacts in the region are droughts, floods, and extreme storms (Nhamo, Mabhaudhi and Modi, 2019[117]; Trivangasi, 2019[118]; CRED, 2019)

In the Southern African region, 60 percent of rural livelihoods depend on rainfed agriculture, which makes them vulnerable to the effects of climate change and highly vulnerable to disasters such as droughts and floods (Nhamo, Mabhaudhi and Modi, 2019). They are also vulnerable to economic impacts, as the majority of workers in these areas are engaged in agriculture-related jobs. This is why poverty is one of the main drivers of, and also one of the concerning factors contributing to disaster risk in sub-Saharan Africa (Fourie and Terblanché-Greeff, 2020). World Vision International (2021) indicated that '40% of the region's people live on less than $1.90 a day' and that they are classified as 'extreme poverty' [119]. Internationally, the disaster risk reduction fraternity agrees that disasters happen at the point of interaction between a hazard and existing vulnerability and impact wider range of areas.

---

[116] Centre for Research on the Epidemiology of Disasters (CRED). 2019. Disasters in Africa: 20 Year Review (2000 – 2019). CRED and USAID.

[117] Nhamo, L., Mabhaudhi, T. and Modi, A.T., 2019. Preparedness or repeated short-term relief aid? Building drought resilience through early warning in southern Africa. *Water Sa*, *45*(1), pp.75-85.

[118] Tirivangasi, H.M., 2018, 'Regional disaster risk management strategies for food security: Probing Southern African Development Community channels for influencing national policy', *Jàmbá: Journal of Disaster Risk Studies* 10(1), a468. https:// doi.org/10.4102/jamba. v10i1.468

[119] https://www.worldvision.org/sponsorship-news-stories/global-poverty-facts

Figure 3-368　Inundations in South Africa

Source：Times Live. 2022. Flood Risk in South Africa（Left）
Flood list. 2022. Floods in South Africa（Right）

To mitigate such disasters causing economic damages, there is a need for implementation of policies and measures for government authority to promote consideration of not only human lives but also mitigation of disaster impacts on property. However, most of these areas have little awareness of the need for upfront investment in DRR and its prioritization. Thus, they have not reached the stage to promote such policies and measures at this moment. Furthermore, their way of thinking has to be changed and DRR education at various levels are required.

On the other hand, in this situation in Southern Africa, there is a need to focus not only on a higher level of disaster management education for higher education institutions and government officials to raise their awareness of pre-disaster investment, but also on basic DRR education for local residents and students to teach them to be able to take life-saving actions.

(2)　DRR Education in South Africa

In South Africa, most of the professional studies on DRR are at the higher education level, focusing on disaster risk, including short study programs (3 days per year) and degree courses such as bachelor, master and doctoral degrees. General disaster risk reduction education is not provided at the secondary and undergraduate levels, and there is insufficient support for students who wish to study disaster risk reduction at the secondary level. In addition, although there is a need[120]for a degree focused on disaster management at the practical level, it is at the graduate level that research on disaster risk management is addressed.

[120] Ngcamu, B.S. 2020. B.S. Disaster Management Programmes in South African Universities. Conference Paper delivered at 11th International Conference on Social Sciences. 14 and 15 October 2020. Conference Proceedings.

1） Education system in South Africa

The South African education system consists of three levels of education: primary, secondary, and tertiary. The primary education is from age 5 (grade R) to 12 (grade 6), and secondary education is from grade 7 (age 13) to 12 (age 18). However, the defined ages under this system may change by several years, depending on their starting age, or due to skipping grade or repeating grade, etc.

Higher education in South Africa offers a variety of options, with the South African Department for Higher Education and Training (DHET[121]) managing post-secondary education and training at colleges, universities, and adult education centers.

2） Current status and legal system of DRR education in South Africa

Disaster management in South Africa is governed by the National Disaster Management Framework (NDMF 2005) under the South African National Disaster Management Act (NDMMA) No. 57 of 2002. The National Disaster Management Framework ("NDMF 2005") provides the framework for implementation. Section 6.3.3 of the NDMF indicates that disaster risk reduction education needs to be integrated into the primary and secondary school curriculum. The South African National Disaster Management Centre (NDMC) has developed the Disaster Risk Reduction School Toolkit (NDRR School Toolkit) based on the NDMF 2005. The NDMC has developed a Disaster Risk Reduction School Toolkit (NDRR School Toolkit) based on the NDMF 2005.[122] The NDRR School Toolkit indicates that schools should be "a center for raising awareness about DRR". It also states that DRR needs to be "linked to a wider range of educational programs from a development and environmental perspective. Based on these key points, the overall goal of the NDRR School Toolkit is "to provide tools to support national DRR education and training, school infrastructure, and public awareness programs," and the NDRR School Toolkit aims to "provide the South African school system through the integration of DRR in both Structure and non-structure measures approaches". Followings are the specific objectives of the NDRR School Toolkit;

- To protect students, teaching and non-teaching staff from death, injury and harm in schools.
- To plan for educational continuity in the face of expected hazards
- To strengthen climate disaster resilience through education
- To provide people including school children, students with disabilities with better education

[121] https://www.dhet.gov.za/ [Accessed: 16 January 2022]
[122] South African National Disaster Management Centre (NDMC). 2016. Online: http://www.ndmc.gov.za/Pages/DRRSchoolToolkit-programme.aspx [Accessed: 16 January 2022]

to take up DRR measures individually and collectively;

- To stimulate interest for DRR professional training and education;
- To sensitize curriculum developers about a need to integrate DRR education in the school curricula;
- To safeguard investment in Education Sector;
- To highlight the need by the Department of Basic Education to fully implement the National Policy for an Equitable School Physical Teaching and Learning Environment; and
- To stimulate political interest and commitment for school safety

Considering these requirements by the NDMF (2005), the National Disaster Management Centre situated in the Ministry of Cooperative Governance and Traditional Affairs (COGTA) entered discussions with the Department of Basic Education in 2018 to determine how Disaster Education will be incorporated into the South African Schooling System. It was decided that the Disaster Education content will be integrated into the Life Orientation subjects at school. Life Orientation is the study of the self in relation to others and to society (DoE, 2003) and includes topics such as Personal well-being; Citizenship education; Recreation and physical activity; Careers and career choices. The decision was made that Disaster Education will be integrated into Life Orientation subjects for learners Grade 4 (10 years old) to Grade 12 (18 years old). This integration was said to be done for Life Orientation textbooks for 2022.[123]

Furthermore, the NDMC is also involved in teacher development in Disaster Education as part of the NDRR Schools Toolkit. In addition, as an important perspective, NDMC has linked many of its projects dealing with school disaster education in South Africa with public awareness projects.

As an example of a project based on the policy, the Department of Education and the Provincial Disaster Management Centre in Limpopo Province are facilitating a debate club focused on disaster risk reduction. In the project, students are required to write essays on disasters and disaster risks, among others.

[123] This will be included in the Life Orientation textbook of 2022

Figure. 3-369　EAGER Project

Source：EAGER Project Manual (2016)

Another example of DRR education is the EAGER project, which aims to support the design and implementation of programs aimed at equipping youth with the right knowledge and reducing their vulnerability to disasters. In particular, it aims to further reduce the economic challenges that youth experience at home in pre- and post-disaster situations.

The EAGER project was implemented in four Southern African countries, Namibia, Botswana, Eswatini, and Mozambique, and involved 40 students in primary and secondary education from each country. The project instructors were teachers who taught life skills and life orientation in schools in each region.

Figure. 3-370　EAGER Project Objectives

Source:：EAGER Atlas (2016)

The content of the EAGER project was set up so that the role players (specifically the lecturers) in each country could determine and plan what the project would address in order to achieve its objectives. The implementing organization is the Center for Disaster Research in Africa at North-

West University and the funder is USAID South Africa.

Program is consisting of 4 stages as follows,

Stage 1 : Training of Trainer ("ToT") consisting of basic DRR content

Stage 2: Determine how the trainer would like to build the project, what aspects of vulnerability and risk to focus on, etc.

Stage 3: Identify the schools and students who will benefit most from the content.

Stage 4: Implement the project with the content determined by the instructor

3） DRR education with high educational institutes

An example of disaster management education implemented in a higher education institution in South Africa will be presented.

a) Stellenbosch University：RADAR

Research Alliance for Disasters and Risk Reduction (RADAR) is a research center based at Stellenbosch University, South Africa, dedicated to advancing capacity building in the field of disaster risk through academic programs and short courses, and to conducting research and advancing knowledge on hazards, vulnerability and risk in the Western Cape region, South Africa and the African continent as a whole.

RADAR is a member of the Periper U (Partners Enhancing Resilience for People Exposed to Risks) consortium, a collaboration of 12 university research units and departments on the African continent to promote research and capacity building on risk and vulnerability reduction on the continent.

b) University of the Free State：DiMTEC

Disaster Management Training and Education Centre (DiMTEC), University of the Free State in South Africa is located in the bloomfontain campus. The DiMTEC is an education, training and research center within the Faculty of Natural and Agricultural Sciences at the Bloemfontein campus. diMTEC is committed to educating the public on disaster risk reduction and resilience building through undergraduate, graduate and doctoral programs in disaster management, research projects and short term learning programs (SLPs). DiMTEC strives to educate the public on disaster risk reduction and resilience building through undergraduate, graduate and doctoral programs in disaster management, research projects and short term learning programs (SLPs).

c) University of Pretoria： Natural Hazard Centre

University of Pretoria founded in July 2008 has Natural Hazard Centre (Former Aon Benfield Natural Hazard Centre). It is a multi-sponsored collaborative project between the University of Pretoria and industrial partners. The center focuses on a wide range of natural hazards and risk modeling relevant to the entire African continent. The Center plays a dual role in research and education in the field of natural hazards and serves as an information hub for the engineering, mining, disaster management and insurance industries. It has extensive skills in seismic hazard modeling, mining hazards, and flood and weather risks, and can provide independent advice, opinion, and analysis on all aspects of natural hazards in Africa.

d) North West University：ACDS

African Centre for Disaster Studies (ACDS) has initiated various research, training and consulting projects at the regional, provincial, national and international levels. Since 2002, it has embarked on various research, training and consulting projects at regional, state, national and international levels.

e) University of Johannesburg: Department of Emergency Medical Care

University of Johannesburg, Department of Emergency Medical Care offers a variety of programs in the field of emergency medicine, including a two-year emergency medicine degree and four-year bachelor's and master's programs in emergency medicine. The Department of Emergency Medical Care offers a variety of programs in the field of emergency medical care, including a two-year emergency medical care degree, a four-year bachelor's degree in emergency medical care, and a master's degree in emergency medical care, which leads to registration as a paramedic with the Health Professions Council of South Africa (HPCSA), and a bachelor's degree in emergency medical care, which leads to registration as a paramedic. They also have a partnership with RESCUE South Africa (SA), where RESCUE SA provides experienced and qualified employees for their programs, aiming to upgrade the skills of rescue workers.

3.8.2 Disaster response

South Africa is subject to a variety of natural hazards, including droughts, floods, fires, cyclones, and storms. Since projected future climate change will alter the status of these hazards, how to plan for response activities, along with various other processes related to the socio-economic and physical environment, is recognized as a challenge for the future[124].

Effective DRR is also an important issue in minimizing the effort of disaster response. In other words, if DRR activities are focused only on disaster response, funds that should be used for poverty alleviation and development will be spent on disaster response activities and relief materials.[125] Since it will hinder us from breaking out of the "negative spiral of poverty and disaster.

(1) Disaster responses in South Africa

DRRM (DRR and Management) in South Africa, including disaster response, is governed by the National Disaster Management Act of 2002 (NDMA 2005). according to the NDMA, disaster response refers to "measures taken during or immediately after a disaster to bring relief to people and communities affected by the disaster. The NDMA is implemented through the content of the National Disaster Management Framework (NDMF (2005)), which "provides for a coherent, transparent and comprehensive policy on DRRM appropriate for the country as a whole" and ensures that activities across all levels of government and stakeholders in disaster management in the country are standardized. The NDMF is used as a legal instrument to ensure the application of these standardized methods of action.

The following is a summary based on the NDMF (2005).

1） Key Performance Area 4：Responses and recovery

Key Performance Area 4 of the NDMF describes all the major activities related to disaster response, recovery and rehabilitation. The NDMA states that policies for "rapid and effective response and post-disaster recovery" need to be "integrated and coordinated”. The main point is that there should be no confusion as to the roles and responsibilities to be followed or the

---

[124] Bruwer, A., Van Staden, M., Le Roux, A. and Van Niekerk, W. 2017. Disaster Management and Risk Reduction in South Africa. Chapter 13 in South African Risk and Vulnerability Atlas. Department of Science and Technology. PTA-South Africa.

[125] Fourie, K. and Terblanché-Greeff, A.C., 2021. How Disaster Risk Reduction Can Contribute to Sustainable Development: The EAGER Project. In *Sustainable Development in Africa* (pp. 649-669). Springer, Cham.

necessary procedures to be followed when a disaster occurs.

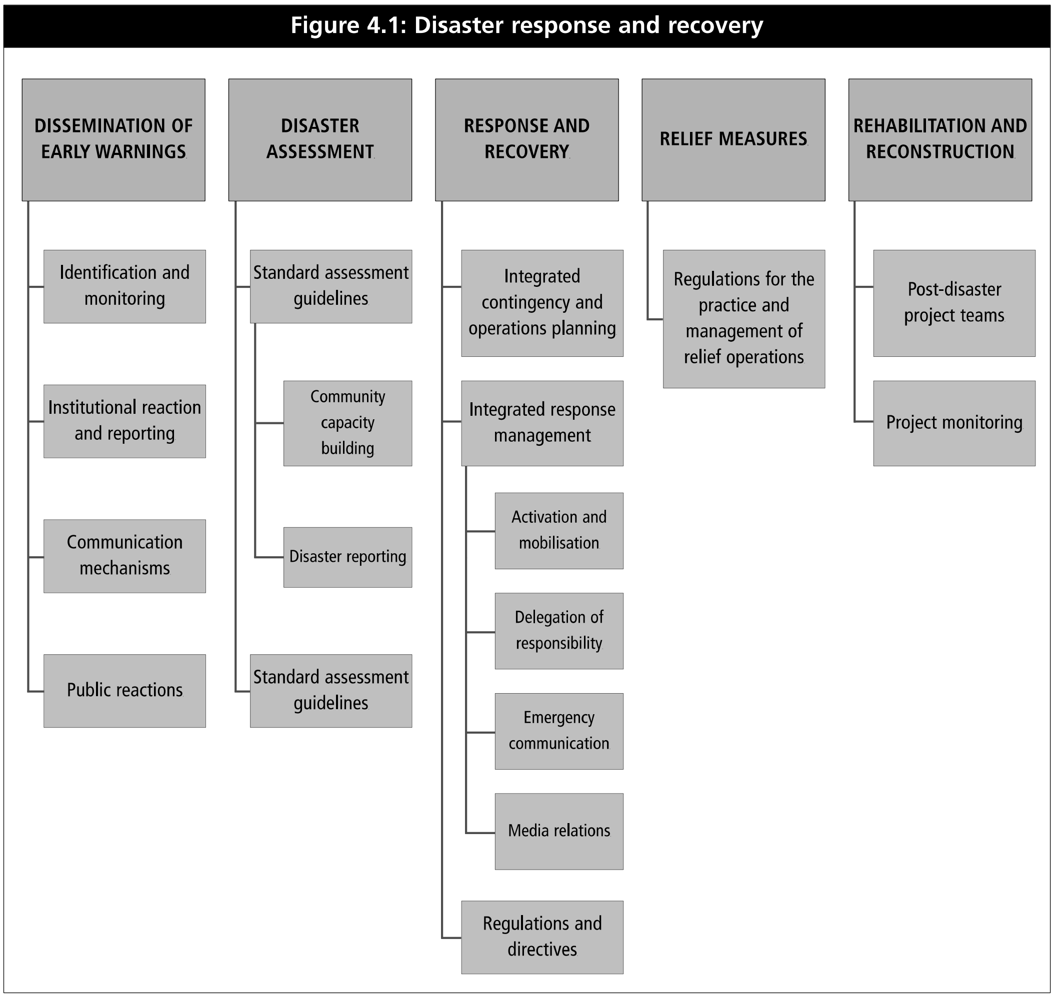


Figure. 3-371 Key requirements and components of the reaction to a disaster event as prescribed by the NDMF

Source:(NDMF, 2005:55)

The main objective of Key Performance Area 4 as indicated by the NDMF (2005) is to 'ensure effective and appropriate disaster response and recovery'. The NDMF indicates that this can be achieved through the distribution of early warnings. Importantly it is indicated that the early warnings that are distributed should follow a 'uniform approach' where accuracy of the information is most crucial.

a) Distribution of early warnings

Early warnings are issued to ensure that communities, households and individuals are prepared for an impending major disaster. Based on the information provided by these early warnings, people can take the necessary decisions and measures to "avoid or reduce risks.

b) Assessment, classification, declaration and review of a disaster

To ensure an immediate and appropriate response and relief action the following steps are important to be carried out

Step 1: Assessment of disaster

Step 2: Classification of a disaster and the declaration of a state of disaster

Step 3 : Disaster Reviews and Reports

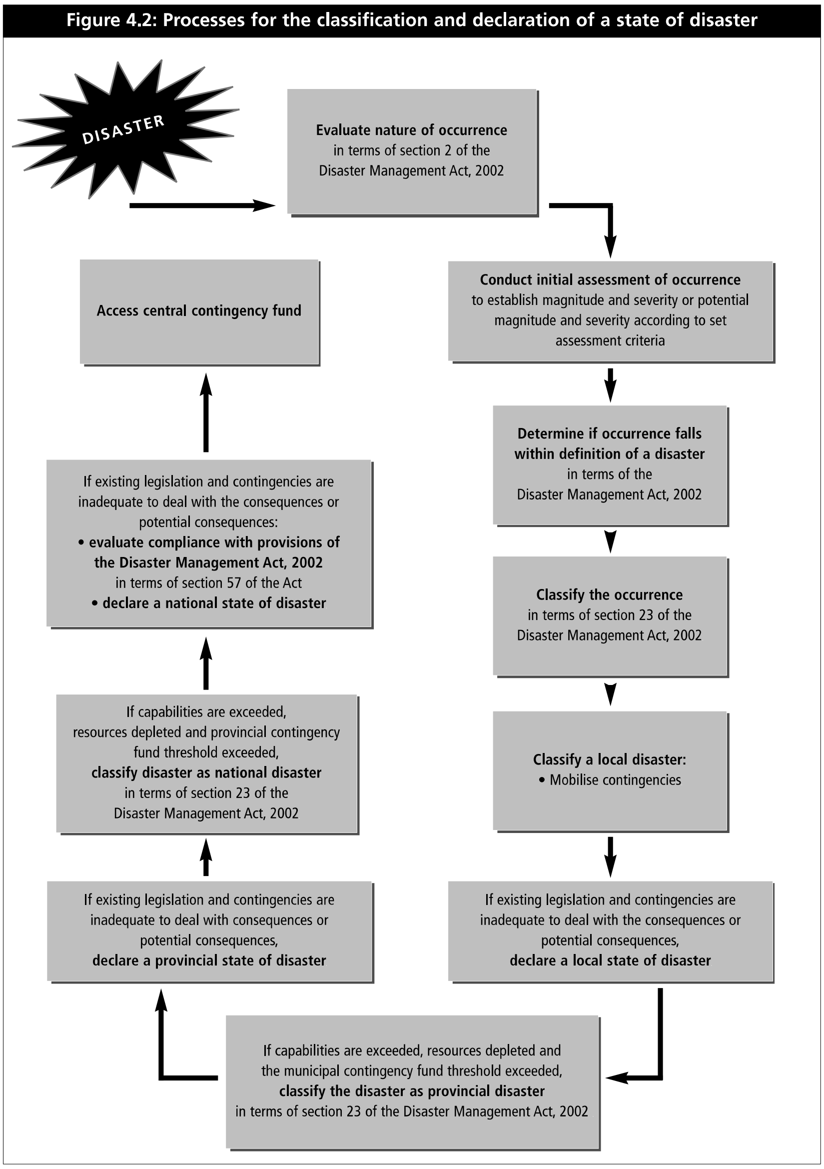


Figure. 3-372 Process for the declaration and classification of a disaster in South Africa

Source: (NDMF, 2005: 57)

c) Integrated Response and Recovery

i) Coordination of response and recovery efforts

The responsibility when a significant event occurs, coordination of response should be given to a specific organ of state. Flood response and recovery for example will definitely include a variety of stakeholders but the main responsibility must be given to one organ of state and others act in a supportive role.

ii) National standard response management system

A response management system must be implemented to ensure effective use of facilities, personnel, equipment, resources, procedures and communication. Such a system gives 'clear allocation of responsibilities, mechanisms for strategic and operational direction'. The NDMC is responsible for 'initiating the development of regulations for the implementation of a national standard response management system'. Details on what such a system should include can be found in the NDMF (2005:60).

iii) Relief measures

The NDMC must 'initiate the development of regulations to standardize and regulate the practice and management of relief operations.' The following are aspects that these regulations must address

- Responsibilities for the release of appeals for donations
- Standards of relief
- Duration of relief efforts
- Acceptance of international assistance
- South Africa's assistance to other countries

iv) Rehabilitation and recovery

Rehabilitation and recovery are a critical component of responding after a significant incident occurs. To 'ensure a holistic approach to both processes the organ of state that is the responsible body for the specific hazard should establish and facilitate project teams for these processes. Projects aimed at rehabilitation and reconstruction should stay focused on developmental outcomes.

2) Preparation of the guidelines

To facilitate the NDMF implementation at every governmental level as easily as possible, National Disaster Management Centre has been creating the guidelines that include each procedure and examples indicated by NDMF. The guidelines described in the NDMF are including the followings:

- National guidelines for conducting disaster assessments
- National guidelines for the classification and declaration of states of disaster
- National guidelines for the process and procedures to be followed in conducting reviews of significant events and events classified as disasters
- National guidelines for the various activities associated with disaster response and recovery

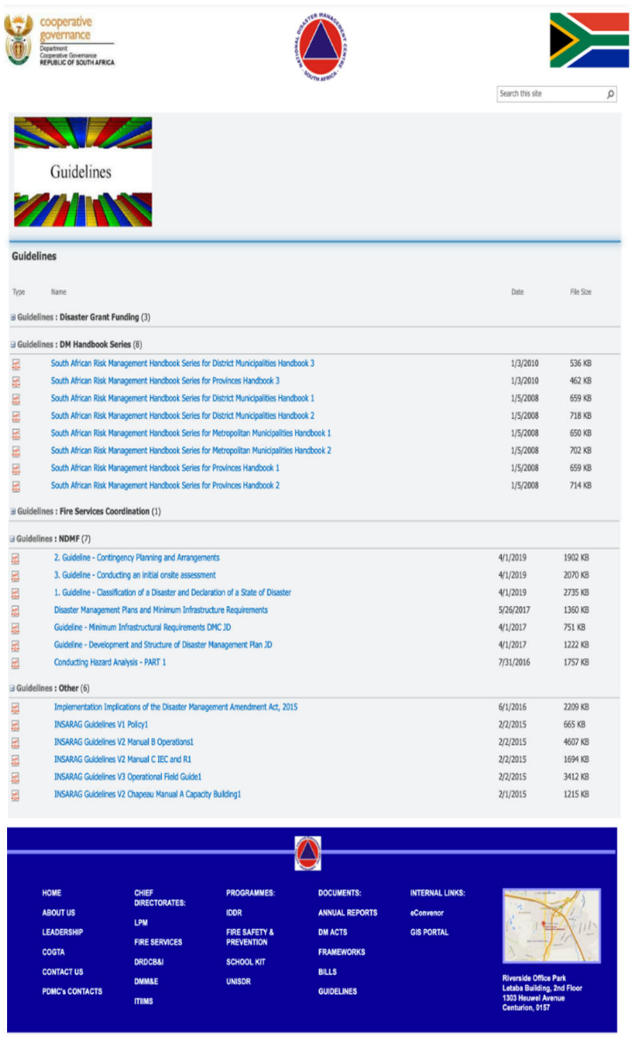


Figure. 3-373 List of available guidelines and resource documents from NDMC

Source: NDMC, 2016

(2) Rescue South Africa (Rescue SA)

Rescue South Africa (Rescue SA) [126] is a non-profit organization in South Africa specializing in various types of recue training and has an 'official South African Disaster Response Team'. They have been active in Africa for over 21 years and during this time have deployed on various rescue missions across the world. One of their main areas of focus is training and Rescue SA has a very specific philosophy about the work that they do. They indicate that they have 'strived to create an NGO that is completely neutral and representative of all South Africans.' Their teams have a wide representation from public and private emergency sector services and include disaster and emergency services from throughout South Africa. They also have a 'rapid Deployment Team' that can respond to a wide range of 'complex emergencies, relief events, rescue operations and mass casualties.

1) Training offered[127]

Rescue SA has trained emergency service personnel throughout South Africa and the Southern Africa Developing Countries (SADC). The courses that are offered are accredited by the University of Johannesburg and carry international recognition as well. The courses they offer include the following:

- Basic Rescue Practitioner that covers areas such as High Angle 1 Rescue, Fire Search and Rescue and Motor Vehicle Rescue
- Bridging course covering High Angle 2 Rescue
- Urban Search and Rescue Practitioner covering Hazardous Materials Rescue; Confined Space Rescue; Trench Rescue; Structural Collapse Rescue and Industrial and Agricultural Rescue
- Wilderness Search and Rescue Practitioner including Aquatic Surface Rescue; Aviation Rescue and Wilderness Search and Rescue

2) Rescue mission and regional network

Rescue SA deployed a team to the earthquake disaster in Gujarat in January 2001 to provide post-disaster assistance. Teams were also deployed to provide post-disaster assistance to Japan following the Haiti earthquake in January 2010 and the Great East Japan Earthquake in 2011. In 2013, Cyclone Hien, also known as Super Cyclone Yolanda, caused a major disaster in the Philippines and was deployed to assist in rescuing victims; in January 2015, a team was deployed at the request of the Malawi government to assist with severe flooding. In January 2015, a team

126 Rescue South Africa. 2018. Home. Online: http://www.rescue-sa.co.za/ [Accessed: 15 February 2022]
127 Rescue South Africa. 2022. Training Prospectus. Rescue SA. South Africa

was sent to Malawi at the request of the Malawian government to assist with severe flooding, and in 2022, a team is also working in Mozambique to assist with Cyclone Ana.

Rescue SA was the first rescue team from Africa to be dispatched to Japan, when it conducted relief operations in Miyagi Prefecture after the Great East Japan Earthquake. The team was the first rescue team ever dispatched from Africa to Japan. After, the Great East Japan Earthquake relief activities triggered a collaboration with Rescue SA as part of the Japanese government's efforts to strengthen disaster resilience in Southern Africa. In March 2015, JICA held a disaster medical workshop in South Africa for Rescue SA members, EMTs, and doctors, and members of the Japan Emergency Medical Services Foundation, DMAT (Disaster Medical Assistance Team), and Disaster Medical Center were dispatched from Japan to share their knowledge and experience in emergency medical services. Japan dispatched members of the Japan Emergency Medical Services Foundation, DMAT (Disaster Medical Assistance Team), and Disaster Medical Center to share knowledge and experience in emergency rescue. At the workshop, the Japanese delegation commented that the capacity of individual paramedics in South Africa is high, and the level of trauma care is one of the highest in the world in some areas, pointing out the advantages of supporting the strengthening of disaster resilience in Africa through Rescue SA.[128]。

Rescue SA has also implemented projects to train paramedics and communities in Southern African countries with the support of JICA, USAID, the United Nations and other organizations. Since 2014, JICA has provided funding through the UN Office for the Coordination of Humanitarian Since 2014, with funding from JICA through the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA), JICA has sent experts to six Southern African countries, including Namibia and Malawi, to conduct disaster response capacity building training for firefighters and others in each country (emergency lifesaving and disaster prevention community training). This is the successor to a three-year project supported by USAID from 2011. In 2016, with the support of JICA, UNOCHA, and USAID, a delegation from Madagascar, Namibia, Lesotho, Botswana, and Malawi was accepted to the training facility at the University of Johannesburg to participate in the Rescue South Africa Respond Program was implemented.

With the support of Japan and the U.S., we have been able to play a role in training a wide range of rescue units in southern African countries and have trained more than 4,500 people and distributed rescue equipment in eight surrounding countries so far. Currently, the training program for neighboring countries has been suspended due to the termination of assistance from Japan and the United States.[129]。

[128] https://www.jica.go.jp/southafrica/office/information/event/20150413.html

[129] https://news.yahoo.co.jp/articles/703562ea80ad5547a5f236efef754eadea544250?page=3

3.8.3 Sharing of South Africa's efforts and the possibility of regional network

A study was conducted on the lessons learned from South Africa's DRR education and disaster response efforts that can be applied to neighboring countries and the possibility of regional network.

Though as this survey only covers South Africa in terms of DRR education and disaster response, it does not indicate that South Africa has an advantage over other countries, as mentioned in the previous section, the ACDS at Northwestern University, for example, has embarked on a variety of research, training, and consulting projects at the international level, with the aim of addressing the training and education needs of the African continent as well as the country itself. The EAGER project mentioned in the case study is also a part of such activities, and we recognize that there is a receptacle in South Africa for regional network in disaster education for future activities of the platform. Similarly, in terms of disaster response, Rescue SA has conducted disaster response training in collaboration with the University of Johannesburg. Therefore, it is believed that the host country will be able to respond sufficiently if, for example, training in a third country is conducted as an activity of the platform.

(1) DRR education

As mentioned above, DRR education in South Africa has long been a research topic in higher education, and there has been insufficient awareness-raising activities for primary and secondary education and citizens. However, in recent years, schools have been positioned as the center of DRR education, and the integration of DRR education into the school curriculum has been realized through the introduction of the NDRR School Toolkit for integration of DRR into the school system and discussions with the Department of Basic Education. In addition, it can be confirmed that efforts are being made not only for DRR education for school students, but also for community awareness education such as training of teachers in disaster reduction education and collaboration with citizen awareness projects, as mentioned in the examples.

It can be said that the integration of DRR into the school system to raise awareness of disaster reduction among the general public was a major step forward in the country's disaster reduction education efforts, and that the path to this goal and the specific efforts such as the NDRR School Toolkit can provide lessons and results that can be shared with the Southern African region. On the other hand, the general public and elementary and junior high school students have also been involved. So, the lessons learned and ideas for improvement can be a useful subject for discussion with other countries.

As for the disaster prevention education at the level of higher education that has been conducted so far, it was confirmed that research on disaster at universities and collaboration within the African region in the same field are already underway. The University of Mauritius, which we visited during the field survey, also proposed collaboration among universities as one of the platform activities in the Southern African region, and it is possible that the collaboration between South Africa and Mauritius will be the starting point for the development of human resources for disaster management practitioners and the establishment of a system to strengthen their technical capabilities.

The themes to be covered in human resource development and technical capacity building include information sharing in the field of disaster research conducted by South African universities, and collaboration in engineering disaster research, technical capacity building programs for disaster prevention and mitigation practitioners, and awareness-raising and disaster prevention education programs for citizens and elementary and junior high school students.

(2) Disaster Response

In terms of disaster response, as seen in the activities of Rescue SA, teams have been dispatched to disasters around the world, and their advanced skills have been highly evaluated by the Japanese delegation. Training is also one of the pillars of Rescue SA's activities, and since Rescue SA has already gained a wealth of experience in providing disaster response capacity building training (emergency lifesaving and disaster prevention community training) to neighboring countries with the financial support of Japan, the United States, and other countries, the implementation of training as part of the activities of the Southern Africa Regional Platform is a good idea. Therefore, we believe that it is possible to conduct the training as part of the activities of the Southern Africa Regional Platform. Since the lack of funds is an issue for the continuous implementation of the training, the implementation of the training using JICA's Third Country Training Scheme is practical.

CHAPTER 4 Proposals of priority disaster risk reduction measures for each country

Based on the results of the above study, the disaster risk reduction measures that should be prioritized in each country are summarized in Table 4-1 below and on the following pages. The list of proposed measures is a compilation of desirable disaster risk reduction measures to be implemented by each country based on surveys and analyzes of disaster characteristics and the status of countermeasures implementation, etc. It does not indicate the projects to be supported by JICA, etc.

Table 4-1 shows the priority sectors targeted in this study when examining and identifying disaster reduction measures in each country. Table 4-2 shows the regional classification and disaster characteristics based on the geographical characteristics of each target country.

Table 4-1 Sectors targeted in this study

Target country	Sectors prioritized for this study
Mozambique	Transportation, Power, Telecommunication, Water and Sanitation, Education, Health service, Agriculture, River management and coastal management
Madagascar	Transportation, Power, Telecommunication, Water and Sanitation, Education, Health service, Agriculture, River management and coastal management, Land slide disaster, Metrology
Malawi	Transportation, Power, Telecommunication, Water and Sanitation, Education, Health service, Agriculture, Embankment
Zimbabwe	Transportation, Power, Telecommunication, Water and Sanitation, Education, Health service, Agriculture, Embankment
Mauritius	Transportation, Power, Telecommunication, Water and Sanitation, River management and coastal management

Source: JICA Study Team

Table 4-2 Regional classification and disaster characteristics

Category	Disaster characteristics	Target country
Archipelago countries	- It is the first region among the eight target countries to be affected in the event of a cyclone. - As an island nation, all coastal areas are at high risk of being affected by storm surges. - Among the archipelago countries, Madagascar is 1.6 times the size of Japan, and it has the same risks of natural disasters and issues in infrastructure development as continental areas. -	Madagascar, Mauritius, the Union of the Comoros, Republic of Seychelles
Continental coastal countries	- In addition to the risk of storm surges as it is located at the coastal area, there is also the problem of river flooding attributed to its connection to the continental interior. - There is a high need to develop infrastructure such as ports and roads as a logistics hub and network not only for the country itself but also for inland countries. - Major cities are located in relatively flat areas with open coastal areas.	Mozambique
Continental inland countries	- Although damage from cyclone storms is limited, there is a risk of flooding and landslides due to rainfall. - As a landlocked country, there is no port which is the key to logistics, logistic infrastructure network such as roads and other from neighboring countries is vital. - Due to the irregular geographical characteristics with hills and valleys, there is a high risk of flooding and landslides in urban areas and on roads and other critical infrastructure. - The country's industry is dependent on agriculture, which makes it susceptible.	Malawi, Zimbabwe

Source: JICA Study Team

In addition, the identification of disaster risk mitigation policies and measures were based on the following points. Priority was given to policies and measures directly related to "human security" and "sustainable development".

- Transportation and traffic (roads, ports, airports, etc.), which play a fundamental role in the regional economy, should be considered in terms of continuity not only with the target country, but also with neighboring countries.
- For electricity, telecommunications, water supply and sewage, the need for improvement from the perspective of DRR (disaster risk reduction) should be examined after confirming the degree of basic existing urban infrastructure.
- As for education and medical care, the target countries are only Mozambique and Madagascar, and we will consider a type of the support which focuses on the current status of education

and medical care in those countries, their medical systems for receiving the patients, and future directions.

- Although seawalls and levees are limited to island and coastal countries, these are so called long-term, hard infrastructure development. Thus, the target area for development is limited and it should be considered as a precondition.
- In the target countries, the importance of agriculture as a basic industry is high, and support measures should be considered from the perspective of coping with damage caused by disasters and preventing economic loss.

Based on the above, the following list of proposed DRR measures is the result of the identification of measures for each country.

Table 4-3 List of proposed disaster risk reduction measures in each country (1/2)

Country	**Number**	**Disaster risk reduction measures to be implemented**	**Candidate measures**
Mozambique	1-1	Enhancement of Air Traffic Control Systems at Beira Airport	●
	1-2	Reconstruction of existing educational facilities	
	1-3	Review of the Maputo Standard Model and reconstruction of schools in high-risk areas	
	1-4	Formulation of design guidelines and principles for the strengthening of medical facilities	
	1-5	Revision of design guidelines and standards for improving resilience of water supply and sanitation infrastructure	
	1-6	Flood adjustment capacity enhancement for dam discharges	
	1-7	Irrigation and drainage system upgrade and improvement	●
	1-8	Formation of emergency logistics hubs in Beira City	●
	1-9	Strengthen Road Operations and Planning for Emergencies in the Greater Maputo Area	
	1-10	Functional enhancement to Beira Airport	
	1-11	Telemetering of hydrological stations on ARA Sul managed rivers	
	1-12	Strengthening of the network of INGD field offices (8 regions)	
	1-13	Greater Maputo Metropolitan Area Comprehensive River Management Master Plan Development	●
	1-14	Greater Maputo Metropolitan Area Comprehensive River Management Master Plan Development（Phase 2）	
	1-15	Dam management improvement related to dam rehabilitation technologies	

Source: JICA Study Team

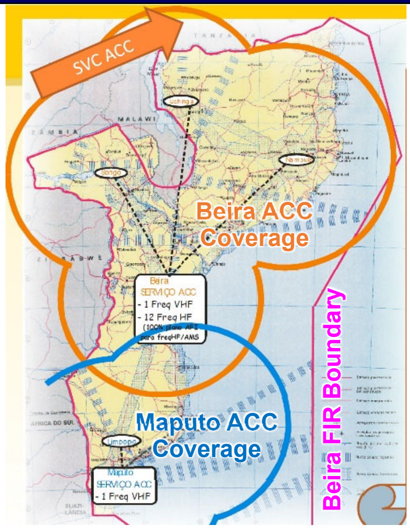
Table 4-4 List of proposed disaster risk reduction measures in each country (2/2)

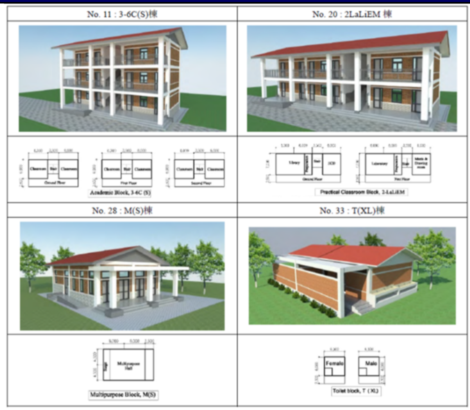
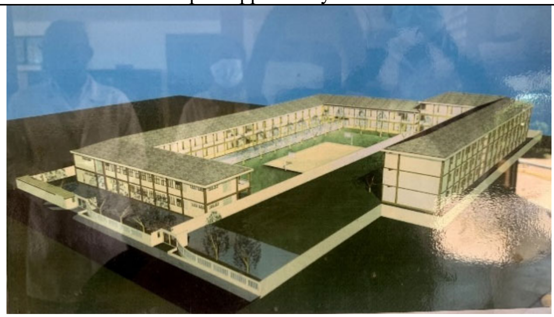
Country	Number	Disaster risk reduction measures to be implemented	Candidate measures
Madagascar	2-1	Disaster risk reduction and developing resilience of Antananarivo-Toamasina urban economic axis	●
	2-2	Meteorological Observation and Forecasting Capacity Development / Installation of Radar Rain Gauge and Surface Weather Observation Equipment	●
	2-3	Antananarivo Metropolitan Area Water-related Disaster Risk Reduction	
	2-4	Urban coastal disaster risk reduction in Toamasina	
	2-5	Disaster risk reduction and Resilience in irrigation system	
	2-6	Disaster risk reduction measures for National Highway No. 7	
	2-7	Disaster risk reduction measures for and strengthening of telecommunication hubs and undersea cables	
	2-8	Formulation of design guidelines and principles for the strengthening of educational and medical facilities	
	2-9	Development of communication networks between rainfall radar stations and GDM central station	
	2-10	Construction of a meteorological telecommunication network to connect Synop stations to rainfall radar stations	
Malawi	3-1	Construction of a backup wireless network for domestic optical fibre cables	
	3-2	Strengthening the disaster risk management capacity of Blantyre Water Board	●
	3-3	Introduction of Hybrid Power Generation System	●
	3-4	Development of River Management Master Plan in the Shire River lower basin	
	3-5	Disaster Risk Reduction Measures for Important Roads in the Southern Region of Malawi	
	3-6	Recovery and improvement of operation of the Kapichira Dam	
	3-7	Preparation of 3D hazard maps using GIS and formulation of land use plan, based on the study of flood control and drainage master plans in Lilongwe	
	3-8	Formulation of Urban Structure Plan Considering Hazard in Blantyre city	
Zimbabwe	4-1	Expansion of community information centres	
	4-2	Harare Ring Road Construction	
	4-3	Introduction of Hybrid Power Generation System	●
Mauritius	5-1	Disaster risk reduction monitoring network with IoT devices connected to 5G network	
	5-2	Introduction of Hybrid Power Generation System	●
Seychelles	6-1	Introduction of Hybrid Power Generation System	●

Source: JICA Study Team

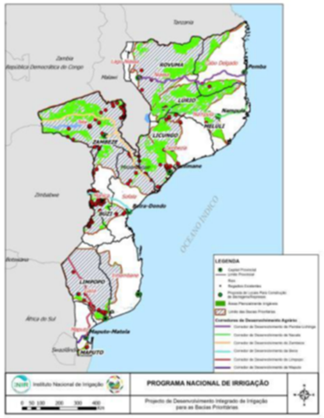
4.1 Mozambique

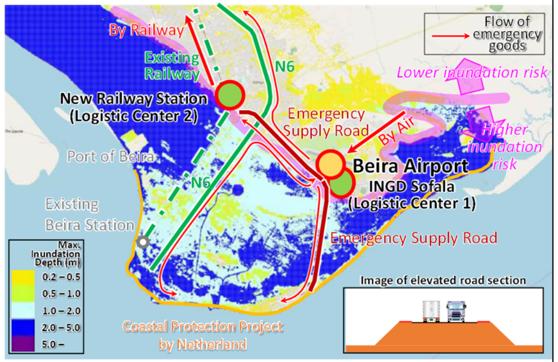
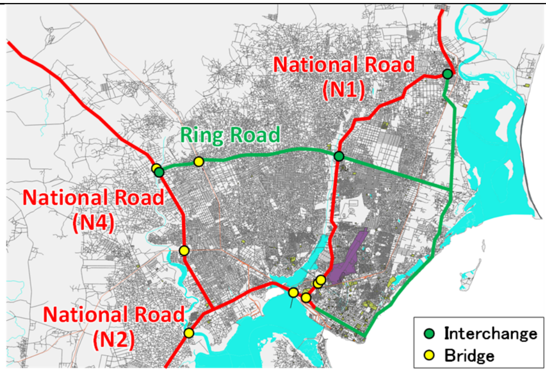
- In Mozambique, in addition to the specific expansion of the air traffic control system and functions of the damaged Beira Airport, it is proposed that the airport be positioned as a logistics hub, including the area around the airport, so that it can serve as a base for future disaster relief supplies and emergency support systems.
- Mozambique is at high risk not only from cyclones, but also from flooding caused by long rains during the rainy season. In urban areas, drainage system development in line with the progress of urban development, and in rural areas, irrigation system development is also an issue, and the formulation of a comprehensive master plan that includes the management of dams and other flood prevention measures is an urgent issue.
- In addition, there is a strong need for design guideline etc., for medical facility development as a social infrastructure or water supply and sewage development as basic infrastructure.

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
1	**Enhancement of Air Traffic Control Systems at Beira Airport** *Refer Chapter 5 for details **Assumed C/P: ADM (especially, Beira Airport)**	 <Boundaries of Beira FIR, Beira ACC, and Maputo ACC>	Beira Airport is an important regional airport to control, not only for aircraft landing and taking off at the airport, but also those flying from Parallel 22 North over Mozambican airspace. However, many of the air traffic control systems at Beira Airport are outdated, and those systems do not comply with the related ICAO standards. Thus, the safety of air traffic is not secure, and it is believed this situation can affect emergency activities via Beira Airport in the event of a disaster.	Replacement or upgrading of air traffic control systems to ensure safe landing and take-off at Beira Airport and the general safety of air traffic in the Mozambican airspace	**Points to note** ❑ Details need to be studied based on further investigation of current status, as there are systems currently being replaced or planned to be replaced ❑ The Vulnerable financial condition of ADM should be considered **Issues to confirm** ❑ Backup system and organization for high-altitude air traffic control ❑ Air traffic control systems installed at other airports, including Maputo Airport ❑ Necessity of Air Traffic Control System **C/P's intentions** ❑ ADM is requesting upgrade or replacement of outdated systems

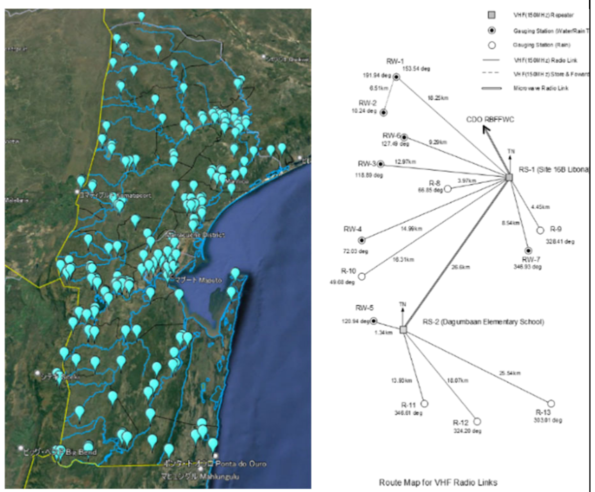
No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
2	**Reconstruction of existing educational facilities** **Assumed C/P: MINEDH, Maputo Municipality**	 <Image: Model for earthquake-resistant design of schools in Nepal supported by JICA>	The Maputo City Department of Education has been rebuilding two to three schools every year since 2012, based on the disaster situation and the shortage of land due to the concentration of population. Two more projects are still under consideration and will be rebuilt as soon as the budget is finalized.	Reconstruction of existing school buildings in Maputo based on the risk of internal flooding.	**<u>Issues to confirm</u>** ❑ Disaster damage occurrence in schools. ❑ Survey on the status of legislation, guidelines and manuals developed by government agencies for the development of strong educational facilities and the actual situation in school construction.
3	**Review of the Maputo Standard Model and reconstruction of schools in high-risk areas** **Assumed C/P: MINEDH, Maputo Municipality**	 <Image: Maputo Standard Model>	The Ministry of Education recommends the construction of one-story buildings for elementary school, but given the shortage of land, the Maputo City Department of Education and Human Resources Development has devised an original, standard design model with two to three stories. There have been no reports of flood damages for the standard model devised by the Maputo City Department of Education. There have been no cases of the facility itself being flooded because the ground level has been raised to prevent flooding. There may be a need to address disaster risks that were not assumed in the standard model, such as high winds and sediment disasters.	Strengthening and maintaining schools that require disaster risk countermeasures beyond the Maputo Standard Model	**<u>Issues to confirm</u>** ❑ Identify schools with high disaster risks using hazard maps ❑ Confirm the durability of the Maputo Standard Model against assumed disaster risks

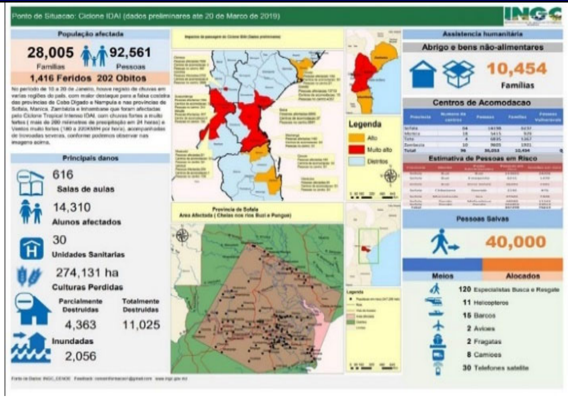
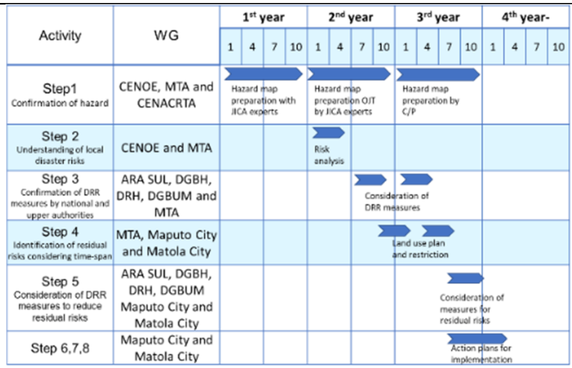
No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
4	**Formulation of design guidelines and principles for the strengthening of medical facilities** **Assumed C/P: MISAU**	 <Image: Model for earthquake-resistant design of schools in Nepal supported by JICA>	Cyclones, which hit the country almost every year during the rainy season, have caused damages to medical facilities. On the other hand, there is no widespread use of architectural design standards and guidelines, especially for medical facilities, and it is of primary importance to formulate and disseminate facility design methods to mitigate disaster damages in the future. In addition, it is considered necessary to confirm the ability of major medical facilities to maintain their functions as disaster preparedness centers in the future.	Formulation and dissemination of design guidelines for water-, wind- and sediment disaster-resistant medical facilities to make them more resilient to cyclones, as well as strengthening of the facilities based on these guidelines	**<u>Issues to confirm</u>** ❑ Disaster damages to medical facilities ❑ Status of legislation, guidelines and manuals developed by government agencies for the development of resilient educational and medical facilities
5	**Revision of design guidelines and standards for improving resilience of water supply and sanitation infrastructure** **Assumed C/P: DNAAS**	-	A revision of the design standards for water supply and sanitation infrastructure (2003) is under consideration by DNAAS. On the other hand, some water supply and sanitation facilities are not included in the design standards. In order to promote the development of disaster-resilient infrastructure and organization systems in the water and sanitation sectors, it is considered necessary for the national government to develop design standards and guidelines including the effects of disasters.	Revision of the design standards for water supply and sanitation infrastructure to make them more resilient to flood damages. Strengthening of resilience of the water and sanitation facilities based on the standards.	**<u>Issues to confirm</u>** ❑ Monitor the progress of the ongoing revision of the standards.

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
6	**Flood adjustment capacity enhancement for dam discharges** **Assumed C/P: ARA Sul**	 <Location of the river and area damaged in the 2012 flood>	During the floods of January 2012, the gates of Massingir Dam was fully opened for emergency discharge and the discharged water flowed down the Elephant River as a flood current, before breaking the bank at the confluence with the Limpopo River. The floodwaters reached the Chokwe district and caused extensive damage. The lack of capacity to properly manage dams remains an issue.	Construction of an inflow forecasting system using precipitation data, enhancement of the flood forecasting and warning system for downstream areas	**Issues to confirm** ❑ Actual situation and needs of C/P ❑ The capacity of ARA Sul on dam operation, meteorological and hydrological observation **Points to note** ❑ ARA Sul has submitted a concept note for request of support on the management, improvement of four target dams around the Greater Maputo Metropolitan Area and support shall be aligned with the concept note
7	**Irrigation and drainage system upgrade and improvement** **Assumed C/P: MADER**	 <National Irrigation Program>Major River Basins Green area: Potential Irrigation Areas, Shaded area: Priority basins	The provinces of Manica, Sofala, Tete, Nampula, Zambézia and Maputo, which have been affected by recent floods and cyclones, are the breadbasket of Mozambique. Any damage to these areas will result in a food crisis in the country. Possible causes of damage to agricultural land and irrigation infrastructure due to floods include breaches in river embankments and inadequate capacity of drainage systems.	Review of irrigation and drainage plans, rehabilitation and improvement of canals and related structures, rehabilitation of river levee, training in operation and management of irrigation and drainage system	**Issues to confirm** Details of the area and activities should be decided after confirming the following points, since only desk research has been conducted due to Covid-19. ❑ Need for assistance ❑ Target area ❑ Cause of flood damage ❑ Irrigation and drainage diagram ❑ Design report of existing irrigation and drainage system (profile and cross section of canal, design drawings of related structures, etc.) ❑ Profile and cross section of river, design flood discharge and flood water level

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
8	**Formation of Emergency Logistics Hubs in Beira City (See Chapter 5 for details)** *Refer Chapter 5 for details **Assumed C/P: INGD, Municipality of Beira, ADM (especially, Beira Airport), CFM, and ANE**	 <Proposal of emergency supply routes based on emergency logistics hubs>	The City of Beira is a core city that serves as a hub for Sofala Province and surrounding areas, as such, it will serve as a base for providing support in the event of a disaster. However, emergency transportation and activities have not occurred smoothly in the past, owing to the difficulty of emergency transport using damaged roads. Thus, it is urgent to secure emergency supply routes in Beira.	Establish logistics hubs around the airport and INGD; in addition, build a new railroad cargo station outside the risk area, as well as a logistics hub, so that emergency relief supplies can be transported even if the current railroad station is damaged Also, ensure access to these hubs and secure emergency supply routes in the event of a disaster.	**<u>Points to note</u>** ❑ Discussion with Beira Airport (and ADM) is required for the installation of an emergency logistics hub at the airport. ❑ This needs to be discussed as part of a reconstruction plan by ARPOC, which in turn, needs to be discussed with INGD, CMB, State Secretary, CFM, etc.
9	**Strengthen Road Operations and Planning for Emergencies in the Greater Maputo Area** **Assumed C/P: ANE**	 <Main roads that form the backbone of the Greater Maputo Area>	The main arterial roads in the Greater Maputo Area are relatively well maintained, including the international corridor. However, since most other roads are unpaved and/or have poor drivability, there are no alternative routes that heavy vehicles can use when those main arterial roads cannot be used due to not only the occurrence of a large-scale disaster, but also heavy rains or accidents. In addition, there are areas that are difficult to access in the event of flooding or heavy rains, which may hinder the transportation of emergency relief supplies and rescue activities.	Improvement of roads that can be used as alternative routes to main arterial roads (paving, securing road widths, etc.) Improvement of high-priority sections of non-paved roads (paving, securing road widths, etc.)	**<u>Points to note</u>** ❑ It is necessary to review the latest future plans, such as urban master plan. ❑ Target sections need to be determined based on the status of urban expansion and the results of the study of flood countermeasures.

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
10	**Functional Enhancement to Beira Airport (See Chapter 5 for the details)** **Assumed C/P: ADM (especially, Beira Airport)**	 <Damages to the cargo terminal (left) and warehouses (right)>  <Damaged perimeter fence (left) and aging RFF vehicles (right)>	In the event of a disaster, due to insufficient land transportation infrastructure, Beira Airport has played an important role in the past in transporting emergency relief supplies, not only to Beira, but also surrounding areas. However, Beira Airport was damaged by Cyclone Idai and other events and has not yet fully recovered. It is still operating under conditions of reduced safety and passenger service in aviation operations. This situation threatens not only the functioning of the airport as a base for disaster risk reduction, but also the survival of the airport itself, as it does not meet international standards (ICAO).	Renovation and upgrading of airport facilities (passenger terminal, cargo terminal, airport fire-fighting facilities, airport doppler radar, drainage, airport security, etc.) to maintain current airport functions.	**Points to note** ❑ Since minimum repairs were carried out immediately after the disaster, further study is needed. ❑ Since Beira Airport is an important logistic hub in the event of a disaster in Beira and the surrounding areas, it is recommended to consider cooperation in the recovery of the cargo terminal from the perspective of its functions as a disaster risk reduction base.

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc.(Donor trends, C/P intentions, etc.)
11	**Telemetering of hydrological stations on ARA Sul managed rivers** **Assumed C/P: ARA Sul**	 Location map of the water level observation facilities near Maputo City received from ARA Sul (left) and the system configuration of the FFWS (Flood Forecasting and Warning System) for the Cagayan de Oro River Basin, Philippines, offered by JICA Grant Aid (for reference, right)	▪ Interviews with ARA Sul senior management revealed that most of the existing precipitation and water level observation stations are not automated or telemetered, and that only about three stations are telemetered (upstream of the Umbeluzi River dam, near the border between the Incomati and Limpopo rivers). ▪ Due to the lack of automation, there is almost no hourly data for both rainfall and water level, which is necessary for MP preparation and flood control activities. ▪ Flood forecasting and flood control measures through dam flood control are not possible due to lack of automation and telemetering, even though the existing dam (Umbeluzi River) can be used for flood control. ▪ The lower reaches of the Incomati River need to establish an EWS because of the potential impact from external water flooding.	Promote the telemetering of hydrological stations. For example, (1) by automating rainfall and water level monitoring and acquiring hourly data, it is possible to use the data for verification when preparing MPs and for calculating the design flow rate for drainage plans; (2) by automating and telemetering rainfall and water level monitoring, it is possible to predict floods and use dam flood control as a flood control measure; and (3) by telemetering water level monitoring stations, it is possible to monitor river water levels in real time and establish an early warning system.	**<u>Points to note</u>** ❑ Confirm the location of the water level observation stations. (The optimal communication system differs depending on the location.) ❑ Establish a warning distribution system (flow) after a rise in water level is observed. ❑ Since multiple donors are involved, it is desirable to make the observation instruments and hydrological observation network system as universal as possible. ❑ As a communication channel, it is easier to build a system using data communication on public mobile communication networks, but there is a high possibility the upper reaches of rivers are out of range. Use of the dedicated VHF band is recommended, but an application for frequency use needs to be submitted.

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc.(Donor trends, C/P intentions, etc.)
12	**Strengthening of the network of INGD field offices (8 regions)** **Assumed C/P: INGD**	 < INGD document >	・ INGD has field offices in eight counties in Mozambique, but internet access is poor (information from WFP).	Enhance internet environment in INGD's field offices.	**Issues to confirm** ❑ Understanding the current status in each office.
13	**Greater Maputo Metropolitan Area Comprehensive River Management Master Plan Development** *Refer Chapter 5 for details **Assumed C/P: INGD, ARA Sul, AIAI, MTA, Maputo City, Matola City**	 < Proposed implementation steps of the project >	The current Maputo metropolitan area will become more urbanized and more vulnerable to disaster, and the expansion of areas that are expected to become urbanized in the future (such as the Matola River basin) will make the city more vulnerable. There is a need to develop a plan for appropriate development based on this perspective of future disaster risk reduction (DRR).	Through JICA's technical cooperation project on disaster risk reduction planning in line with the 8 Steps, DRR will be mainstreamed through (1) flood hazard maps and understanding of the causes of disasters (external water, internal water, and storm surge), (2) risk assessment using flood risk maps, (3) consideration of hard measures and understanding of the risk reduction effects of such measures, (4) consideration of cities equipped with appropriate measures against future disasters, and (5) urban development plans that reduce future disaster risks and costs of structural measures.	**Issues to confirm** ❑ It is necessary to have some quantitative understanding of the following items: (1) the rainfall characteristics of the Maputo metropolitan area and (2) the possibility of external water inundation.

<table>
<tr><th>No</th><th>Priority disaster risk reduction measures</th><th>Location map and related diagrams</th><th>Disaster risk reduction issues and risks, etc.</th><th>Details of measures, effects, etc.</th><th>Points to note, directions, etc.(Donor trends, C/P intentions, etc.)</th></tr>
<tr><td>14</td><td>Greater Maputo Metropolitan Area Comprehensive River Management Master Plan Development (Phase 2)
*Refer Chapter 5 for details

Assumed C/P: INGD, ARA Sul, AIAI, MTA, Maputo City, Matola City</td><td>

< Image of the Land use planning and River management counter measures ></td><td>From among the measures identified in Phase 1, select a few and implement them as a pilot project.</td><td>- Formulation of hard countermeasure plans for river structures and reservoir development
- Formulation of a site optimization plan
- Risk awareness and evacuation planning
- Formulation of a plot development plan
- and others</td><td><u>Points to note</u>
❑ Candidate sites and contents shall be selected by the project, and areas with large effects on other areas (e.g., Matola River basin) and areas that are easy to implement will be selected as models.</td></tr>
<tr><td>15</td><td>Dam management improvement related to dam rehabilitation technologies

Assumed C/P: ARA Sul</td><td>
Massingir Dam

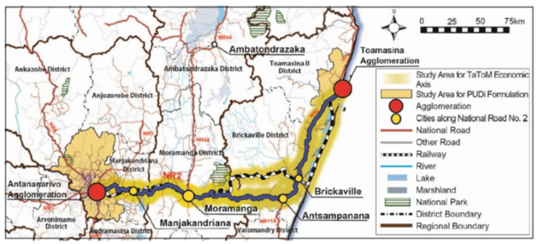
Corumana Dam

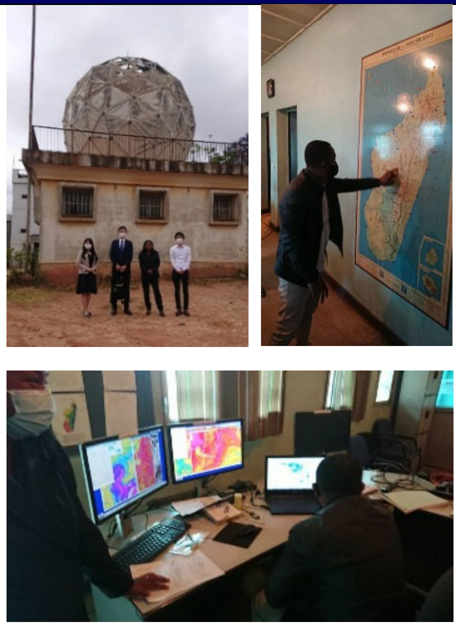
Macarretane Dam

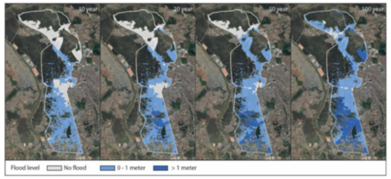
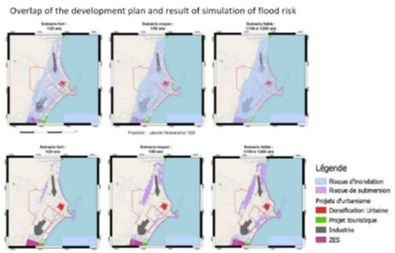
Pequenos Limbombos Dam
<Target 4 dams listed in the concept note submitted to JICA for request of technical cooperation></td><td>The Macarretane Dam was completed in 1956 and other dams, including the Macarretane Dam, are almost completely unmaintained.
The equipment necessary for dam maintenance and hydrological observation is out of order or not available in the first place.
Proper maintenance and management of the dams is not possible due to lack of acquisition of skills necessary for dam maintenance and management.</td><td>It is necessary to improve the safety of dams from the viewpoint of water supply to the Maputo metropolitan area, as well as flood control.
Installation of observation equipment necessary for dam maintenance, management, and measurement.
Capacity building for dam. maintenance and management.
Capacity building for flood control functions by improving dam operation rules.</td><td><u>Points to note</u>
❑ These dams were built by other donors (Italy, Portugal); so, Japanese equipment may be noncompatible.
<u>Issues to confirm</u>
❑ Sluice gates and discharge outlets for flood discharge need to be checked.</td></tr>
</table>

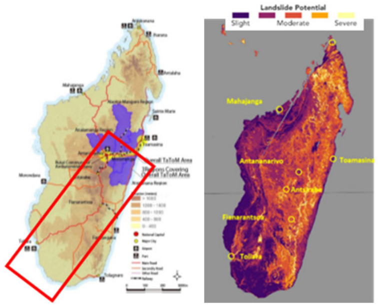
4.2 Madagascar

- Madagascar's capital, Antananarivo, is located in the island's center, therefore, it is necessary to transport necessary goods from Toamasina Port in the east to its political and economic center. However, this inevitably means transport occurs on treacherous roads with a width of about 6 meters. Since there are some mountain passes and roads are cut off due to landslides, the most important measure is the "Economic Axis of TaToM (Antananarivo-Toamasina, Madagascar) / Disaster Prevention and resilience" centered on National Route 2, the most important arterial road.
- The capital, Antananarivo, needs to address urban disaster prevention, while Toamasina needs to focus on urban coastal disaster prevention.
- In Madagascar, old meteorological radar systems installed several decades ago have been damaged and cannot be used for accurate weather forecasting during cyclone strikes, so the development and use of radar rain gauges is deShired.
- From an industrial perspective, the area around Alaotra-Mangorou, which supports the foundation of Madagascar's agriculture, suffers damage from cyclones every year, and disaster prevention measures for stable industrial development in the region are an urgent issue.
- For Madagascar, being an island nation, disaster prevention measures, along with enhancing telecommunication hubs and submarine cables are important issues as well.

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
1	**Disaster risk reduction and developing resilience of Antananarivo-Toamasina urban economic axis (Landslide countermeasures and functional enhancement of National Road No.2)** *Refer Chapter 5 for details **Assumed C/P: MTP**	 Source: TaToM report, JICA, 2019.	While it is an important route in the national growth strategy to connect major cities, the road conditions are problematic and traffic disruptions occur during the rainy season and cyclones, affecting the development of urban and regional economies. It is also vulnerable to landslides.	Strengthening of disaster risk reduction measures for economic axis through slope disaster risk reduction, slope protection works, and climbing lane development in traffic problem areas and bottleneck sections.	**<u>Issues to confirm</u>** ❑ Identify the occurrence of disaster damages, traffic disruptions, and problem areas ❑ Consistency with the TaToM plan

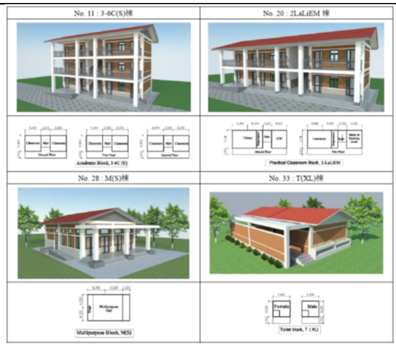
No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc.(Donor trends, C/P intentions, etc.)
2	**Meteorological Observation and Forecasting Capacity Development & Installation of Radar Rain Gauge and Surface Weather Observation Equipment** *Refer Chapter 5 for details **Assumed C/P: DGM**	 < Aging and decaying weather radars and active weather workstations >	An agency of the Ministry of Transport and Meteorology that provides weather forecasts for cyclones, floods and droughts. It consists of the Meteorological Bureau, which mainly provides weather forecasts, and the Applied Meteorology Bureau, which organizes, analyzes, and conducts research on data other than weather forecasts. The annual budget is around 300 million ariary. Though, there are 20 meteorological observation points as of 2012, the basic measuring instruments such as thermometers and rain gauges at the observation points are outdated, and there is considerable missing data and low accuracy. In addition, since telecommunication from the observation points is through cellular phone lines and radio networks, the DGM wants to update the observation instruments and telecommunication networks. The only weather radar they have was installed over 30 years ago and is broken, so there is no weather radar in operation.	The following objectives will be achieved through the introduction of necessary equipment and capacity building for accurate weather forecasting during a cyclone. Basic studies on the location of doppler radar and meteorological observation equipment shall be conducted and installed. DGM use of quality-controlled meteorological data to improve forecasts and warnings, which will be provided to the public and disaster management agencies.	**<u>Points to note</u>** ❑ According to interviews held with the Bureau of Meteorology of the Ministry of Transport and Meteorology, these workstations are useful for weather forecasting and disaster prevention for the entire country of Madagascar. However, they are operated by means of a limited amount of outdated equipment. ❑ As their weather radar is aging and/or damaged, it is assumed that if the weather radar and other equipment provided to Mauritius and other countries were to be installed in these workstations, they will be useful for weather disaster prevention in Southern Africa. (Three radar rain gauges were in operation until 1989). ❑ It is necessary to conduct basic studies on the location of doppler radar and meteorological stations to be installed in the future. ❑ DGM has less than 100 staff and an annual budget of less than JPY 10 million, there are some challenges in basic operation and meteorological stations could be installed before the installation of doppler radar.

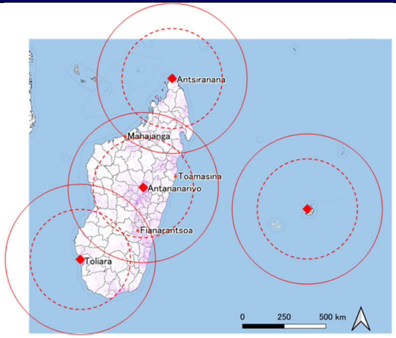
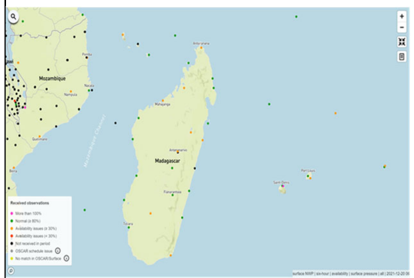
No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc.(Donor trends, C/P intentions, etc.)
3	**Antananarivo Metropolitan Area Water-related Disaster Risk Reduction (Hazard Analysis - Urban Development Planning and Disaster Risk Reduction Infrastructure Development)** **Assumed C/P: BNGRC, APIPA, Antananarivo Urban Commune, MTP**	 ＜Flood Assessment by WB＞	In the Antananarivo metropolitan area, flooding (inland water overflow) occurs during cyclone strikes and long rains in some urban areas, causing frequent flood damage and threatening safe livelihoods and the urban economy. Cities are expanding rapidly, including areas with high risk of flooding (it is reported that about 50% of urban expansion is taking place in areas at risk of flooding), but the development of disaster risk reduction infrastructure (drainage, etc.) is lagging. Hazard mapping has not been sufficiently implemented, and the challenge is to promote urban development and establishment of disaster risk reduction infrastructure in a planned manner.	Hazard analysis and hazard mapping based on scientific evidence (inland water overflow due to heavy rainfall and cyclones), risk analysis (understanding of potential damages), planning of comprehensive disaster risk reduction measures and implementation of pilot projects (planning of disaster risk reduction infrastructure such as drainage), urban planning (urban development, land use, water supply and sewerage system, etc.), human resource development and capacity building for promotion of climate change and disaster risk reduction measures, etc.	**Points to note** ❑ For flood control (urban drainage), etc., various structural and non-structural measures are being implemented with support from donors such as AFD (French Development Agency), WB, etc. Coordination is required for project implementation.
4	**Urban coastal disaster risk reduction in Toamasina (Hazard analysis - Urban development planning and disaster risk reduction Infrastructure development)** **Assumed C/P: BNGRC, Toamasina Urban Commune**	 ＜Flood simulation in Toamasina (CPGU, WB)＞	In the Toamasina metropolitan area, inland water overflow and high water occur during cyclones and other events, and flood damage occurs frequently. While urban development is proceeding even in areas with high risk of flooding, development of disaster risk reduction infrastructure (drainage facilities, seawalls, etc.) is lagging. Hazard mapping has not been implemented, and the challenge is to promote urban development and the establishing of disaster risk reduction infrastructure in a planned manner.	Hazard analysis and hazard mapping (inland water overflow due to heavy rains and cyclones, high water damage), risk analysis (assessing potential damages), planning of comprehensive disaster risk reduction measures and implementation of pilot projects (infrastructure planning (drainage, coastal protection, etc.), urban planning (urban development, land use, water supply and sewerage systems, etc.) human resources development and capacity building for promoting of climate change and disaster risk reduction measures, etc.	**Points to note** ❑ WB supported CPGU to publish a report in 2020 on the hazard study related to open water flooding and high water. Current status needs to be checked. ❑ Role sharing, coordination with related donors is necessary. **C/P's intentions** ❑ BNGRC intends to support disaster risk reduction planning and deployment involving local governments and universities.

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc.(Donor trends, C/P intentions, etc.)
5	**Disaster risk reduction and Resilience in irrigation system (around Alaotra-Mangoro District, etc.)** **Assumed C/P:** **MAE**	-	Districts around the Alaotra-Mangoro Province, where agriculture is the key industry, suffer damage from cyclones and other disasters every year. JICA agricultural support projects have been implemented, but disaster risk reduction measures for flooding, agricultural facilities and irrigation facilities in the area are urgent issues for the stable industrial development of the region.	Disaster risk reduction and resilience in irrigation scheme (details need to be checked)	**Points to note** ❑ Identify the occurrence of disaster damages, traffic disruptions, and problem areas
6	**Disaster risk reduction measures for National Highway No. 7** **Assumed C/P:** **MTP**	 <left: Location map of National Highway No. 7, right: Landslide risk>	National Highway No.7 is also highlighted in the TaToM economic axis concept as a transportation axis between the southwestern cities of Toliara and Antananarivo. Since it is an important route connecting the capital city and the southern region, it is critical to strengthen National Highway No.7 and take measures against landslides, etc., as the case for National Road No.2.	Strengthening of disaster risk reduction measures and economic axis through slope disaster risk reduction, slope measures, and climbing lane development at traffic problem areas and bottleneck sections	**Points to note** ❑ Given the importance of the route, National Highway No. 7 is an important route, but National Road No.2 has a higher priority. The following surveys and studies are necessary when considering countermeasures. **Issues to confirm** ❑ Identify the occurrence of disaster damages, traffic disruptions, and problem areas ❑ Alignment with TaToM plan

<table>
<tr><th>No</th><th>Priority disaster risk reduction measures</th><th>Location map and related diagrams</th><th>Disaster risk reduction issues and risks, etc.</th><th>Details of measures, effects, etc.</th><th>Points to note, directions, etc.(Donor trends, C/P intentions, etc.)</th></tr>
<tr><td>7</td><td>Disaster risk reduction measures for and strengthening of telecommunication hubs and undersea cables

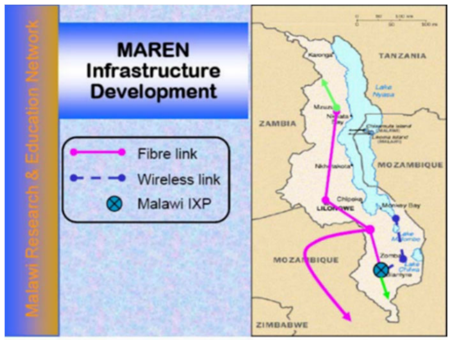
Assumed C/P:
Telma(EASSy)
Orange(LION)</td><td>Table 7 Cable landing stations in East Africa
<table>
<tr><th>Country</th><th>City</th><th>TEAMS
2009</th><th>SEACOM
2009</th><th>LION
2009</th><th>EaSSy
2010</th><th>SEAS
2012</th><th>BRICS
2014*</th></tr>
<tr><td>Djibouti</td><td>Djibouti</td><td></td><td></td><td></td><td>√</td><td></td><td></td></tr>
<tr><td>Somalia</td><td>Mogadishu</td><td></td><td></td><td></td><td>√</td><td></td><td></td></tr>
<tr><td>Kenya</td><td>Mombasa</td><td>√</td><td>√</td><td>√</td><td>√</td><td></td><td></td></tr>
<tr><td>Tanzania</td><td>Dar es Salaam</td><td></td><td>√</td><td></td><td>√</td><td>√</td><td></td></tr>
<tr><td>Seychelles</td><td>Beau Vallon</td><td></td><td></td><td></td><td></td><td>√</td><td></td></tr>
<tr><td>Comoros</td><td>Moroni</td><td></td><td>√</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mayotte</td><td>Kaweni</td><td></td><td></td><td>√</td><td></td><td></td><td></td></tr>
<tr><td>Mauritius</td><td>Terre Rouge</td><td></td><td></td><td>√</td><td></td><td></td><td>√</td></tr>
<tr><td>Réunion</td><td>St Paul</td><td></td><td></td><td>√</td><td></td><td></td><td></td></tr>
<tr><td>Madagascar</td><td>Tamatave</td><td></td><td></td><td>√</td><td></td><td></td><td></td></tr>
<tr><td>Madagascar</td><td>Toliara</td><td></td><td>√</td><td></td><td>√</td><td></td><td></td></tr>
<tr><td>Mozambique</td><td>Maputo</td><td></td><td>√</td><td></td><td>√</td><td></td><td></td></tr>
<tr><td>South Africa</td><td>Mtunzini</td><td></td><td>√</td><td></td><td>√</td><td></td><td></td></tr>
<tr><td>South Africa</td><td>Melkbosstrand</td><td></td><td></td><td></td><td></td><td></td><td>√</td></tr>
</table>
<Cable Landing satations in East Africa></td><td>There is an undersea cable landing station in Toliara, southwest Madagascar, but if it is damaged by a disaster, there is a risk of Internet connection lost for the entire country.
*Potential disaster risk is needed to be evaluated. (In the case of Taiwan, a cable landing station and several undersea cables were severely damaged in the 2006 Hengchun earthquake, requiring 49 days for restoration.)</td><td>Disaster risk reduction measures for the communication hub and undersea cable in Toliara. Specific measures, such as duplicating the power supply system of the submarine cable landing station or adding a backup private power generation facility, can reduce the risk of communication disruption due to the suspension of power supply to the submarine cable in the event of a disaster.</td><td>❑ There are currently three telecommunications companies in Madagascar, including Telma and Orange. Telma was a state-owned company but is now fully privatized. It is difficult to provide support to private companies using JICA ODA scheme.</td></tr>
<tr><td>8</td><td>Formulation of design guidelines and principles for the strengthening of educational and medical facilities

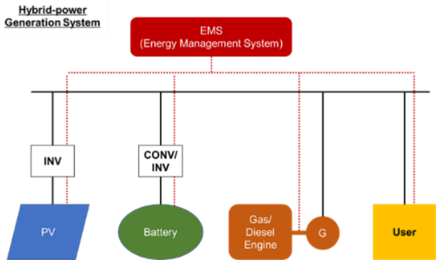
Assumed C/P:
Ministry of Education, Ministry of Public Health</td><td>
<Model for earthquake-resistant design of schools in Nepal supported by JICA></td><td>In the event of a disaster, medical and educational facilities are expected to attract a large number of evacuees and disaster victims, and it is considered necessary to ensure a certain level of strength and scale for these facilities. The cyclone and strong wind countermeasure standard were formulated in 2010. However, as damage caused by cyclones and other events occurs every year, it is unclear whether this standard has actually been widely adopted and whether such facilities are expected to be used as a disaster center,</td><td>Formulation and promotion of guidelines for the development of facilities to make educational and medical facilities more resilient to natural disasters</td><td><u>Issues to confirm</u>
❑ Disaster damage to schools and medical facilities
❑ Status of legislation, guidelines and manuals developed by government agencies for the development of resilient educational and medical facilities</td></tr>
</table>

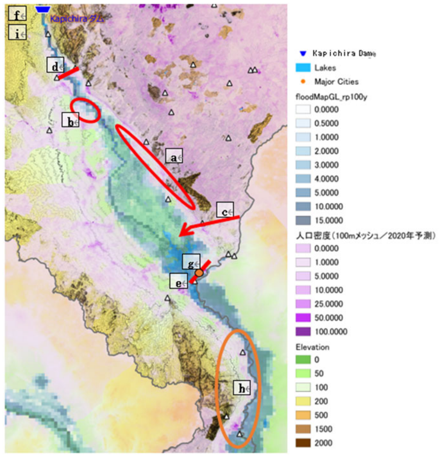
No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc.(Donor trends, C/P intentions, etc.)
9	**Development of communication networks between rainfall radar stations and GDM central station** **Assumed C/P:** **DGM**		Madagascar has three rainfall radars, but all have been out of operation since 1989, making it difficult to observe cyclones coming from the east.	It is proposed that three to four rainfall radars be deployed in Madagascar to strengthen its meteorological observation network. Rainfall radar is to be installed in the existing Synop station(s) and a telecommunication network to transmit rainfall radar data (about 2Mbps) to the DGM central station needs to be considered as well.	**<u>Points to note</u>** ❑ Wired connection (fiber optic cable) has higher bandwidth, but it takes more time to install. So, it is necessary to compare which is more cost effective, a wired or microwave wireless communication network. **<u>Issues to confirm</u>** ❑ Investigate the current status of the existing communication network ❑ Existence of support plans by other donors
10	**Construction of a meteorological telecommunication network to connect Synop stations to rainfall radar stations** **Assumed C/P:** **DGM**		Madagascar has a total of 34 Synop stations as defined by the WMO, many of them, however, are not functioning, making it difficult to obtain real-time weather information.	Deploy telecommunication network system that aggregates data from existing Synop stations in the vicinity to the rainfall radar station proposed in No.9. Data from Synop station is multiplexed with rainfall radar data and transferred to DGM central station.	**<u>Points to note</u>** ❑ In terms of telecommunication stability, a comparative study between public mobile communication network and dedicated wireless line using the VHF band is needed. **<u>Issues to confirm</u>** ❑ Current status of existing communication networks ❑ Existence of support plans by other donors

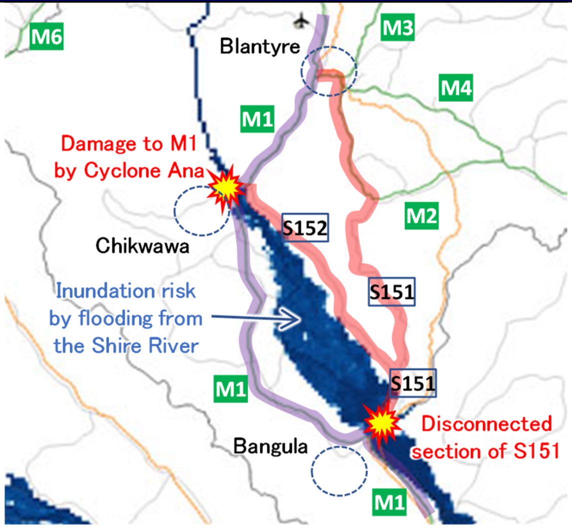
4.3 Malawi

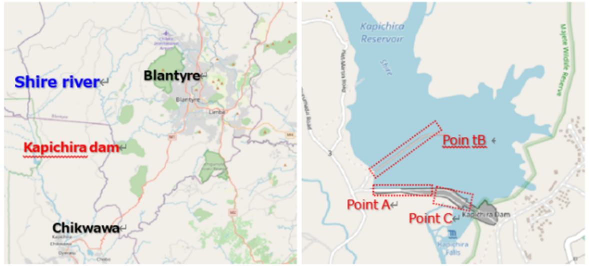
- Malawi is a landlocked country with varying geographical characteristics, such as hills and valleys, that cause prolonged rainfall during the rainy season and frequent flooding in low lying areas due to cyclones. Owing to these geographical features, especially in regions along the valley where major roads or rivers are concentrated this results in damage attributed to floods, etc. on a regular basis.
- In Lilongwe and Blantyre, there is a need for action, including a review of the urban structure where various urban functions are concentrated, and urban development has increased the risk of flooding. Even in suburban areas, important urban arteries such as National Highway No. 1 and local roads are frequently cut off due to flooding, making it important to take proactive countermeasures. Following Cyclone Idai, damage caused by Cyclone Ana in January 2022 was extensive. It is also important to take measures that address damage in the Shire River basin, Kapichira Dam, Blantyre Water Authority, etc., as one-third of the country's energy has been lost due to the collapse of the Kapichira Dam, caused by flood damage. Moreover, since Blantyre Water public corporation's hydroelectric dams require energy to be operational, it is necessary to consider the demand for hybrid power generation that can flexibly meet these demands.

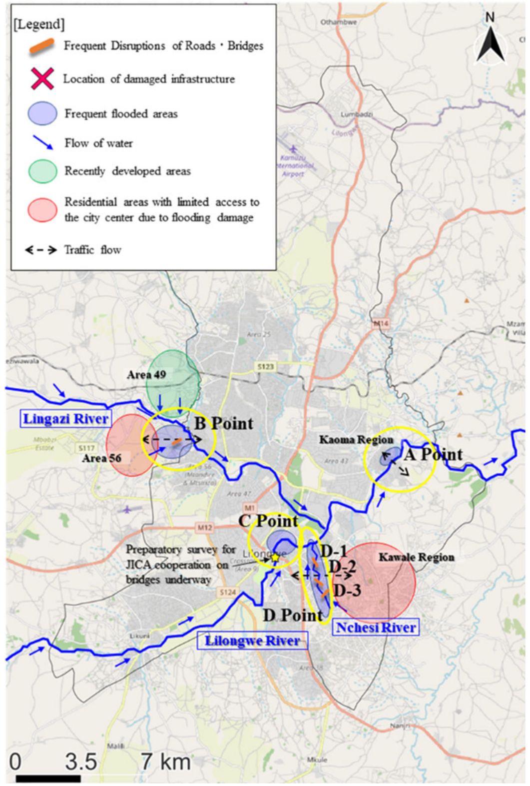
No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
1	**Construction of a backup wireless network for domestic optical fibre cables** **Assumed C/P: MACRA, OCL**	 *Source: Malawi Research and Education Network (MAREN)* <Domestic Optical Fibre Network>	Malawi's domestic fiber optic cable network runs from Mzuzu to Lilongwe (capital city) to Blantyre (international GW station), and important facilities are concentrated in these three cities, which have relatively high hazard risks when compared to the country.	Establish a HF or VHF wireless network connecting these three cities to serve as a backup in the event of a disaster.	❑ Examine how this can be positioned in the development cooperation policy and whether it can be implemented as an urban infrastructure development program. ❑ Need to sort out the relationship with the National Fibre Backbone Project, which is being implemented with support from China.

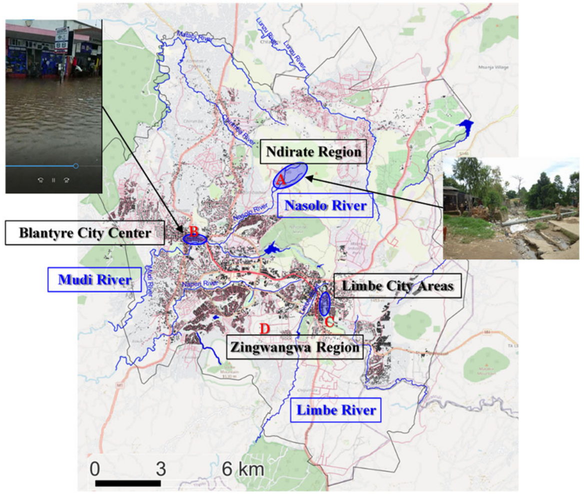
No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
2	**Strengthening the disaster risk management capacity of Blantyre Water Board** *Refer Chapter 5 for details **Assumed C/P: BWB**	-	In the Southern Region, pumping stations and wells were severely damaged by flooding associated with Cyclone Idai. Blantyre, the main city in the region, has the second largest population after Lilongwe, so it is necessary to establish a system that allows for faster and better reconstruction of water supply systems after disasters.	Grant and technical cooperation projects for Lilongwe Water Board (LWB) have been continuously implemented by international donors including JICA. There is a need for Blantyre Water Board (BWB) to strengthen its disaster risk management and disaster risk reduction planning capacity for its water supply.	<u>**Issues to confirm**</u> ❑ Consider including a component on mainstreaming disaster risk reduction in the water and sanitation sector in JICA's ongoing technical assistance programs for Malawi in the water sector. ❑ Existence of support plans by other donors.
3	**Introduction of Hybrid Power Generation System** *Refer Chapter 5 for details **Assumed C/P: EGENCO, ESCOM, Ministry of Natural Resources, Energy and Mining**	 <The hybrid power generation system>	Power generation facilities have insufficient capacity to meet demand and blackouts are frequent in urban areas. The country relies on hydropower as its power source, but with decreasing rainfall and less water available, as well as increasing sedimentation due to decreasing vegetation, energy strategy aims to diversify the power sources. EGENCO owns the main power generation facilities and ESCOM owns all the transmission and distribution facilities, but there is a noticeable lack of capacity due to financial difficulties. In the past, the impact of cyclones and other disasters was not considered significant, but Cyclone Ana in January 2022 damaged the country's maximum power supply and cut off the water supply to Blantyre.	A hybrid power generation system consisting of photovoltaic power generation, storage batteries, and engine generators will be introduced for important public or industrial sectors to realize a BCP to continue power supply in the event of a disaster as a private power generation system that includes renewable energy. It will also improve sustainability by introducing renewable energy regardless of grid constraints.	<u>**Points to note**</u> ❑ Blantyre Water Authority's power generation facility plan also to be considered. ❑ In cooperation with a Japanese heavy industry manufacturer, we can provide remote operation and maintenance support; this can also include capacity building for business owners, if necessary. <u>**Issues to confirm**</u> ❑ Feasibility study on increasing power supply and availability by adding hybrid system to existing diesel power generation facilities. ❑ Survey of important public sectors and enterprises in urban areas that require stable power supply (Lilongwe, Blantyre, Dwangwa [Illovo]). ❑ Technical and economic feasibility study

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
4	**Development of River Management Master Plan in the Shire River lower basin (Update of the National Resilience Plan)** **Assumed C/Ps:** **Main: DoDMA** **Related institutions: NWRA**	 <Location of possible flood control measures in the Shire River lower basin>	In the Shire River lower basin, flood damage due to overflow from rivers is a frequent occurrence. Previous JICA studies have pointed out the importance of a mix of structural and non-structural measures for flood control in Malawi. Currently, the World Bank is supporting the development of important structural measures. That being said, the World Bank-supported project is asking for the expansion of the scope of hazard analysis and the continuous implementation of flood control measures. As such, flood control measures are required.	Currently, the following structural measures and non-structural measures, can be considered, based on the considerations done by the support of WB. a,b: Riverbank protection of the tributary c: Construction of divergent channel d, e: Improvement of M1 and S151 road f: Improvement of Kapichira dam g: Development of DRR and response center h: Land use regulation in possible inundation area i: Improvement of Kapichira dam's flood control function The Shire River basin is the center of agricultural production in Malawi and important roads, such as M1, run through the basin, which causes damage to agricultural and irrigation facilities, alongside the roads themselves due to riverine flooding. Comprehensive flood control measures could efficiently reduce disaster risk in the area.	**<u>Points to note</u>** ❑ Flood control infrastructure development plan has been formulated with WB support; it is necessary to ensure consistency with the plan. ❑ DoDMA recognizes the importance of pre-investment in DRR countermeasures, however, the budget for flood control measures is relatively small when compared to the budget for disaster response. Therefore, it is necessary to prioritize measures and implement flood control measures step-by-step ❑ The result of the hazard maps developed by the WB needs to be taken in account. **<u>Issues to confirm</u>** ❑ Detail situation of river characteristics for the Shire River lower basin.

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
5	**Disaster Risk Reduction Measures for Important Roads in the Southern Region of Malawi** **Assumed C/P: MoTPW, RA**	 <Damages to roads of M1 and S151, alternative routes to M1>	Main Road M1 is the most important road in Malawi, since it traverses the country from north to south and, at the same time, forms parts of North-South Corridor, Nacala Corridor, and Beira Corridor. However, the southern region of the country, especially the Shire River basin area, experiences damage from flooding every year and M1 has also been damaged by those floods. Secondary Road S151, which is an important regional road connecting the east side of the Shire River and Bangula, has been disconnected for several year due to washouts from repeated flooding.	It is proposed to construct a new bridge at the Shire River crossing section of Main Road M1. It will enhance the function of M1 as an international corridor and is also expected to perform as an emergency supply route, better ensuring emergency operations in the event of a disaster in the southern region of Malawi. It is also proposed to recover the disconnected section of Secondary Road S151 and upgrade it. This will enable access from the east side of the Shire River to Bangula and ensure the redundancy of M1.	**<u>Points to note</u>** ❑ Not only the construction of the bridge, but also embankment of road sections connected to the bridge is required. ❑ The embanked road sections need appropriate measures to be protected from washout caused by the Shire River's flooding. ❑ The entire section of S151 or S152 need to be upgraded to ensure heavy vehicle usage, if it is intended to be used as an alternative route to M1.

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
6	**Recovery and improvement of operation of the Kapichira Dam** **Assumed C/Ps:** **Main: DoDMA** **Related Institutions: NWRA, Department of Irigation, EGENCO**	 <Location of damage of the Kapichira Dam>  ＜Damage situation in point-A (left) and point-B (right)＞	Kapichira Dam was severely damaged by Cyclone Ana in 2022, with part of the dam's embankment having collapsed and needing to be restored as soon as possible. Functional improvement (addition of flood control functions) based on the BBB perspective, at the time of restoration, will contribute to flood control of the Shire River lower basin. Flooding frequently occurs in the lower basin, where rainfall in the upper basin of the Shire River flows down and the gradient becomes gentler. Therefore, the Kapichira Dam, located directly above the lower basin of the Shire River, will help reduce the burden of flood control measures in the downstream areas by controlling inflow.	For technical cooperation for dam recovery and improvement of operation, the points below shall be confirmed: 1) Operation status of the flood discharge 2) Consideration of emergency spill way 3) Dam operation to secure flood control capacity By the enhancement of operational improvement capacity, the points below could be achieved. Management of dams to prevent serious damage, such as bank collapse, and the study of operations to secure flood control capacity will contribute to flood control measures in downstream areas.	**Points to note** ❑ DoDMA is responsible for strategy of disaster countermeasures, and NWRA is responsible for operations. In addition, there are many related organizations such as the Department of Irrigation and EGENCO; so, the leadership of DoDMA is important ❑ Methods for consensus building among related organizations, such as area management involving local residents, is also considered to be effective. **Issues to confirm** ❑ Need of DoDMA to secure flood control capacity ❑ Consultations with related parties ❑ Flood control capacity that can be secured from the structure itself. (Current use is only for power generation and irrigation).

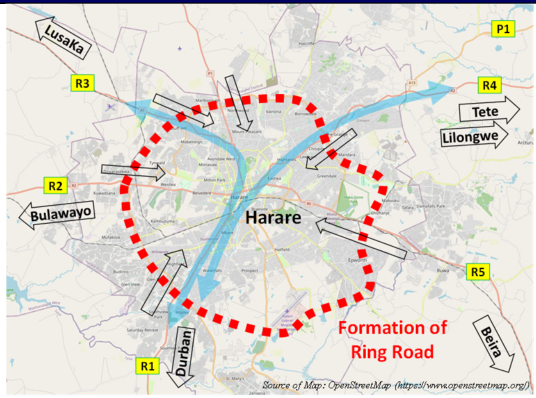
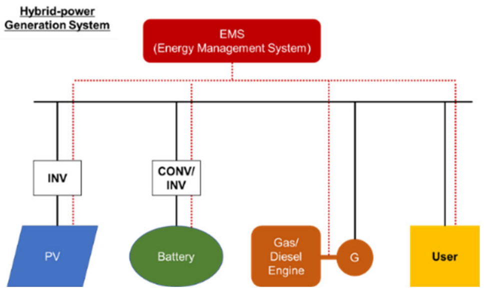
No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
7	**Preparation of 3D hazard maps using GIS and formulation of land use plan, based on the study of flood control and drainage master plans in Lilongwe** **Assumed C/Ps;** **DoDMA,** **Lilongwe City** **Ministry of Local Government and Rural Development**	 <An overview of the flow of water in Lilongwe City and the areas that are frequently affected by flooding>	In Lilongwe City, rainfall during the rainy season often has caused flooding, which restricts movement between areas. In addition, due to the increase in surface water flow caused by urbanization, riverbanks and roads have been washed away by the powerful flow of water. In order to improve these situations and make cities more resilient, the following is necessary. ・ Understand hazard maps to grasp the flow of water in three dimensions. ・ A comprehensive master plan for drainage and flood control to ensure that floodwaters in the city flow quickly. ・ Land use plans to control development ・ Establishment of measures and implementation system to carry out the plan.	・ In order to accurately grasp the flow of water, it is effective to visualize the topography in three dimensions. Therefore, a 3D hazard map should be prepared to visualize a comprehensive picture of hazards in the city. ・ Formulate a master plan for flood control and drainage based on an overall understanding of water flow. ・ Formulate a land use plan reflecting structural and non-structural measures based on the above plan. ・ Study the measures to guide residents to appropriate locations, based on land use plan. By implementing the above as a series of projects, an urban structure that is less prone to damage will be realized.	**<u>Points to note</u>** ❑ A relatively long time is needed to implement a series of these projects. ❑ Due to complex terrain, point-by-point improvements will not lead to fundamental improvements; so, it is important to make improvements in a comprehensive manner with an understanding of the overall picture. **<u>Issues to confirm</u>** ❑ Detailed information on river measures

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
8	**Formulation of Urban Structure Plan Considering Hazard in Blantyre city** **Assumed C/P: Blantyre City, Ministry of Local Government and Rural Development**	 <Areas that are frequently affected by floods in Blantyre City>	In Blantyre, the urban area is rapidly expanding, and residential areas are spreading into areas with high landslide and flood risks. In this situation, it is necessary to review the urban structure itself and take measures, such as directing residential areas from high-risk areas to more suitable areas for living, through appropriate land use.	Revise the urban structure plan based on the hazard map supported by WB. In addition to reflecting on the results of land use plans based on the study of structural and non-structural measures, consider measures to guide informal area residents to appropriate areas. This will lead to the realization of a land use optimization for the city and a disaster-resistant urban structure.	**Points to note** ❑ In Blantyre City, the WB is providing support for the development of hazard maps. **C/P's intentions** ❑ Although the city would like to revise the urban structure plan based on the map, it expects the donor to support formulation of the plan based on hazard analysis.

4.4 Zimbabwe

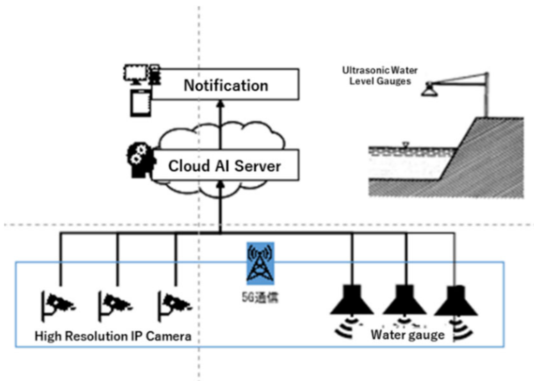
- As in Zimbabwe, the hazard distribution for any disaster types is limited, the economic loss potential is not large, but damage caused by the cyclone to agriculture, houses, and transportation infrastructure is rather significant. On the other hand, since we have not been able to obtain specific needs for cooperation and support in the field, due to the fact that we were unable to conduct a field trip survey, we are examining projects mainly through desktop surveys.
- When we look at transportation infrastructure, Harare is a major transportation hub with the intersection of the North-South Corridor and the Beira Corridor etc. However, as the area has flood risks, there is a growing need for the development of a loop expressway that bypasses the center of Harare to relieve traffic congestion in the international corridor and to decentralize risks in the event of a disaster.
- In view of the aging and poorly maintained energy supply facilities throughout the country and the government's policy of introducing natural and renewable energy, we propose the introduction of hybrid power generation facilities.
- In Zimbabwe, the spread and use of ICT has been growing rapidly in recent years. We propose expansion of community information centers, which are supported by the government to reduce the ICT gap between urban and rural areas.

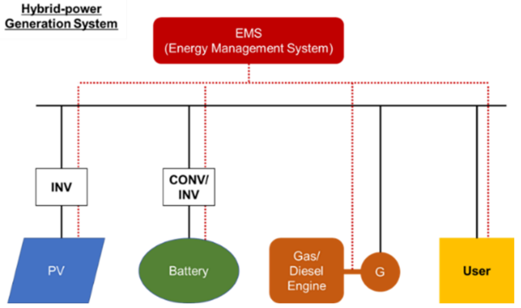
No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
1	**Expansion of community information centers** **Assumed C/P: MoICTPCS**	 <Community Information Centre>	The Zimbabwean government has established community information centers in rural areas and deployed PCs to close the ICT gap between urban and rural areas, but communication bandwidth is not enough to support hub in case of disaster.	Strengthen the communication network of community information centers, so that they can function as communication hubs in the event of a disaster. Specifically, secure satellite communication as a backup line.	**<u>Points to note</u>** ❑ Provision of PCs and related equipment for free is unrealistic for Japan; as such, it is excluded. ❑ A strategy for nationwide expansion of the canters is needed, consideration should be given to strengthening capacity for operation and maintenance.

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
2	**Harare Ring Road Construction** **Assumed C/P: MoTID**	 <Concentration of Regional Trunk Road Network (RTTN) on Harare and idea of a ring road formation>	Harare, the capital of Zimbabwe, is a major transportation hub for the country where the North-South Corridor and the Beira Corridor intersect, which means heavy vehicles pass through Harare when travelling between Zambia/Malawi and the Port of Durban in South Africa. Since no specific ring road exists, these heavy vehicles pass through Harare's city center. However, there have been reports of flood damage from heavy rains in Harare and there is a risk that international corridors through Harare could become paralyzed in the event of a disaster.	It is proposed to form a ring road for the Harare metropolitan area or a North-South Corridor Bypass that bypasses the center of the city. In normal times, it will serve as a traffic countermeasure and, in emergencies, it will ensure the passage through international corridors, which will contribute to securing international cargo transportation routes not only for Zimbabwe, but also for Zambia and Malawi.	**Issues to confirm** ❑ Current traffic condition in Harare ❑ Current situation of disaster occurrence in Harare ❑ Current land use ❑ Latest urban planning
3	**Introduction of Hybrid Power Generation System** **Assumed C/P: ZPC, ZETDC, Ministry of Energy and Power Development**	 <The hybrid power generation system>	Due to aging and inadequate maintenance of facilities throughout the country, the actual supply capacity is 30-260 MW short of demand (2015), causing frequent power outages and making new connections difficult. It is also difficult to get additional supply from SAPP due to tariff arrears.	A hybrid power generation system consisting of photovoltaic power generation, storage batteries, and engine generators will be introduced for important public or industrial sectors to realize a BCP and continue power supply in the event of a disaster as a private power generation system, including renewable energy. It will also improve sustainability by introducing renewable energy regardless of grid constraints.	**Points to note** ❑ Remote operation and maintenance support in cooperation with a Japanese heavy industry manufacturer, including capacity building for business owners as needed. **Issues to confirm** ❑ Survey of key public sector and enterprises in urban areas seeking stable electricity supply (Harare, Bulawayo and Gweru) ❑ Technical and economic feasibility study

4.5 Mauritius

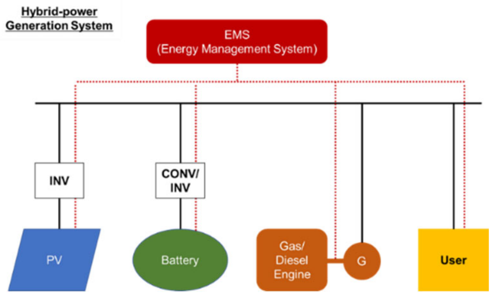
- In Mauritius, there are few urgent issues regarding basic disaster reduction measures, as donor support from various countries is substantial and the country itself continues to actively take measures and invest in DRR proactively.
- As a small island country, the government is actively promoting the introduction of natural/renewable energy sources to address energy supply issues and preserve the natural environment. Thus, we propose to introduce a hybrid power generation facility.
- In addition, JICA has been actively supporting landslide countermeasures, which is one of the biggest disaster risks in Mauritius. As a subsequent effort to utilize advanced IOT, we are proposing a disaster monitoring network that connects IOT devices to a 5G network.
- Moreover, in the chapter 6, we proposed the scheme of HR development on the DRR platform in a wide network with Mauritius as the center.

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
1	**Disaster risk reduction monitoring network with IoT devices connected to 5G network** **Assumed C/P: ICTA(Information and Communication Technologies Authority)**	 <Disaster prevention monitoring network with IoT devices connected to 5G network (image)>	The "Mauritius Slope Disaster Preparedness Support" (completed in 2015), a landslide preparedness unit for the Ministry of Public Infrastructure and Land Transport of Mauritius, shows that the country needs to strengthen its capacity to deal with slope disasters (i.e., landslides, slope failure, rockfall and mudslide, etc.). ICTA Annul Report (2019) states that 5G network development is a national policy.	IoT sensors (IP cameras and, if necessary, water level gauges) will be installed at locations where landslides are likely to occur and transmit data in real time over the 5G network. At the same time, digital platforms such as the Smart City OS will be introduced to provide more accurate and effective evacuation information in the event of a disaster by cross-checking landslide data observed by IoT and human flow data.	**<u>Points to note</u>** ❑ Need to coordinate intentions with various ministries such as the Ministry of Disaster Risk Management and the Ministry of IT.

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
2	**Introduction of Hybrid Power Generation System** *Refer Chapter 5 for details **Assumed C/P: MEPU, CEB, EMMO, MARENA**	 <The hybrid power generation system>	The current power development plan is to supply electricity at the lowest possible cost, to effectively balance supply and demand, and to increase sustainability, which is a fundamental part of national policy. However, the country is highly dependent on thermal power generation, with coal and heavy oil accounting for 70-80% of power generation, and hydropower resources are fully exploited. Solar power is a promising source, but its output fluctuates easily and the amount of solar power in remote islands with small grid sizes is limited.	A hybrid power generation system, consisting of photovoltaic power generation + storage batteries + engine generators, will be installed for important public or industrial sectors on Rodrigues Island to realize a BCP and continue power supply in the event of a disaster as a private power generation system, including renewable energy. It will also improve sustainability by introducing renewable energy regardless of grid constraints.	**Points to note** ❑ In cooperation with a Japanese heavy industry manufacturer, we can provide remote operation and maintenance support, and can also include capacity building for business owners if necessary. **Issues to confirm** ❑ Survey of public sector and companies seeking stable power supply ❑ Survey of needs/grid constraints in Rodrigues Island, a remote island area ❑ Technical and economic study

4.6 Seychelles

- Seychelles, likewise, is a small island nation that faces many similar problems to Mauritius. So far, a JICA-supported master plan for the introduction of hybrid power generation (2016) has been implemented and the introduction of FIT is under consideration for the active introduction of natural and renewable energy, while the introduction of hybrid power generation facilities has been proposed.

No	Priority disaster risk reduction measures	Location map and related diagrams	Disaster risk reduction issues and risks, etc.	Details of measures, effects, etc.	Points to note, directions, etc. (Donor trends, C/P intentions, etc.)
1	**Introduction of Hybrid Power Generation System** *Refer Chapter 5 for details **Assumed C/P:**	 <The hybrid power generation system>	In order to reduce the cost of electricity supply and improve sustainability, the current policy is to increase the percentage of renewable electricity to 15% by 2030. The Ministry of Energy alone is planning to increase the percentage of renewable electricity to 100% by 2030. However, in reality, more than 90% of electricity is derived from diesel. In addition to financial difficulties, the small scale of the grid prevents introduction of variable renewable power sources, such as solar. (According to the JICA survey, the limit is 10MW in Mahe Island and 2MW in Praslin Island, assuming that no storage batteries are used.)	In cooperation with a Japanese heavy industry manufacturer, a hybrid power generation system consisting of photovoltaic power generation, storage batteries, and engine generators will be installed in an area with severe grid constraints to achieve a stable power supply, while introducing renewable energy regardless of grid constraints.	**Points to note** ❑ In cooperation with a Japanese heavy industry manufacturer, we aim to provide remote operation and maintenance support, which can include capacity building for business owners, if necessary. **Issues to confirm** ❑ Survey of important public sectors and enterprises in urban areas that require stable power supply ❑ Survey of needs in the tourism sector and industrial parks ❑ Study on the possibility of increasing the ratio of renewable energy by adding hybrid systems to existing diesel power generation facilities ❑ Technical and economic study

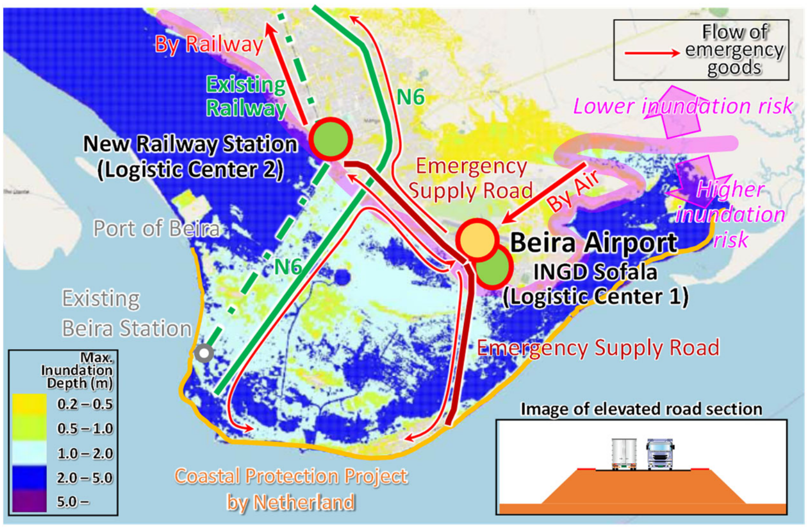
CHAPTER 5 Proposals for disaster risk reduction cooperation measures

Information on disaster risk reduction and issues in each country was collected and analyzed, and priority disaster risk reduction measures for each country were summarized in the previous chapter. The following projects are proposed as disaster risk reduction cooperation measures, based on the understanding of the needs of governmental organizations and local communities through field surveys and other means, as well as consultations with JICA. A summary of each of the proposed measures for disaster risk reduction cooperation is shown on the following pages.

1) Formation of emergency logistics hubs in Beira City (Mozambique)
2) Enhancement of air traffic control systems at Beira Airport (Mozambique)
3) Irrigation and drainage system upgrade and improvement project (Mozambique)
4) Greater Maputo Metropolitan Area Comprehensive River Management Master Plan Development Project (Mozambique)
5) Disaster risk reduction and resilience enhancement for National Road No. 2 (Madagascar)
6) Meteorological Observation and Forecasting Capacity Development / Installation of Radar Rain Gauge and Surface Weather Observation Equipment (Madagascar)
7) Strengthening the disaster risk management capacity of Blantyre Water Board (Malawi)
8) Preparatory Survey for Introduction of Hybrid Power Generation System (Malawi)
9) Preparatory Survey for Introduction of Hybrid Power Generation System (Zimbabwe)
10) Preparatory Survey for Introduction of Hybrid Power Generation System (Mauritius)

5.1 Mozambique: Formation of Emergency Logistics Hubs in Beira City

<table>
<tr><td>Project name (draft)</td><td>Formation of Emergency Logistics Hubs in Beira City</td></tr>
<tr><td>Assumed C/P</td><td>National Institute for Disaster Management and Risk Reduction of Mozambique (INGD), Municipality of Beira, The Airports Company of Mozambique (ADM), Beira Airport, Mozambique Ports and Railways (CFM), National Road Administration (ANE)</td></tr>
<tr><td>Assumed scheme</td><td>Preparatory survey and grant-aid</td></tr>
<tr><td>Period of cooperation</td><td>Preparatory survey: 12 months, grant-aid: 2 years</td></tr>
<tr><td>Location map and related diagrams</td><td>



<Proposal of emergency supply routes based on emergency logistics hubs></td></tr>
<tr><td>Beneficiary</td><td>Beira City and surrounding areas in need of assistance in the event of a disaster
(Population of about 1.5 million in Sofala Province)</td></tr>
<tr><td>Background</td><td><u>Necessity of the formation of emergency logistics hubs</u>
Beira City is a core city for Sofala Province and surrounding areas but is vulnerable to natural disasters and recovery efforts from damage caused by Cyclone Idai in 2019 are still underway. At that time, National Road N6 and the Port of Beira were also damaged, making it difficult to transport emergency relief supplies by road and port following the cyclone. However, Beira Airport, located at a higher elevation than the surrounding areas, and the railroad, which is raised and suffered less damage, played a major role in transporting emergency relief supplies within the country and from abroad. At present, various disaster risk reduction measures are being implemented in Beira with the support of countries around the world. However, it is essential to secure emergency logistics routes to enable efficient and smooth transportation of emergency relief supplies and recovery activities in the event of a disaster. Thus, the formation of logistics hubs in Beira City, using the above two transportation infrastructures, is important as a disaster risk reduction measure for Beira City.

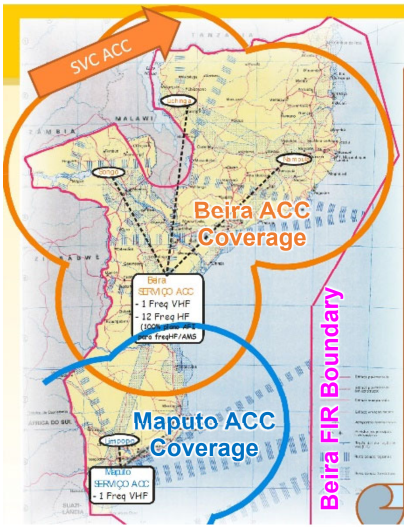
<u>Current situation of Beira Airport</u>
Beira Airport is an important regional airport that covers aviation demand not only for Beira City, but also Sofala Province and surrounding areas. The passenger terminal, cargo terminal, hangars, and warehouses of the airport have not fully recovered from damage caused by Cyclone Idai and other storms. Damage to the cargo terminal, hangars, and warehouses consists mainly of blown-away roofs, caused by strong winds. The cargo terminal was built in 1974 with dimensions that are much larger than required, meaning that only part of the cargo terminal is in use. The unusable area of the cargo terminal, owing to a damaged roof, is estimated at 2,300 m^2 and it is believed that this sufficiently large cargo terminal can be utilized as an evacuation center or an accommodation facility for disaster victims. Thus, if restored, Beira Airport is expected to function in emergency situations as not only a logistics base, but also disaster risk reduction base.</td></tr>
</table>

<table>
<tr><td></td><td><u>Current situation of existing railroad</u>
The existing railroad has mostly a double track in the Beira City area and extends from Beira Station, located near the coast, to Malawi, Zimbabwe, and Tete Province, an inland province of Mozambique. According to CFM's statistics in 2019, items transported by this railroad include cement, fuel, containers, coal, timber, etc., but 86% of the total volume in 2019 was coal transported from Tete to the Port of Beira. The number of passengers using Beira Station is unknown, but passengers who used three passenger train lines connecting Beira Station are reported as approximately 1.51 million. Beira Station was not inundated when Cyclone Idai occurred. However, there is a high risk of inundation when the same scale of cyclone and storm surge occur simultaneously, and, in this case, it becomes difficult to transport emergency relief supplies by railroad. If a facility is prepared for freight loading/unloading at an existing railroad section with low inundation risk, the facility is expected to perform as a logistics base for transporting relief supplies in emergency situations. Also, if the area is facilitated with space for emergency operation staff, evacuees, and disaster victims, this facility will perform as a disaster risk reduction base.

<u>Awareness of C/P</u>
INGD expects utilization of railroad for the transportation of emergency relief supplies in the event of a disaster, understanding the railroad played an important role in the events of Cyclone Idai.</td></tr>
<tr><td>Target</td><td>- Secure emergency logistics hubs that can function, with reasonable certainty, in the event of a disaster, even when a cyclone and storm surge occur simultaneously.
- Enable efficient emergency support activities in the event of a disaster, based on those emergency logistics hubs as disaster risk reduction base.
- Furthermore, secure emergency logistics routes connecting those emergency logistics hubs and protect the safety of residents.</td></tr>
<tr><td>Implementation details</td><td>- Enhance Beira Airport as a disaster risk reduction base (restore the cargo terminal and warehouses damaged by Cyclone Idai and secure space for emergency operation staff, evacuees, victims, etc. in the event of a disaster).
- Construct a new railroad cargo station (simple type) and designate it as a disaster risk reduction base (secure space dedicated to emergency operation staff and space to accommodate evacuees and victims in the event of a disaster, etc.). Although discussion and coordination with C/P are required for planning the use of the new railroad cargo station, it is expected that it can be used in ordinary situation for parking space for buses and heavy vehicles, public space such as service area, and/or an ordinary logistics base. It is also expected that an indoor sports facility, such as gymnasium, can be constructed instead of public buildings and warehouses for the space for emergency operation staff, evacuees, victims and perform the same function.
- Strengthen the existing road (4.6 km) between Beira Airport and the new station and the road (5.2 km) connecting Beira Airport and the coastal road (rehabilitation, raising of road sections where there is a high risk of flooding, etc.)
- Smooth connection between Beira Airport, the new station, and other transportation infrastructures (road and port)</td></tr>
<tr><td>Project size (JPY billion)</td><td>- Preparatory survey for cooperation: JPY 80 million
- Grant-aid: JPY 3.0 billion
  ➢ Restoration of the cargo terminal, etc. of Beira Airport: JPY 0.3 billion
  ➢ Cargo station site development (cargo yard, pavement): JPY 0.15 billion
  ➢ Construction of a public building and a warehouse: JPY 0.35 billion
  ➢ Construction of railroad track (1 km in consideration): JPY 0.7 billion
  ➢ Upgrade of the road between Beira Airport and the new station: JPY 0.5 billion
  ➢ Upgrade of the road between Beira Airport and the coastal road: JPY 1.0 billion</td></tr>
<tr><td>Things to keep in mind</td><td>- Although INGD expects the utilization of the existing railroad for the emergency logistics, INGD is not aware of the designation of Beira Airport as a disaster risk reduction base and the construction of a new railroad cargo station. Thus, discussion and consultation with INGD and other counterparts is necessary.
- Since various development projects are currently being planned in Beira, investigation of the latest situation needed to occur as part of the preparatory survey for cooperation, including coordination with other projects.
- The roads between the new railroad cargo station and Beira Airport, alongside those</td></tr>
</table>

	between Beira Airport and the coastal road, need to be studied in relation to serving as an emergency transportation road in the event of a disaster, such as a flood, by considering flooding countermeasures, which includes raising them if necessary. - In case Beira Airport cannot be used as a disaster risk reduction base, strengthening the function of the new railroad cargo station needs to be studied. For example, measures for accommodating more emergency operation staff, evacuees, victims, etc. could be studied. - Location of the new railroad cargo station should be studied carefully to minimize the resettlement of existing residents. - Although the existing railroad is raised and relatively resilient against flooding, it is reported that train operation has been suspended due to the yearly flood occurring near Pungwe River. These details should be investigated, and, if necessary, countermeasures should be studied. - In the case of Cyclone Idai, fully loaded large size aircrafts could not land on Beira Airport due to the limitations of the runway's length (currently 2,400 m), and trans-shipment of the emergency supplies from small aircraft was required at Maputo Airport. Beira Airport also experienced a lack of aircraft parking capacity due to the increased number of aircraft. It, therefore, is desirable to expand the capacity of these facilities for emergency cases, but it is believed this does not have high priority from the aspect of maintenance cost in ordinary situations and benefit. Further study is necessary. - Repairing the damaged passenger terminal is not included in this proposal due to its low priority. However, it is necessary to study when considering discussion with counterparts.

5.2 Mozambique: Enhancement of Air Traffic Control Systems at Beira Airport

Project name (draft)	Enhancement of Air Traffic Control Systems at Beira Airport
Assumed C/P	The Airports Company of Mozambique (ADM), Beira Airport
Assumed scheme	Preparatory survey for cooperation, grant aid
Period of cooperation	Preparatory survey for cooperation: 10 months, Grant aid: 2 years
Location map and related diagrams	 <Boundaries of Beira FIR, Beira ACC, and Maputo ACC>
Beneficiary	Annual passengers of ADM: approximately 2 million (passengers in 2019)
Background	Status Beira Airport is the most important airport in the country, as it monitors and controls not only the aircrafts that land and take off at the airport itself, but also all aircraft that fly at high altitude in Mozambican airspace (except the airspace around Maputo Airport) and over the ocean in the Beira Flight Information Region (FIR). However, Beira Airport does not have the latest air traffic control system and many of the systems in its possession are outdated, meaning the safety of high-altitude navigation in the airspace controlled by Beira Airport and the safety of aircraft landing at Beira Airport are not ensured. If this situation continues, the possibility of accidents cannot be ruled out and if the number of flights passing through the Beira Flight Information Region or serving Mozambique decreases to avoid such risks, it will directly reduce revenue such as fees for the use of navigation aid facilities. The number of visitors from abroad will also decrease, which will affect the national economy. In addition, Beira City and the surrounding areas are frequently hit by natural disasters, including cyclones, and Beira Airport functions as an important disaster risk reduction base in the area. Therefore, from the perspective of strengthening the functions of Beira Airport for the transportation of emergency relief supplies, the expansion of the air traffic control system at the airport is urgently required. FIC and ACC in Mozambique Flight Information Center (FIC) of Mozambique is installed at Beira Airport (Beira FIC) and Area Control Centers (ACC), which control aircraft flying at high altitudes of the Beira FIR, are installed at Beira Airport and Maputo Airport (Beira ACC and Maputo ACC, respectively). In detail, flights at the high altitudes of the south of Parallel 22 are allocated to Maputo ACC and those of north of Parallel 22 are allocated to Beira ACC, while those flying over the ocean in Beira FIR are allocated to Beira FIC. If an ACC goes out of service, aircrafts flying in the boundary of the ACC should be suspended. If Beira FIC goes out of service, all aircrafts cannot land and take off at all airports in Mozambique, all international flights that pass the Beira FIR should change their routes to remain outside of the Beira FIR. According to the Contingency Plan for the Beira FIR, in the event that the Beira FIC premises are out of service for an extended period, the temporary relocation of the Beira FIC should be arranged and facilitated

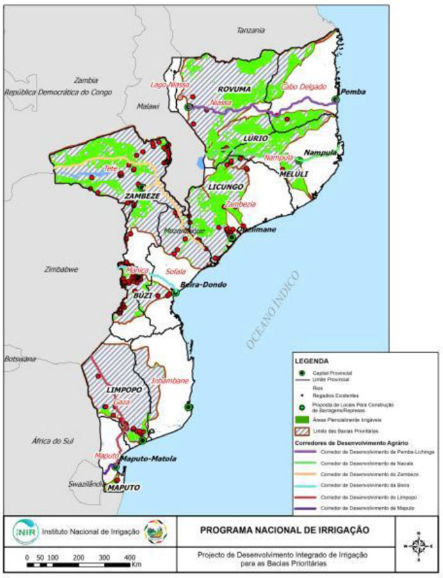
at the Maputo ACC, restoring FIC services. However, the Maputo ACC cannot restore all FIC services due to reasons including lack of a HF communication system that enables the oceanic air traffic control.

Current Status of Air Traffic Control Systems at Beira Airport

System	Status
Voice Communication Control System [VCCS]	・ Model: SITTI MULTFONO M600S/77.971 ・ Year of installation: 2009 ・ Condition: Obsolete ・ Necessity: Upgrade required, as the existing VCCS is an analogue system and does not comply with the current needs for ATM Integration to IP environment
VHF (Very High Frequency) Communication System	・ Model: T6T & T6R ・ Year of installation: 1988 ・ Condition: Obsolete ・ Necessity: Upgrade NOT required, as this system will be replaced by digital radios * Current Plan For ACC VHF coverage, including local and remote stations, 6 digital transmitters and 6 digital receivers; and for TWR and APP, 4 digital transceivers and 2 back-up mobile transceivers with power autonomy (internal batteries)
HF (High Frequency) Communication System	・ Model: INVELCO ・ Year of installation: 2021 ・ Condition: As of Dec. 29, 2021, operation started, but only one receiver is installed, the system does not comply with the related ICAO standard (6 receivers required) ・ Necessity: To comply with the ICAO standard and ensure redundancy, additional devices required including one 1 KW transmitter, 7 receivers (2 for redundancy), one coupler, and other interfaces
ATS (Air Traffic Service) Message Handling System [AMHS]	・ Condition: Not installed ・ Necessity: Installation NOT required, as an AMHS will be installed in Maputo and connected to Beira Airport in 2022
Automatic Dependent Surveillance – Broadcast [ADS-B]	・ Model: INTELCAN ・ Year of installation: 2016 ・ Condition: In service ・ Necessity: Software upgrade required
Very Small Aperture Terminal [VSAT]	・ Model: PolarSat ・ Year of installation: - ・ Condition: Installation completed (operation will start in 2022 after approval) ・ Necessity: Further investment NOT required
Aeronautical Fixed Telecommunication Network [AFTN]	・ Model: COPPERCHASE ・ Year of installation: 2008 ・ Condition: Out of service since December 2017 ・ Necessity: Investment NOT required, as this system will be replaced by AMHS as mentioned above
VHF Omnidirectional Range with a Distance Measuring Equipment [VOR/DME]	・ Model: 512 D/721 THOMSON ・ Year of installation: 1993 ・ Condition: In service but obsolete ・ Necessity: Replacement required
Multichannel Voice Recorder	・ Model: - ・ Year of installation: 2007 ・ Condition: In service, but obsolete ・ Necessity: Replacement required
Centralized maintenance Management System	・ Condition: Not installed ・ Necessity: ADM desires installation for the modernization of maintenance service
Airport Doppler Radar	・ Model: Not investigated (installed by Government of Germany)

	・Year of installation: 2007 ・Condition: Out of service due to malfunction ・Necessity: Repair or replacement required to ensure the safety of landing and take-off by the prompt detection of downbursts
Target	Expand and upgrade the air traffic control systems owned by Beira Airport to ensure the safety of aircraft flying at high altitude and over the ocean in the Beira FIR, as well as aircraft landing and taking off at Beira Airport.
Implementation details	- Implementation of New Communications, Navigation, Surveillance and Air Traffic Management System (New CNS/ATM System) (including implementation at Maputo and other airports as needed) - Repair and reactivation of the currently unused airport doppler radar - Expansion of other facilities and equipment related to air traffic safety, as needed
Project size (JPY billion)	Preparatory survey for cooperation: JPY 80 million Grant aid: JPY 1.7 billion Equipment: JPY 1.5 billion Design & installation: JPY 0.2 billion
Things to keep in mind	Additional information needs to be collected by a basic information survey, including the following data that has not been investigated in this study, but is required for a study on a cooperation scheme. Also, details of the cooperation and the required budget need to be examined based on the result of the survey. <u>Backup System and Organization for the Beira FIC</u> - Backup system and organization for the Beira FIC, in the event that a temporary FIC should be arranged at Maputo Airport, based on the Contingency Plan was not investigated in this study. This information is required though and further study on the implementation of additional equipment at other airports, including Maputo Airport, is required. Also, the following data is considered necessary. ➢ Current status of air traffic control operations, traffic volumes, and air traffic control systems in place at each ACC in Mozambique ➢ Coordination method on the air traffic control operations between Mozambique and neighboring countries ➢ Future plans for the implementation of the New CNS/ATM in Mozambique and neighboring countries <u>Number of Air Traffic Control Officials and the Organization for Backup at Beira Airport and ADM</u> - It is necessary to evaluate the current air traffic control capacity for expanded systems and further study is required for countermeasures if the capacity is not sufficient. - It should be noted that appropriate maintenance is not currently carried out due to the vulnerable financial condition of ADM.

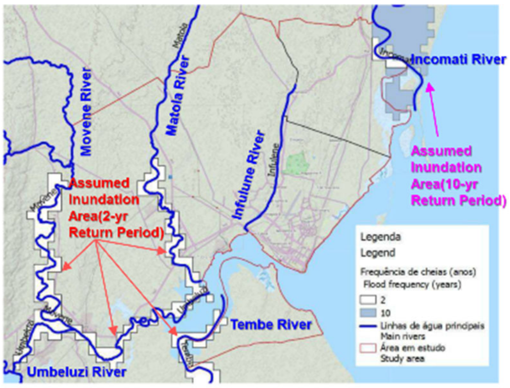
5.3 Mozambique: Irrigation and Drainage System Rehabilitation and Improvement Project

Project name (draft)	Irrigation and Drainage System Rehabilitation and Improvement Project
Assumed C/P	Ministry of Agriculture and Rural Development / Ministério da Agricultura e Desenvolvimento Rural (MADER) National Irrigation Institute / Instituto Nacional de Irrigação (INIR)
Assumed scheme	Grant Aid
Period of cooperation	3 years
Location map and related diagrams	 <National Irrigation Program>Major River Basins Green area: Potential Irrigation Areas, Shaded Area: Priority basins
Beneficiary	Farmers affected by flooding
Background	<u>Agriculture in Mozambique</u> In Mozambique, the agricultural sector is a key industry accounting for 26.0% of GDP, 12.6% of exports and 70.2% of the working population. However, most of farmers rely on subsistence farming with low-external input level and low productivity depending on rainwater, meaning their income is remarkably low. While domestic supplies of staple foods such as cassava and maize are sufficient, most rice is imported. In addition, chronic food insecurity is exacerbated by climate change and natural disasters. The government of Mozambique has identified the transformation of agriculture and fisheries as one strategy for development of key areas in the National Development Strategy (2015-2035). Is also aims to (1) improve agricultural productivity and (2) commercialization of agricultural/livestock production. The average crop production of major cereals has been set as a development goal and indicator in the agricultural sector to be achieved by 2035. The strategy suggests flooding in irrigated areas and drought in rainfed areas as risk factors. Therefore, it has proposed infrastructure projects to protect irrigated areas (dam and protection dike), the adaption of dry farming, alternative irrigation techniques and the introduction of the agricultural insurance. <u>Donor Assistance for Irrigation Development</u> Considering the Master Plan for Water Resources Management (2018), MADER has confirmed consistency with the National Irrigation Program from the point of view of protection and production support infrastructures. The cultivation of sugar cane in the Chokwe District of the Limpopo River basin and in the Incomati, Buzi and Zambezi River basins is the most important irrigation development plan currently formulated. The irrigation and drainage system of 4,200 ha has been rehabilitated and improved in 3

	provinces (Manica, Sofala and Zambezia) through "MZ PROIRRI Sustainable Irrigation Development (2011-2018)" implemented by the WB. Although the irrigation system of 3,000 ha had been developed in 4 provinces (Manica, Nampula, Sofala and Zambezia) through "Smallholder Irrigated Agriculture and Market Access Project (IRRIGA 1) (2018-2024)", the system of 1,700 ha was damaged by Cyclone Idai. AfDB has rehabilitated the irrigation system of 3,050 ha in Xai-Xai district of Gaza province. In 2006, the government of Mozambique allocated a crop field of 1,000 ha in Xai-Xai district of Gaza province to Hubei province of China. A farm for rice production was later constructed there. China Wanbao Co., Ltd. in Hubei province will expand the field to 20,000 ha with rehabilitation of irrigation infrastructure. They encourage farmers around the project to cultivate rice and refer to their technique. In 2014, irrigation development for the crop field of 6,000 ha was planned in Chokwe district of Gaza province. Japan's Aid Policy in the Agricultural Development is to improve livelihood for rural residents, assistance for improvement of government administration in agriculture and rural development, assistance for increasing rice production and nutrition improvement. JICA has assisted with rehabilitation of the main canal, intake and weir for regulating water levels affected by flooding in 2000 and construction of 2 road crossings in the project for rehabilitation of Chokwe irrigation scheme (2002) (Total irrigation area 26,030 ha.) In addition, assistance has been provided in improving of techniques for rice production and the smallholder empowerment in irrigated areas of Gaza province and Zambezia province through the "Integrated Agricultural Development Project for Small Scale Farmers in Chokwe Irrigation Scheme (2007-2010)", "Project for Rice Productivity Improvement in Chokwe Irrigation Scheme (2011-2014)" , "Project for Improvement of techniques for increasing rice cultivation productivity in Nante, Maganja da Costa District, Zambezia Province (2011 - 2015)" and "Project for Improvement of Rice Production in Zambezia Province (ProAPA) (2016-2022)". <u>Flood Risk of Crop Field and Irrigation Infrastructure</u> As a result of the flood risk analysis implemented in the Master Plan for Water Resources Management across Mozambique, Gaza province of Limpopo River basin and Sofala Zambezia provinces of Zambezi River basin are vulnerable to flooding. The irrigation infrastructure in Chokwe district and Xai-Xai district (Chicumbane posto) of Gaza Province in 2013, in Zambezia province of Licungo River basin in 2015 and in Zambezia province of Zambezi River basin in 2019 has been severely damaged. <u>Necessity of Assistance</u> To satisfy the demand for rice, rice productivity should be improved while protecting crop fields from flooding. In particular, Zambezia province is the top region in terms of rice production in Mozambique. The loss of rice by flooding in Zambezi province causes food insecurity in Mozambique. Therefore, reducing loss and damage of crop fields by irrigation and drainage systems is important for rehabilitating and improving, including rehabilitation of levee along Licungo River or Zambezi River. For instance, supposing a crop field is protected by the construction of a levee along Zambezi River in Chinde District, rice production would satisfy the demand for 280 thousand people, which is calculated based on the rice yield of 4.1 t/ha . The yield, in part, is based on the project (rehabilitation and improvement of river levee, irrigation and drainage system, and training of rice production). The project contributes to a reduction in the cost of rice imports of US$ 3.3 million.
Objectives	Upper-Level Objective: To reduce flood risk in project area Project Objective: To rehabilitate and improve irrigation and drainage systems in Zambezia province affected by flooding
Results (Technical Cooperation)	- River levee: Rehabilitation of collapsed area (Licungo River or Zambezi River) - Irrigation and drainage system: Review of design discharge of canals for irrigation and drainage, rehabilitation of infrastructures affected by flooding and improvement of infrastructure (canal and related structures such as intake and regulating structure) - Training in operation and management of irrigation and drainage system (soft component)

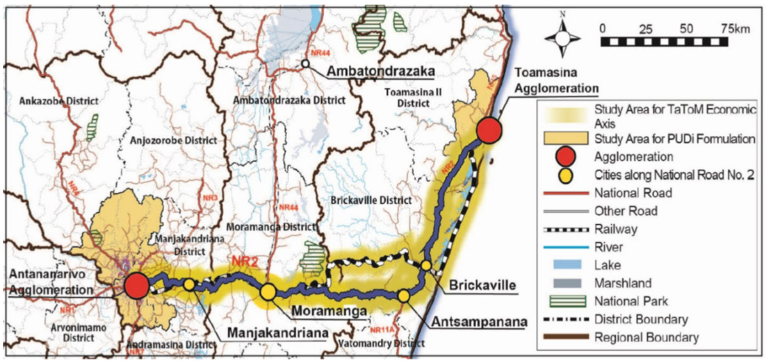
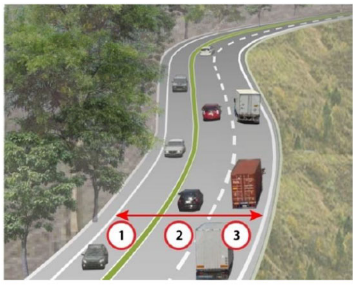
Project size	Grant Aid: JPY 2 billion
Points to note	The details of area and activities should be decided after confirming the following points, since only desk research has been conducted due to Covid-19. - Need for assistance - Target area - Cause of flood damage - Irrigation and drainage diagram - Design report of existing irrigation and drainage system (profile and cross section of canal, design drawings of related structures, etc.) - Profile and cross section of river, design flood discharge and design flood water level

5.4 Mozambique: Greater Maputo Metropolitan Area Comprehensive River Management Master Plan Development Project

Project name (draft)	Greater Maputo Metropolitan Area Comprehensive River Management Master Plan Development Project
Assumed C/P	INGD (National Disasters Management Institute), ARA SUL (Southern Regional Water Authority, MOPHRH), AIAS (Water and Sanitation Infrastructure Management), MTA (Ministry of Land and Environment), Maputo City, Matola City
Assumed scheme	Technical cooperation on the development study
Period of cooperation	Three years
Location map and related diagrams	 < Overview of river basin in Greater Maputo Metropolitan Area >
Beneficiary	Residents living in the flooded area (37% of the Maputo capital area), population about 1 million.
Back ground	Mozambique is exposed to extreme climate-related disasters which can be affected by climate change, including floods, cyclones, and droughts. The government is aware of these risks and has prepared a Master Plan (MP) for Disaster Risk Reduction (2017 to 2030). According to this MP, in the last 30 years, at least 14% of the population have been affected by floods, cyclones and droughts. On the other hand, disaster risks in urban areas are increasing as the urban population grows. According to the Sanitation and Drainage MP for the Greater Maputo Metropolitan area, the population is growing at 1.46%/year and will reach 4 million by 2040, most of which will be concentrated in the cities of Maputo and Matola. The Maputo capital area is surrounded by the basins of five rivers. In 2000, the Umbeluzi and Incomati rivers flooded (the worst in the last 150 years), again in 2001 the Umbeluzi and Incomati rivers flooded, and also in 2013 the Incomati river flooded (causing extensive damage to urban areas). Rapid urbanization will also increase the vulnerability of metropolitan areas to disasters. Therefore, there is a need to formulate a plan for appropriate development based on the perspective of future Disaster Risk Reduction (DRR).
Objectives	A comprehensive flood management master plan based on the flood hazard and risk analysis in the Greater Maputo Metropolitan Area will be developed in collaboration with relevant agencies, and a model of the Metropolitan area and river basin of the target rivers will be created with considering future urbanization. In addition, concrete counter measures would be implemented with the emphasis on the infrastructure measures to fundamentally reduce the risk of flood hazard and risk.
Output (Technical Cooperation)	To protect the Greater Maputo Metropolitan Area from the water related hazard, hazard and risk analysis would be implemented for the hazard of river-line flooding of the Maputo river and Infulene river, urban flooding in the central area of the city and inundation in the coastal area due to Storm Surge. As well, to promote pre-disaster investment for infrastructure measures for disaster risk reduction, the “Master Plan for Comprehensive Flood Management” would be developed.

	1. Flood risk assessment (river-line flood, urban flood) - Study on the mechanism of flooding and the identification of bottleneck factors of the flood event - Evaluation of the flood hazard and risk (including the effect of climate change and future urbanization) 2. Development of a "Master Plan for Comprehensive Flood Management" - Consideration of the ideal situation of the river basin, taking into account future urbanization - Flood control planning including consideration of the appropriate design for high water level setting. 3. Study on effective infrastructure measures - Countermeasures against river-line flooding (experience and knowledge from experience in Japan to be considered) - Countermeasures against urban flooding (For the residual risk even if the countermeasures for river-line flooding is implemented and the drainage capacity of the river has been improved as well as counter measures against extreme rain in a short period of time) 4. Study on effective non-infrastructure measures - Land use plan including Land use regulation - Development of building codes or architectural zoning regulations
Project size	Technical cooperation on the development study: about JPY 330 million
Points to note	In order to identify the target basin and the contents, it is necessary to confirm the following points in the study for a detailed plan. - Record of damage caused by flooding and characteristic of rainfall conditions in the Greater Maputo Metropolitan Area. - The potential of flooding in the future, taking in to account the effect of climate change and urbanization. - Capacity of the implementing institution and related and supporting institutions - Basin information for each basin - Situation of dam operation of the Umbeluzi dam - Plan on urban flooding countermeasures, storm surge countermeasures and urban planning and urban development

5.5 Madagascar: Disaster risk reduction and resilience enhancement for National Road No. 2

Project name (draft)	Antananarivo-Toamasina economic axis disaster risk reduction and resilience enhancement (Disaster risk reduction and resilience enhancement for National Road No. 2)
Assumed C/P	The Ministry of Housing and Public Works, Madagascar (Ministère de l'Aménagement du Territoire, de l'Habitat et des Travaux Publics, MAHTP)
Assumed scheme	Preparatory studies for cooperation, grant aid project
Period of cooperation	Preparatory study for cooperation (survey planning and design): 1-2 years, Grant aid: 3-4 years (The grant aid project is to be implemented as a model project and is expected to be rolled out to supports from other donors and ODA loans.)
Location map and related diagrams	 Antananarivo-Toamasina economic axis (National Road No.2)   Left: Project for disaster risk reduction (countermeasures for collapse of artificial slopes) Right: Construction of climbing lanes (concept)
Beneficiary	Vehicles using the National Road No.2, mainly vehicles for logistics between the Port of Toamasina and Antananarivo, and residents of the areas along the route. Current (2018) Traffic volume: 1,700 vehicles, population along the route including Antanarivo Toamasina: about 4.4 million people Future (2033) Traffic volume: 6,240 vehicles, population along the route including Antanarivo Toamasina: 5.8 million people If National Road No.2 is closed for two days, the <u>economic loss costs are estimated to be approximately JPY 1.8 billion per closure,</u> according to the projected traffic volume for the year 2033 (estimated by multiplying the hours of road closure by the number of vehicles affected by the closure and the time value of each vehicle type). If the road is frequently closed due to landslides, etc., economic losses will be much greater. According to BNGRC, annually there are about one to ten times landslides on the National Road No.2. If there are three two-day closures in a year, the economic loss could be estimated at approximately JPY 5.4 billion. If such damage and road closure occur every year for thirty years, the economic loss would be approximately JPY 162 billion. The implementation of disaster risk reduction projects is expected to reduce related economic losses.
Background	<Importance and route characteristics of the National Road No.2> National Road No.2 is a 353.4 km route connecting the capital city of Antananarivo and the port of Toamasina, along the Antananarivo-Toamasina economic axis (TaToM). It takes about eight hours for a standard vehicle and two days for a freight vehicle to travel this distance. Seventy-five percent of domestic outbound freight from the Port of Toamasina (which handles

about 90% of international freight) is transported to Antananarivo via National Road No.2 and, thus, the road is functions as an essential artery for the country's economic development.
Since the altitudes of Antananarivo and Toamasina differ by about 1,400 meters and, as National Road No.2 passes through mountainous area, there are many sharp curves and steep slopes on the road. Container freight vehicles and large logistics vehicles must slow down significantly in intermittent uphill sections, forcing the vehicles behind them to slow down and, thereby, causing traffic congestion. The road surface condition is also poor outside of the urban area, with many unmaintained surfaces and uneven sections, which pose a problem in terms of traffic performance and safety.

<Expansion and improvement of the Port of Toamasina and future traffic demand>
The Port of Toamasina has been undergoing expansion work since 2018, with financial and investment cooperation from JICA, with the prospect of new berths that can accommodate the largest container ships, improvement of existing berths, and expansion of container yards by 2026. This extension will greatly expand the port's functions and is expected to increase the number of international freight ships making calls at the port, rapidly increasing freight volume handled at the port. This will increase the traffic on National Road No.2, which carries most of the import and export freight of the Port of Toamasina, making the role of the road as an urban economic axis even greater. While the current traffic volume is about 1,700 vehicles/day, it will more than triple to 6,240 vehicles/day in 2033.

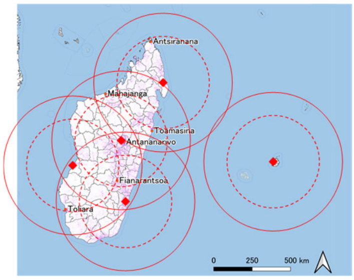
<TaToM economic axis development plan>
The Master Plan for the Economic Axis of TaToM outlines a strategy for the TaToM economic axis, which requires the enhancement of transportation on the National Road No.2 for economic development. To achieve this, first, safety and resilience enhancements are required; second, freight volume needs to be increased; and third, speed needs to be improved. Relating to this, 7 high priority projects have been formulated in the plan to achieve functional enhancement of the TaToM economic axis (National Road No.2). One of them is the "Project for Construction of Climbing Lane in Steep Slope" between Antananarivo-Moramanga-Brickaville on National Road No.2 and the proposal for this project section is also under consideration. Countermeasures for collapse of artificial slopes facing the road are also recommended to be partially implemented, along with climbing lane construction. Among the high-priority projects, two bridges where the passages of vehicles are difficult, the "Rehabilitation Project for Mangoro Bridge and Antsapazana Bridge on the National Road No.2" is underway with grant aid support and is scheduled for completion around 2024-2025.

<Support by donors for the National Road No.2>
In terms of donor support for National Road No.2, road improvements within the urban areas of Antananarivo and Toamasina, as well as development of load and weight inspection facilities for freight vehicles, are being implemented in 2018 with support from the World Bank and EU. That being said, there are not many donor-supported projects for most of the inter-city sections. Although China seems to have considered the construction of an expressway and shorter roads connecting Antananarivo and Toamasina, no specific policies or donor support have been determined, and there are no concrete plans or prospects at present.

<Disaster risk and vulnerability>
Madagascar is highly vulnerable to heavy rains and cyclones, and the national highway network suffers from damage caused by slope collapse, rockfalls, flooding and wash off of roads at various locations each year. Although no precise data exist on damage caused by disasters on National Road No.2 and other highways, partial/total closure of roads due to landslides and flooding is widely observed on many highways during cyclones.
In January 2022, Cyclone Ana caused landslides and flooding in many sections of National Road No.2, causing severe traffic disruptions. The damage caused by Cyclone Ana resulted in the closure of National Road No.2 for 36 hours and, even after traffic resumed on some sections of the road, following the establishment of an emergency alternative road, recovery work on the damaged sections continued.
In the event of a such disaster on a road, it may take 6 to 12 hours or even a day or more, to restore function. If the scale of damage is large, it may be difficult to restore function of the

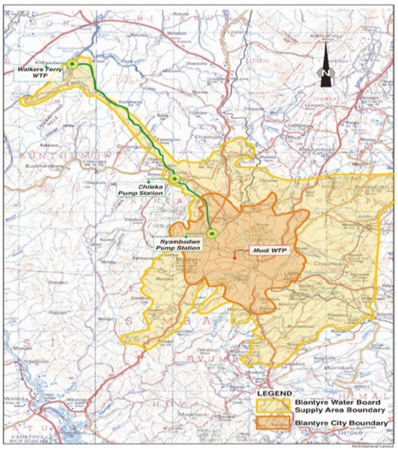
	road in a few days. When the National Road No.2 is closed, there basically is no alternative route between Toamasina and Antananarivo that is accessible by large freight vehicles.
Objectives	**Benefit 1:** Improvement of safety, resilience, and connectivity of the TaToM economic axis, which is an essential artery for Madagascar, through disaster risk reduction projects on National Road No.2 (such as risk reduction measures for slopes through countermeasures for collapse of artificial slopes) **Benefit 2:** Improvement of traffic capacity and travelling speed of the TaToM economic axis, as well as connectivity between cities, through a project for construction of climbing lanes on the National Road No.2. **Benefit 3:** Improvement of the capacity of local counterpart organizations through the implementation of disaster risk reduction projects (Benefit 1) and climbing lane construction project (Benefit 2) in priority sections as pilot projects, and rollout to ODA loans and other donors, leading to improved safety, resilience, and speed in other sections.
Project overview	<Outline of the proposal for National Road No.2 disaster risk reduction and resilience enhancement project > For the purpose of reducing the disaster risk and improving the traffic functions of the TaToM economic axis (National Road No.2), which is the primary engine for Madagascar's economic development, we propose a project to implement risk reduction measures (artificial slope protection measures and road ground reinforcement) in areas with a high risk of landslides (collapse of slopes and falling rocks) and a project for construction of climbing lanes on steep sections with coordinated activities. To implement countermeasures for collapse of artificial slopes and improvement of road structure to reduce disaster risks, priority sections will be selected based on disaster history, field survey, analysis, and consulting with relevant organizations, to identify sections with high concentration of landslides in the past and study the details of the engineering/construction works as countermeasures. The construction of a climbing lane is a high priority in the section from the Port of Toamasina to Antananarivo, where the traffic demand of large freight vehicles loaded with freight from the Port of Toamasina is high and where there are steep gradient sections causing significant speed reduction. Since it is difficult to implement countermeasures for all the issues with the budget size of the grant aid, the approach of this project may be to identify the priority areas for countermeasures after conducting surveys and analysis and to implement the project as a pilot project in combination with capacity building of relevant government agencies. Selection of priority sections for grant aid projects and support for study of countermeasures to serve as model activity for other sections, in particular, are expected to trigger subsequent support from other donors and the provision of ODA loans. <Preparatory survey for cooperation: 1-2 years> - Survey of current conditions and analysis of problems and issues - Implementation of the disaster risk reduction project as a pilot project and selection of sections for construction of climbing lanes - Examination of countermeasures at target sections and locations - Study and design of countermeasure project plan <Grant aid project: 3-4 years> - Implementation of countermeasure projects and construction works
Project size	Grant aid: JPY 2-3 billion (Target section and activities to be studied according to the budget size)
Points to consider	- High priority sections will be selected as a model project and disaster risk reduction projects, such as countermeasures for collapse of artificial slopes and climbing lane construction, should be promoted in the sections. - The sections between the Port of Toamasina and Antananarivo with steep slopes and high risk of landslides are possible candidates for the high priority sections, but the final selection should be made after relevant survey, analysis, and consultation with relevant organizations is conducted, including the study of damage caused by Cyclone Ana. - At the same time, in selecting the sections in scope, the contents of countermeasure work that are feasible from technical and budgetary perspectives should be considered. - It is also important to develop and improve the capacity of related organizations to improve the technical level of countermeasures for collapse of artificial slopes and other risks, with a view to expanding the project to other roads and regions.

5.6 Madagascar: Meteorological Observation and Forecasting Capacity Development Project & Project for Installation of Radar Rain Gauge and Surface Weather Observation Equipment

Project name	Meteorological Observation and Forecasting Capacity Development Project (Technical Cooperation) & Project for Installation of Radar Rain Gauge and Surface Weather Observation Equipment (Grant Aid)
Assumed C/P	DGM (Direction Générale de Météorologie)
Assumed scheme	Technical Cooperation／Grant Aid
Period of cooperation	2 years for Technical Cooperation project 3.5 years for Grant Aid project
Location map and related diagrams	  <Aging and decaying weather radars and active weather workstations>  <Location and observation range of the proposed radar rain gauges to be repaired and installed>
Beneficiary	Direct: Madagascar DGM staff (89 employees) Indirect: People of Madagascar (27.69 million people)
Background	Madagascar is in the southwest Indian Ocean area, a cyclone-prone area, and has been severely affected by natural disasters such as cyclone storms, storm surge, floods, and landslides. For Madagascar to contribute to mitigating the damage caused by tropical cyclones and other weather-related disasters due to climate change in the southwest Indian Ocean, including its own country, it is required to strengthen its meteorological observation, communication, and forecasting and early warning systems through the following two measures. 1) Effective meteorological observation (monitoring by radar rain gauge system) 2) Timely and prompt exchange of meteorological observation data and information on tropical cyclones with countries in the southwest Indian Ocean and southern Africa Madagascar is a country which is affected by cyclone earlier then the countries in the African continent, due to the lack of budget and lack of number of technical staff for the construction of facilities and the procurement and installation of equipment to deal with the aforementioned issues, it is difficult for the country to implement the project on its own. Therefore, it is important to support the introduction of radar rain gauge and meteorological observation equipment, as well as to improve the capabilities for meteorological observation and forecasting and early warning.
Overall Goal	Improve the capacity to respond to natural disasters in Madagascar.
Projects Objectives	Meteorological Observation and Forecasting Capacity Development Project: DGM will use the quality-controlled meteorological data to improve and issue early-warning, which will be provided to public and disaster management agencies.

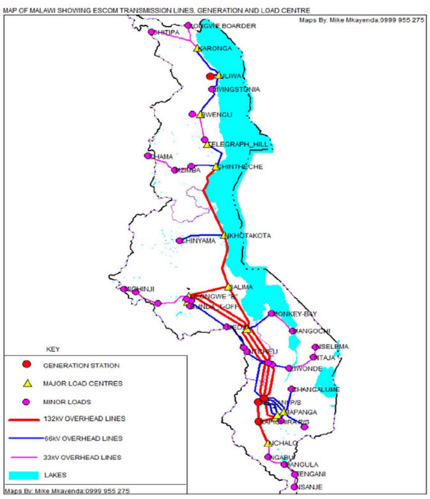
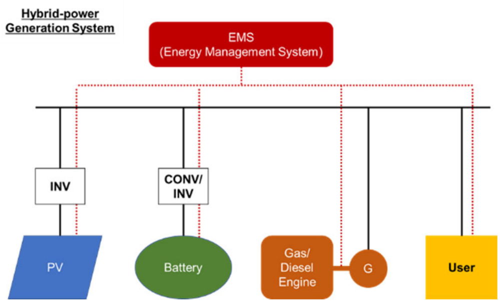
	Project for Installation of Radar Rain Gauge and Surface Weather Observation Equipment: Basic study for the instalment of the equipment including the location of the radar rain gauges and surface weather observation equipment would be installed.
Activities	Outcome 1: Highly reliable meteorological observation data are collected from meteorological radars and ground-based instruments. 1-1. Identify issues related to the operation of the three newly installed weather radars. 1-2. Establish guidelines for the operation and maintenance of the three weather radars to obtain reliable data from them. 1-3. Provide OJT according to the guidelines prepared in 1-2. 1-4. Identify issues related to the maintenance of automated meteorological observations and ground meteorological observations at representative sites. 1-5. Establish guidelines for quality control of automated and ground-based meteorological observations. 1-6. Establish a manual for periodic check, calibration, and maintenance of meteorological instruments. 1-7. Establish a traceability method for observation instruments and prepare a manual. 1-8. Provide OJT based on the manual prepared in 1-6 and 1-7. Outcome 2: The ability to analyze weather radar data will be improved. 2-1. Conduct training on analysis of radar data. 2-2. Provide training on methods to obtain reliable weather radar data using automated meteorological observations data and GPV (Grid Point Value) data. 2-3. Continuously improve QPE information. Outcome 3: Quantitative weather forecasts will be developed. 3-1. Provide training on the use of HimawariCast (forecast analysis using meteorological satellite data) for weather forecasting. 3-2. Introduce a weather guidance system (Model Output Statistics (MOS) and Kalman filter) using GPV data for quantitative weather forecasting. 3-3. Identify and analyze issues related to the status of acquisition of domestic and international meteorological data necessary for comprehensive weather forecasting. 3-4. Provide training on comprehensive weather forecasting techniques using data obtained from weather guidance systems, HimawariCast, weather radar, and automated meteorological observations. 3-5. Forecast support materials will be prepared and quantitative forecasts will be provided. Outcome 4: Easy-to-understand weather information is provided. 4-1. Identify issues with weather information content on the DMH website. 4-2. Improve meteorological information content to make it easier for users to use. 4-3. Improve weather information contents for mobile phones.
Project size	Meteorological Observation and Forecasting Capacity Development Project (Technical Cooperation): JPY 300 million Approximate costs for radar rain gauge (Grant Aid): JPY 4,320 million (JPY 1,080 million per one location) Approximate project cost of surface weather observing equipment (Grant Aid): JPY 510 million (JPY 15 million per one location)
Points to note	- It is necessary to conduct basic studies on the location of doppler radar and meteorological stations to be installed in the future. - Three radar rain gauges was in operation until 1989 - DGM has less than 100 staff and an annual budget of less than JPY 10 million, there are some challenges in the operation and meteorological stations could be installed before the installation of doppler radars. - As experts were not able to travel to Madagascar in the JICA survey, the JICA survey team have not been able to fully discuss the specific details of the project formation with our counterparts. It is necessary to confirm and discuss with the relevant counterparts from the overall goal to formulate the project.

5.7 Malawi: Strengthening the disaster risk management capacity of Blantyre Water Board

Project name (draft)	Strengthening the disaster risk management capacity of the Blantyre Water Board
Assumed C/P	Blantyre Water Board (BWB)
Assumed scheme	Technical Assistance
Period of cooperation	2 years
Location map and related diagrams	
Beneficiary	Population in service area of BWB (Approximately 1.25 million people).
Background	The access rate to water supply in rural area of Malawi has improved from approximately 47% (2000) to approximately 65% (2017), but the urban water supply rate has remained stable at approximately 85% (2000 and 2017) (WHO/UNICEF), a situation that needs improvement. In addition, the urban population is growing significantly at about 3% (WB, 2016) per year, and the demand for water supply is expected to continue to increase. Blantyre City (population 1.2 million (2018)) is a commercial and industrial city located in the Southern Region, second only to Lilongwe, the capital city, and is the economic center of the country. Blantyre is served by the BWB, which has three Water Treatment Plants (WTP), including Walker's Ferry WTP, which is fed by the Shire River. In 2022, Cyclone Ana resulted in a power outage that disrupted the water supply of the BWB for several days. The most significant risk in the event of future cyclones is that power outages could result in a prolonged shutdown of the facilities and operations of the BWB. It is necessary to establish a system to ensure a stable water supply, even in the event of power outages, and to strengthen water resource management during the dry season. However, a Business Continuity Plan (BCP) and other disaster risk management plans have not yet been formulated. JICA has continued to provide technical support to the BWB through the dispatch of volunteers in cooperation with Yokohama City, and from 2020, they are conducting an "Information Collection and Confirmation Survey in the Field of Urban Water Supply," in which an expert team analyzes the overall problems of water supply services in Blantyre and sorts out the issues and priorities of the BWB and considers the policy of cooperation with the BWB. This project will provide support to strengthen the capacity of the BWB against disasters, focusing on the development of a medium-term disaster risk management plan and a BCP.
Objectives	Project Purpose: Business Continuity Plan functions of the BWB
Results (Technical Cooperation)	Outcome 1: Disaster risk analysis of BWB facilities is conducted Outcome 2: A BCP for BWB is developed Outcome 3: A BCP manual for BWB is developed Outcome 4: BCP is established as a business element at BWB
Project size	Technical Assistance

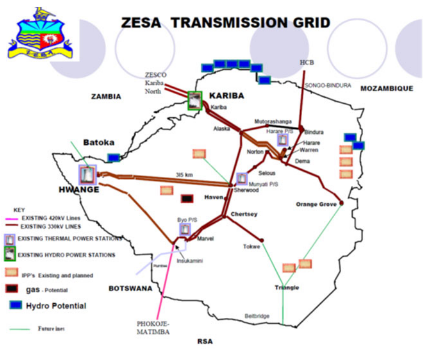
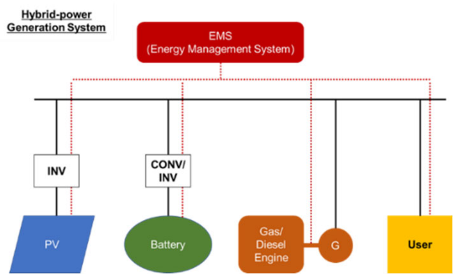
Points to note	- It was found that no major flood damage was reported in the critical water supply facilities managed by BWB. There was a period of increased sedimentation and high turbidity in the Mudi Dam due to sediment inflow, but reforestation activities have been implemented in the surrounding catchment area since 2016 to improve it. - The Blantyre City Council has not yet developed a disaster risk management plan and a BCP but is preparing to conduct a hazard analysis with the support of the World Bank. The result of the hazard analysis in the city is essential to develop the plans for the BWB. - According to the expert team of the ongoing "Information Collection and Verification Survey on Urban Water Supply Sector," there is no plan to include a disaster risk reduction component which is currently considering support for the BWB. It is necessary to avoid confusing the BWB with proposals that have not been presented in the current survey, and it is desirable to clarify the disaster risk reduction issues of the BWB and develop support proposals while continuing support and dialogue with them.

5.8 Malawi: Preparatory Survey for Introduction of Hybrid Power Generation System

Project name (draft)	Preparatory Survey for Introduction of Hybrid Power Generation System for the Republic of Malawi
Assumed C/P	EGENCO (Electricity Generating Company), ESCOM (Electricity Transmission and Distribution Company), Ministry of Natural Resources and Environment
Assumed scheme	Preparatory survey for cooperation (to be converted to grant aid in the future)
Period of cooperation	About 10 months for preparatory research
Location map and related diagrams	 
Beneficiary	Depends on the scale of installation (20MW is about 4000 households)
Background	The key points for disaster reduction measures in Malawi are Lilongwe and Blantyre, where important political and economic facilities are concentrated. Similarly, disaster reduction measures in the power sector can be made more cost-effective by focusing on areas where the public sector and major industries are concentrated. The concept of disaster reduction in the power sector is to enhance the resilience of important facilities and areas to disasters in order to maintain and sustain public services and industrial activities. For example, in the public sector, it is possible to form and operate facilities that can continue to supply energy to water treatment facilities, hospitals, and telecommunication facilities in the event of a disaster. Power generation facilities have insufficient capacity to meet demand and blackouts are frequent in urban areas. Almost all the country's power sources are dependent on hydropower, but as less water is available due to the decline of rainfall, and the vegetation cover declines and sedimentation progress, energy strategy aims to diversify power sources. The existing hydropower plants in Malawi are located in six river basins that flood regularly and require risk reduction for the future. In particular, Cyclone Ana in January 2022 caused severe flooding in the Shire River basin around Blantyre and shut down or damaged the Tedzani, Nkula, and Kapichira hydropower plants, which are the country's main power sources. The Kapichira power plant, which is the country's largest with a total capacity of 130MW, lost its water intake due to the floods and stopped generating power as of February 16, 2022. It is expected to take a considerable amount of time to fully recover. Malawi, however, has lost about 1/3 of its power generation capacity, resulting in rolling blackouts and other major impacts on both the public and private sectors. These power outages disrupted the supply of electricity to the Blantyre area and, consequently, affected the temporary suspension of water supplies to the city. EGENCO owns the main power generation facilities and ESCOM owns all the transmission and distribution facilities, but there is a noticeable lack of capacity due to financial difficulties.

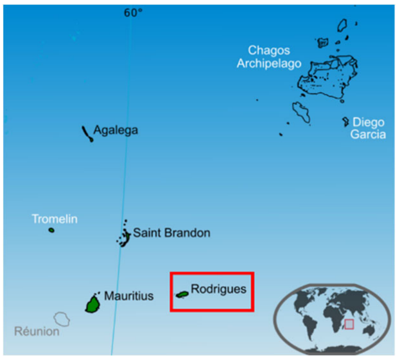
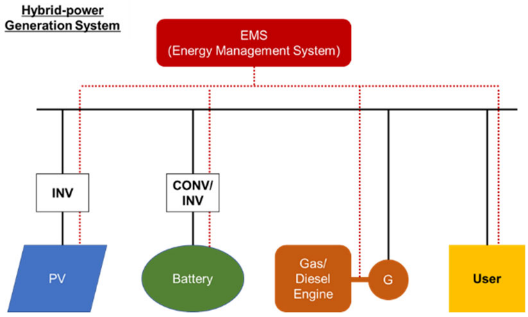
	Thus, there have been instances where damage caused by Cyclone Ana has had a significant impact on the operation of critical infrastructure, and the BCPs of these facilities are now attracting attention. It is imperative to ensure that power sources are available for operation during adverse weather conditions and other emergencies, and that renewable energy sources are used to reduce fuel consumption and improve sustainability, while improving the functioning of government and industry by maintaining their functionality during disasters.
Objectives	A hybrid power generation system consisting of photovoltaic power generation, storage batteries, and engine generators will be introduced for important public or industrial sectors to realize a BCP continuation of power supply in the event of a disaster as a private power generation system, including renewable energy. It will also improve sustainability by introducing renewable energy regardless of grid constraints. To achieve this through grant aid, it is necessary to conduct a detailed local situation, technical and economic assessment.
Survey details	- Understanding the power supply system in major cities - Survey of local power sector needs/grid constraints - Survey of key public and industrial sectors that require stable power supply - Study on the possibility of increasing the power supply and operation rate by adding a hybrid system to the existing diesel power generation facilities - Discussion of cooperation policies with counterparts - Technical study in cooperation with Japanese heavy industry manufacturers - Economic feasibility study
Deal size	Preparatory survey for cooperation: 1.25 MM USD Grant Aid (construction cost): approximately 18 MM USD for a new 5MW engine + 5MW solar + storage battery
Points to note	- To understand the role of hybrid power sources by studying the JICA study, SAPP development plan, and the impact of flood and drought on hydropower generation. - The unit capacity of the hybrid system is several MW, and it is possible to install several units in a row to achieve about 20-30 MW per site (there is no restriction on the scale). The project will benefit a wide range of beneficiaries, if the hybrid system is installed in multiple locations based on the needs of important districts, factories, and industrial parks where power outages are an issue. - In addition to the major cities of Lilongwe and Blantyre, we will also consider cities such as Dwangwa (Illovo), where sugar and tobacco industries are flourishing. Blantyre Water Authority's power generation facility plan is also to be considered. - In cooperation with a Japanese heavy industry manufacturer, we can provide remote operation, maintenance support, and, if necessary, capacity building for business owners. - For solar modules to be used, this is not limited to those made in China, but also those made in Korea and the U.S. (they do not have to be made in China for functionality).

5.9 Zimbabwe: Preparatory Survey for Introduction of Hybrid Power Generation System

Project name (draft)	Preparatory Survey for Introduction of Hybrid Power Generation System for the Republic of Zimbabwe
Assumed C/P	Zimbabwe Power Company (ZPC), Zimbabwe Electricity Transmission and Distribution Company (ZETDC), Ministry of Energy and Power Development
Assumed scheme	Preparatory survey for cooperation (to be converted to grant aid in the future)
Period of cooperation	About 10 months for preparatory research
Location map and related diagrams	 
Beneficiary	Depends on the scale of installation (20MW is about 4000 households)
Background	The key to disaster reduction measures in Zimbabwe is to focus on Harare and Bulawayo, where important political and economic facilities are concentrated. Similarly, disaster reduction measures in the power sector can be made more cost-effective by focusing on areas where the public sector and major industries are concentrated. Harare, the capital, and Bulawayo are in particularly mountainous terrain and are among the most vulnerable areas in Zimbabwe to landslides. Landslides can lead to the collapse of power generation facilities, transmission, and distribution networks, which, in turn, can lead to the suspension of various public and private activities due to power outages. The concept of disaster reduction in the power sector is to enhance the resilience of important facilities and areas, to maintain and sustain public services and industrial activities. For example, in the case of the public sector, it is possible to form and operate facilities that can continue to supply energy to water treatment facilities, hospitals, and communication facilities in the event of a disaster. In addition, as indicated in Section 3.1.2, the 2021 NDC Update aims to "ensure climate resilient infrastructure and design" by, among other things, achieving the following. - Provide the means and incentives to plan, design, build and operate new infrastructure that takes into account future climate change, including extreme weather events. - Promoting the retrofitting of existing infrastructure to ensure its resilience to future climate change - Energy supply using technologies that are less sensitive to climate change (wind power, solar power). In addition, Zimbabwe's power sector is suffering from aging and inadequate maintenance of facilities throughout the country, with actual supply capacity some 30-260 MW short of demand (2015), making new connections difficult. It is also difficult to get additional supply from SAPP due to late payment of tariffs. On the other hand, there are policies to introduce renewable energy to improve sustainability and economic efficiency. Zimbabwe is trying to recover economically by improving its political system, but power shortages are holding it back. The power sector is also experiencing financial difficulties and is unable to make large scale capital investments. Thus, Zimbabwe is facing difficulties in supplying electricity due to lack of investment, but the financial difficulties are making it difficult to improve the situation. At this point, foreign

	aid should be used to provide a stable power supply to improve the functioning of government and industry, and to maintain functioning in the event of a disaster.
Objectives	A hybrid power generation system consisting of photovoltaic power generation, storage batteries, and engine generators will be introduced for important public or industrial sectors to realize a BCP and to continue power supply in the event of a disaster as a private power generation system, including renewable energy. It will also improve sustainability by introducing renewable energy regardless of grid constraints. In order to achieve this through grant aid, it is necessary to conduct a detailed local situation, technical and economic assessment.
Survey details	- Understanding the power supply system in major cities - Survey of local power sector needs/grid constraints - Survey of key public and industrial sectors that require stable power supply - Discussion of cooperation policy with counterparts - Technical study in cooperation with Japanese heavy industry manufacturers - Economic feasibility study
Deal size	Preparatory survey for cooperation: 0.8 MMUSD Grant Aid (construction cost): approx. 18 MMUSD for a new 5MW engine, 5MW solar, storage battery
Points to note	- The role of the hybrid power source is to be understood in light of the JICA study and the SAPP development plan. - The unit capacity of the hybrid system is several MW, and it is possible to set up multiple hybrid systems in a row to achieve about 20-30 MW per site (there is no restriction on the scale). If important city districts, factories, and industrial parks where power outages are a problem are picked and hybrid systems installed in multiple locations based on their needs, the overall shortage of 30-260 MW (2015) can be greatly improved. - Harare, Bulawayo, and Gweru, which is a major city that has a well-developed mining industry, will be the target of the study. - The development plan of SAPP shows a large-scale power plant and international interconnection, which is not easy to realize considering the financial difficulties of ZESA and Zimbabwe. That being said, the promotion of more small-scale projects, such as hybrid power generation facilities, can quickly benefit Zimbabweans. - In cooperation with a Japanese heavy industry manufacturer, we can provide remote operation and maintenance support, and if necessary, include capacity building for business owners. - For solar modules to be used, this is not limited to those made in China, but also those made in Korea and the U.S. (they do not have to be made in China for functionality).

5.10 Mauritius: Preparatory Survey for Introduction of Hybrid Power Generation System

Project name (draft)	Preparatory Survey for Introduction of Hybrid Power Generation System for Rodrigues Island, Republic of Mauritius
Assumed C/P	MEPU (Ministry of Energy), CEB (Central Electricity Board), EEMO (Energy Saving Agency), MARENA (Renewable Energy Agency)
Assumed scheme	Preparatory survey for cooperation (to be converted to grant aid in the future)
Period of cooperation	About 8 months for preparatory research
Location map and related diagrams	 
Beneficiary	Approximately 37,000 islanders
Background	In Mauritius, cyclones cause disturbances and damage to power transmission and distribution networks, resulting in large-scale power outages for thousands of households or more, and Cyclone Berguitta, in 2018, caused 6,800 power outages on the main island. On Rodrigues Island, about 600 km from the main island, two cyclones caused power outages in 2018-19, the CEB and SMF (security forces) worked together to restore power. The CEB has also mobilized engineering cadets to work on recovery from cyclones, as it expects to be affected by major natural disasters several times a year. Some resort hotels are equipped with their own emergency generators. While the main island of Mauritius, where important political and economic facilities are concentrated, is a country that has achieved a certain degree of economic development, the focus should be on the remote islands, where vulnerability is more apparent. In the same way, focusing on remote islands in the power sector would be a better way to provide support from Japan. In the case of Rodrigues Island, traditional primary industry and ecotourism are important livelihoods and the population size is small, but Mauritian government officials told us that they are interested in international assistance for electricity and water supply when we visited the island. The concept of disaster reduction in the power sector is to enhance the resilience of key facilities and areas to disasters in order to maintain and sustain public services and industrial activities. For example, in the public sector, the formation and operation of facilities that can continue to supply energy to water treatment facilities, hospitals, communication facilities, etc. in the event of a disaster can be considered. In addition, the current power development plan (IEP 2013-2022) states that electricity should be supplied at the lowest possible cost, effectively balancing the supply and demand of electricity, while enhancing sustainability, which is a fundamental part of national policy. Furthermore, Mauritius' first renewable energy strategy, the Renewable Energy Strategic Plan (RESP) 2018-2023, calls for improving on-grid/off-grid renewable energy deployment technologies and promoting capacity building. However, there is a high dependence on thermal power generation as the overall power source type and, even in the main island where the grid size is large and the introduction of renewable energy is relatively advanced, coal and heavy oil account for 70-80% of power generation. Hydropower resources have been fully developed. Solar power is a promising source of

	renewable energy, but its output tends to fluctuate, limiting the amount of power that can be introduced to remote islands where the grid size is small. In particular, Rodrigues Island, which is far from the main island, has only 0.1 MW of solar power and 1.3 MW of wind power installed, while the grid size is about 14 MW, which is only about 5% of the total power generated. In such small remote island areas, measures should be adopted to improve sustainability through fuel efficiency and decarbonization, as well as to continue to operate and improve the functions of important public and private facilities even in times of disaster.
Objectives	A hybrid power generation system consisting of photovoltaic power generation, storage batteries, and engine generators will be introduced for important public or industrial sectors to realize a BCP and to continue power supply in the event of a disaster as a private power generation system including renewable energy. It will also improve sustainability by introducing renewable energy regardless of grid constraints. In order to achieve this through grant aid, it is necessary to conduct a detailed local situation, technical and economic assessment.
Survey details	- Understanding of the power supply system in Rodrigues Island - Survey of local needs/grid constraints in the power sector - Discussion of cooperation policy with counterparts - Technical study in cooperation with a Japanese heavy industry manufacturer - Economic feasibility study
Deal size	Preparatory survey for cooperation: 0.7 MMUSD Grant Aid (construction cost): approx. 18 MMUSD for a new 5MW engine, 5MW solar, storage battery
Points to note	- The unit capacity of the hybrid system is several MW, which is commensurate with the size of Rodrigues Island. - In cooperation with a Japanese heavy industry manufacturer, we can provide remote operation and maintenance support, and can also include capacity building for business owners. - For solar modules to be used, this is not limited to those made in China, but also those made in Korea and the U.S. (they do not have to be made in China for functionality).

CHAPTER 6 Development of a Regional DRR Network in Southern Africa

Although disaster risks and DRR systems in the target areas differ from country to country, it is important to make effective use of resources from the perspective of wide-area cooperation for issues common to multiple countries such as cyclones and floods. In this chapter, we address the current situation and issues of the existing DRR network in Southern Africa, confirmed through the holding of the second workshop on the Indian Ocean / Southern Africa DRR platform established by the Mauritius government in 2019. Based on the needs of each country ascertained from the workshop, we examined the possibility of the future Southern Africa regional DRR network.

6.1 Current Status and Issues of the Existing Regional DRR Network in Southern Africa

6.1.1 Current Status of Existing DRR Networks in Southern Africa

Existing DRR networks that include Southern Africa are summarized. In the interview survey conducted with donors, it was confirmed that information was exchanged regularly and mutual participation in workshops was carried out between each DRR network.

(1) DRR network by donors, etc.

1） UNDRR-Africa

a) Overview

The United Nations Regional Office for Disaster Reduction (UNDRR-Africa), based in Nairobi, Kenya, is coordinating the DRR initiative to support 44 member states in sub-Saharan Africa. UNDRR-Africa has strong partnerships with the African Union Commission, regional UN agencies in the five regional economic communities (RECs) and other development partners. It also includes stakeholders such as science and technology consortia, youth representatives, media, and civil society members and groups.

The UNDRR-Africa Liaison Office, based in Addis Ababa, Ethiopia, supports the African Union Commission in implementing the Plan of Action (POA) for the implementation of the Sendai Framework for Disaster Risk Reduction 2015 to 2030 in Africa. The UNDRR-Ethiopia office also organizes biannual meetings of the African Working Group on Disaster Risk Reduction (AWGDRR) in collaboration with the AUC. AWGDRR’s chairperson is AUC and the UNDRR will serve as the Secretariat. It has become the main institution for continental coordination of DRR in Africa. At the AWGDRR meeting, regional and national DRR focal points will be brought together with key DRR actors to implement the POA.

b) Efforts and activities

Various activities related to the following initiatives are being carried out to implement the Sendai Framework for Disaster Risk Reduction.

- Strengthen global monitoring, analysis, and coordination of the Sendai Framework for Disaster Risk Reduction
- Support regional and national implementation of the Sendai Framework for Disaster Risk Reduction
- Promote action through countries and partners to implement the Sendai Framework for Disaster Risk Reduction
- Strengthen knowledge, management, communication, and global support
- Enhance organizational performance

Specifically, this includes activities and information dissemination through the Working Group on DRR/DRM, etc., hosting of the Africa-Arab Platform on Disaster Risk Mitigation (2018), development of the Extended Action Plan for the Implementation of the African Regional Strategy for Disaster Risk Mitigation (2006 to 2015), and the launch of a website to mitigate Disaster Risk in the East and Central Africa.

The program to "Build Disaster Resilience of Sub-Saharan African Regions, Countries and Communities to Natural Disasters" was launched at the request of the African Union Commission (AUC) and the Regional Economic Communities (RECs) with the aim of strengthening the resilience of sub-Saharan African regions, countries and communities to the impacts of natural disasters, including the potential impacts of climate change, in order to reduce poverty and promote sustainable development. This is the first comprehensive approach to DRR in sub-Saharan Africa and is a cooperative program among Africa, Caribbean and Pacific (ACP)-European Union (EU) funded under the 10th European Development Fund (EDF).

(2) Network of African and Indian Ocean countries

1） AU (African Union): African Union

a) Overview

The African Union (AU) is one of the world's largest regional organizations, with 55 member states and territories (note), headquartered in Addis Ababa, the capital of Ethiopia. Its objectives are to achieve greater unity and solidarity among African countries and peoples; to accelerate political, economic and social integration in Africa; to promote peace, security and stability, democratic principles and institutions, public participation and good governance in Africa, and to promote sustainable economic, social and cultural development. Since its establishment, it has been rapidly expanding its functions and roles as the core of Africa's regional integration and cooperation. It is particularly active in the areas of peace and security, but is also involved in UN reform and climate change.

In terms of DRR, the Department of Rural Economy and Agriculture (Agriculture, Rural Development, Blue Economy, and Sustainable Environment [ARBE]) is promoting policies and strategies for disaster mitigation.

b) Efforts and Activities

Bi-annual Report on the Programme of Action for the Implementation of the Sendai Framework for Disaster Risk Reduction 2015 to 2030 in Africa has been prepared as an action plan for the implementation of the Sendai Framework for Disaster Risk Reduction 2015 to 2030 to reduce disaster risks and losses, and build resilience to disaster and climate risks. There are also specialized and technical organizations, treaty bodies, and other organizations, such as the African Risk Capacity (ARC), working to improve the efficiency of emergency response to natural disasters such as extreme weather, droughts, floods, and tropical cyclones.

In addition to this, the African Working Group on Disaster Risk Reduction (AWGDRR) is working to strengthen resilience of sub-Saharan Africa regions, countries and communities to the impacts of natural disasters, including the potential impacts of climate change. In line with regional coordination and policy guidance role of Africa for DRR, their role includes the signing of a grant agreement with the EU.

2） SADC (Southern African Development Community): Southern African Development Community

a) Overview

The Southern African Development Coordination Council (SADCC), the predecessor of SADC, was established in 1980. When it was first established, it was aimed at helping Southern African countries break free from the economic domination of the former apartheid South African regime. After South Africa abolished apartheid, the name was changed to the current Southern African Development Community (SADC) in 1992. The SADC aims to achieve development, peace, security, and economic growth in the region in order to reduce poverty and improve the lives of people in Southern African countries. It also aims to achieve economic integration, the creation of a common market, and conflict resolution and prevention.

The member states are 16 countries in Southern Africa: Tanzania, Zambia, Botswana, Mozambique, Angola, Zimbabwe, Lesotho, Swaziland, Malawi, Namibia, South Africa, Mauritius, Congo (DRC), Madagascar, Seychelles, and Comoros.

All SADC member states have disaster management structures that conduct domestic activities, sometimes with the support of international organizations and cooperating partners. After unexpected floods in Southern Africa in 2007, they began meeting annually to prepare for the future. SADC established the Disaster Risk Reduction Unit, which is responsible for coordinating regional preparedness and response programs for cross-border hazards and disasters and launched the SADC Regional Platform for Disaster Risk Reduction in 2011.

The main disaster risk management/international cooperation partners are Global Facility for Disaster Reduction and Recovery (GFDRR), United Nations Office for Disaster Risk Reduction (UNDRR), UN Office for the Coordination of Humanitarian Affairs (OCHA), UNDP Crisis Prevention & Recovery, and Swedish Civil Contingencies Agency.

b) Efforts and activities

In promoting strategic development in the region, they are working to implement effective programs and projects aimed at early detection, early warning, and impact reduction in disaster management and food security. They are actively engaged in holding ministerial meetings to regularly report on the progress of DRM programs in each country and to identify necessary linkages among regions.

The AU’s Africa Risk Capacity (ARC) has committed to strengthen cooperation in a number of areas focused on scaling up disaster risk financing in policy frameworks, vulnerability assessment and capacity building. They aim at disaster risk financing and early warning to enhance the preparation and sharing of data and information to reinforce lessons learned among SADC member states.

With the aim of mitigating the negative impacts of droughts, floods and other adverse weather and climatic conditions on sustainable socio-economic development, they have a Climate Service Center (formerly the Drought Monitoring Center) in Botswana and hold an annual forum to present the outlook for the rainy season from October to March in Southern Africa. The SADC Council of Ministers also approved Mozambique's offer to host the SADC Humanitarian Emergency Operations Centre (SHOC) in March 2021, which will be responsible for facilitating disaster risk preparedness, response and early recovery in the region. They also have the SADC Regional Development Fund (RDF) to provide assistance in the event of a disaster in a member state.

3） IOC (Indian Ocean Commission): Indian Ocean Commission

a) Overview

The Indian Ocean Commission (IOC) is an intergovernmental organization that brings together five member states: France (Reunion Island), Comoros, Madagascar, Mauritius, and Seychelles. It is the only regional organization in Africa composed entirely of islands, and was institutionalized in Seychelles in 1984. Benefiting from the active support of international partners, member states stand in solidarity through cooperative projects covering a wide range of areas, including ecosystem conservation, sustainable management of natural resources, maritime safety, public health, and renewable energy.

b) Efforts and activities

As island nations, IOC member states are highly vulnerable to weather and climate hazards, such as floods, droughts, storms, tropical cyclones, and high waters, and various projects have been implemented to address climate change and extreme weather events that affect coastal areas.

i) ISLANDS Project

The Mauritius Strategy (MS) of 2004 to 2014 was implemented in the Eastern and Southern Africa-Indian Ocean (ESA-IO) region with funding of €10 million from the EU in 2011. The MS Plan of Action strongly emphasizes the need to develop adequate financial protection mechanisms to protect island countries and their populations from economic and financial losses resulting from disasters, and is the only global development plan that sets out the basic principles and specific actions needed to support sustainable development at the national, regional, and international levels, as discussed at the Sustainable Development Conference of Small Island Developing States (SIDS) held in Mauritius in January 2005. A regional platform, the ISLANDS Financial Protection Program (IFPP, Platform for Financial Protection against Disaster Risk), was established to study the feasibility of financial schemes for risk transfer adapted to the region and to assist in establishing such schemes. They have also launched the Indianocéanie Regional Climate Change Portal, which provides information and data related to climate change in the Western Indian Ocean.

ii) BRIO (Building Resilience in the Indian Ocean) Project

With the aim of strengthening the resilience and adaptive capacity of local and national communities to the impacts of climate change in the island nations of the southwestern Indian Ocean, a two-year (2018 to 2020) project was undertaken to develop high-resolution climate projections that describe the region's climate. Long-term trends in regional temperature, rainfall, and cyclone activity were analyzed to provide an understanding of the impact of climate change on humans, animals, food security, water storage, soil erosion, and natural risks.

iii) HYDROMET Project

The project was co-funded by the EU, AFD and the Green Climate Fund, and aims to introduce better climate data and early warning systems to better plan for adaptation to climate change in the region. Improved hydro-meteorological instruments, better infrastructure for decision-making and adaptive planning, and capacity building will enable local governments to make the necessary decisions in different areas, especially contributing to urban planning, economic sectors (tourism, agriculture, industry), and social sectors.

iv) Building resilience and managing disaster response (#TeamEurope Partnership)

The European Union and its member states have united as "Team Europe" to sign financing agreements with European institutions for new projects in 2021 that aim to improve risk preparedness, better manage disaster response, and strengthen institutional and operational capacity to build regional early warning mechanisms. A new regional program for "Strengthening disaster resilience" will be implemented with the EU for €6.65 million from the 11th European Development Fund and a regional project on "Peace, Stability and Governance" for €8 million will be implemented with France through AFD. It will strengthen institutional and operational capacities (tools, information, equipment, etc.) to enhance risk preparedness and disaster response management, strengthen the capacity of national meteorological organizations, and establish regional early warning mechanisms, while using important scientific and statistical information on the climate, infrastructure, and socioeconomic vulnerabilities of the islands.

4) IORA (The Indian Ocean Rim Association): Indian Ocean Rim Association

a) Overview

IORA is a regional organization established in 1997 by India and other Indian Ocean Rim countries to provide a framework for regional cooperation to stimulate trade and investment within the member states. The secretariat is located in Mauritius. The Indian Ocean region (IOR) is geographically prone to both natural and man-made disasters, and the link between climate change and natural disasters, such as rising sea levels and water temperatures, is increasing. In addition, there is an urgent need to promote regional cooperation on preparedness and response strategies for vulnerable and unpredictable situations, given the presence of densely populated small island states and developing coastal countries, and the lack of resources and assets to handle disasters.

b) Efforts and activities

In IORA, under the IORA Action Plan 2017 to 2021, DRM development has been given a focused direction. The DRM Core Group, chaired by India, has been tasked with leading the development of a work plan for this priority area with the aim of strengthening cooperation and developing resilience in the IOR. In September 2019, the International Symposium on Tsunami Early Warning Systems - Lessons Learned from the 2018 Tsunami in Indonesia was held in collaboration with IOC-UNESCO, providing a platform for the development of a draft regional DRM work plan. In November 2019, experts from various technical and medical institutions in member states responsible for post-disaster relief efforts gathered at RWTH Aachen University in Germany to learn about building innovative, resilient communities.

In January 2021, the IORA First Experts Group Meeting on Disaster Risk Management was held to prepare a regional work plan and IORA Guidelines on humanitarian assistance and disaster relief (HADR), as well as to discuss a roadmap for the establishment of a Working Group on Disaster Risk Management (WGDRM) to develop a Disaster Risk Management (DRM) work plan to achieve the goals set out in the IORA Action Plan (2017 to 2021). It is also working to develop joint training programs, share experiences and best practices, build capacity and strengthen technical capabilities within the region, and encourage partnerships among governments and organizations to dispatch disaster response teams or transport relief supplies to affected countries. In collaboration with the United Nations Satellite Centre (UNOSAT) of the United Nations Institute for Training and Research (UNITAR) and with the support of the German Development Agency (GIZ), a training program on "Geospatial Information Technology (GIT) for Operational Planning and Decision Making in Disaster Risk Management (DRM)" was also launched for member states.

6.1.2 Challenges for Existing DRR Networks in Southern Africa

As indicated in 6.1.1, several DRR networks have already been established in Southern Africa, which is highly vulnerable to disasters and climate change, and DRR efforts are underway with the support of donors and other organizations. The SADC is particularly active in sharing issues and exchanging information among member states on a regular basis. On the other hand, the following issues were identified through desktop surveys and interviews.

- Lack of funds: Lack of sufficient funds with policy development and institutional framework for DRR at the local, national, and in some cases regional and community levels.
- Lack of comprehensive and up-to-date risk assessment and analysis methods: In many cases, plans are not based on comprehensive risk analysis and therefore may not address priority needs for effective DRR.
- Vulnerability of information and knowledge management systems in high-risk areas
- Reduce root risk factors
- Mixed platforms: Many donors and DRR-related platforms exist and work individually without aligning their objectives and activities, making it difficult to control for participating countries with limited DRR-related personnel and resources.

6.2 The Workshop in Mauritius

6.2.1 Cooperation with the Indian Ocean-Southern Africa Disaster Reduction Platform and The JICA Ex-participants

The Disaster Risk Reduction Platform (DRRMP) for the Indian Ocean and Southern Africa is a platform of three countries in Southeast Africa (Mozambique, Zimbabwe, and Malawi) and four countries in the Southwest Indian Ocean (Mauritius, Madagascar, Comoros, and Seychelles) established at the Strengthening the DRR Capacity Workshop for Southern India and Southeast

Africa, co-organized by JICA and the Government of Mauritius in July 2019. The platform was established through the collaboration of the Mauritius government's expertise in DRR activities and strong leadership for supporting development in the region, and JICA, which was looking for a way to provide wide-area and sustainable cooperation, considering the damage caused to the entire region by the super cyclone Idai that hit Southeast Africa in March 2019. The platform is expected to become a forum for sharing information and exchanging opinions on DRR to solve problems in Southeast Africa and Southwest Indian Ocean countries, attended by representatives of disaster risk organizations from each country and several development organizations.

On the other hand, due to the Covid-19 pandemic soon after its establishment, which reduced opportunities for activities, reorganization of the government of Mauritius, changing the department in charge of DRR from the Ministry of Public Infrastructure to the Ministry of Local Government and Disaster Risk Reduction, there has been a lack of continuous activities. Accordingly, a workshop was held for the target countries in this project, in order to revive the platform for DRR in the Indian Ocean and Southern African countries. The workshop was held as part of the platform and training program for third countries by JICA, which supports the overall platform, and was prepared in coordination with the government of Mauritius and JICA.

The workshop emphasized the proactive nature of the initiative as a step-by-step approach toward possible future, regional network, while also promoting the active participation of local personnel in its organization. In addition to inviting participants of JICA's issue-specific training programs in the field of disaster management as lecturers, the workshop also incorporated presentations by local officials of the Project on Strengthening Resilience in Cyclone IDAI-Affected Areas[130] implemented by JICA in Mozambique. In the workshop, the JICA ex-participants in Mauritius (2016, Community Disaster Management) supported the administration of the research team.

[130] The project aims to carry out disaster risk assessment, hazard mapping, action planning, and support for implementation in Beira City, an area affected by Cyclone Idai in Mozambique.
https://www.jica.go.jp/project/mozambique/011/outline/index.html

6.2.2 Outline of the Workshop

(1) Method of the workshop

A two-day workshop was held on January 19 (Wed.) and 20 (Thu.), 2022, for eight Southern African countries (Mauritius, Mozambique, Malawi, Zimbabwe, South Africa, Madagascar, Comoros, and Seychelles) with the aim of enhancing DRR capacity throughout the entire Southern African region and building cooperative relationships.

The workshop was located in Mauritius, but also was connected online (ZOOM) with other countries. The research team and participants from Mauritius joined locally at the main site. Participants from Mozambique and Zimbabwe were connected online from their respective venues, while participants from Malawi, Madagascar, South Africa, and Comoros were connected from their homes and offices, making a total of about 90 government officials and people concerned with DRR participated online. There were no participants in the Seychelles, although an invitation was sent out.

Although South Africa is not a member of the Disaster Risk Reduction Platform (DRRMP) for the Indian Ocean and Southern Africa and did not participate in the previous workshop, as mentioned above, the country is making advanced efforts in disaster education and disaster response in Southern Africa, and is expected to play a central role in sharing insights in the future framework of regional cooperation in the region.

(2) Objectives and Themes

1) Objective of the workshop and the background

This workshop aims to contribute to the enhancement of disaster management capacity in Southern Africa, and has the following two objectives.

a) Raising awareness and promoting the mainstreaming of DRR and countermeasures for climate change in the field of urban planning and infrastructure development by utilizing knowledge from Japan

While mainstreaming of DRR is essential for resilient, sustainable development and deeply related to the implementation of priority actions 2 (disaster risk governance) and 3 (pre-investment in DRR) of the Sendai Framework for Disaster Risk Reduction, mainstreaming of DRR from the perspective of urban planning has not been sufficiently addressed in surveys and trainings on individual disaster response organized by several donors.

In order to implement effective DRR measures in Southern African countries in the future, it is important to consider urban development areas and urban structures based on disaster risk assessment, and to make necessary pre-investments for the appropriate placement of residential areas, priority facilities and infrastructure. It was, therefore, considered necessary to reemphasize the importance of the above in order to raise the level of knowledge and develop a common understanding among DRR officials in the region.

b) Strengthen intra-regional networks to enhance wide-area cooperation and capacity building for DRR

In order for Southern African countries to effectively and efficiently promote DRR and climate change mainstreaming in the field of urban planning and infrastructure development with little experience, it was considered important to build a cooperative system among neighboring countries, such as sharing knowledge, transferring technology, and building relationships that allow for easy communication and consultation. In order to create such opportunities, we decided to include the sharing of experiences and lessons learned by countries and local governments with experience in the field, as well as presentations and discussions from each country so that participants could proactively participate in the workshop.

More specifically, three officials from GREPOC, INGD, and Beira City Hall in Mozambique shared their knowledge on reconstruction after Cyclone Idai, and two officials from NDRRMC and MMS in Mauritius shared their efforts in DRR and meteorology. In addition, a BNGRC staff from Madagascar, who was also a trainee (Comprehensive DRR and management in the African region in 2018), made a presentation to share issues and initiatives for mainstreaming disaster management. In addition, a researcher from North West University in South Africa, who is also a trainee (2019, Improvement of Disaster Risk Reduction Education System), shared the importance of education on disaster risk and specific examples from South Africa. At the end of the program, group discussions and presentations were held to discuss the promotion of wide-area cooperation for DRR, and the necessity of wide-area cooperation and methods of cooperation were examined.

Although the importance of mainstreaming DRR and the cooperative system itself cannot be established overnight, it is hoped that the efforts of the regional network will raise awareness and enhance the capacity of those involved in the regional DRR in the future, leading to Priority Action 3 (investment in DRR) of the Sendai Framework for Disaster Risk Reduction.

2） Theme

The following three themes were established to achieve the above objectives.

a) Sharing knowledge of restoration from Cyclone Idai in Beira, Mozambique

- Aim to share experiences and lessons learned during restoration from cyclone damage to help countries consider their own DRR policies and measures.
- The presentations were made mainly by local officials, who were in a similar position and had similar perspectives to the participants in each country, to make the agenda and discussions more accessible and understandable.

b) Sharing of Japan's approach to pre-investment in DRR (e.g., 8 steps to create a DRR plan)

- A presentation was made by the research team on the concept of pre-investment in urban development and infrastructure development based on disaster risk assessment, which is important for effective DRR measures.
- A presentation was made by the JICA ex-participants on application of the learnings of disaster risk assessment to Southern Africa.

c) Consideration of wide-area exchange and cooperation that will lead to mainstreaming of DRR and enhancement of capabilities for DRR

- Future needs and expectations for Japan's cooperation in DRR for the establishment of an intra-regional network that will contribute to resolving issues in each country for the promotion of mainstreaming DRR, etc. were identified.

(3) Details of the workshop

1) Participants

The number of participants from each country and the main participating organizations are as follows.

Table 6-1 Number of participants and organizations by country

Country	Number	Organizations
Mauritius	37	NDRRMC, Ministry of Local Government and Disaster Risk Management, Ministry of National Infrastructure and Community Development, MMS, University of Mauritius, Mauritius Fire and Rescue Services, Road Development Authority, Road Development Authority, Local Authorities, etc.
Mozambique	10	GREPOC, INGD, Provincial Directorate of Public Works, Southern Regional Water Management, Beira Municipality, etc.
Malawi	10	DoDMA, Ministry of Transport and Public Works, Ministry of Agriculture, Department of Land Resources and Conservation, District council (Lilongwe), etc.
Zimbabwe	22	Ministry of Local Government, Ministry of Transport, Ministry of Environment, Climate Change, Tourism and Hospitality Industry, Environmental Management Agency, Civil Aviation Authority of Zimbabwe, POTRAZ, City council (Harare), etc.
South Africa	2	North West University, City of Joburg
Madagascar	7	CPGU, BNGRC, General Directorate of Meteorology, Local Authorities (Antananarivo, Toamasina)
Comoros	2	Ministry of Interior, Information and Decentralization, University of Comoros

Source: JICA Study Team

2） Program

The workshop program was as follows.

Table 6-2 Workshop program (Day 1)

Date	Time		Program	Contents
DAY1 19th Jan	9:30-10:00	30 min	Reception	
	10:00-10:05	5 min	(by Mauritius) **Welcome Remarks**	Explanation of the Workshop outline
	10:05-10:10	5 min	(by Mauritius) **Opening Remarks**	Opening Remarks from The Ministry of Local Government and Disaster Risk Management of Mauritius
	10:10-10:15	5 min	(by JICA) **Opening Address**	Opening Remarks from Ms. Kaori Tanaka, Chief Representative of JICA Madagascar Office
	10:15-10:40	25 min	(by JICA project team) **Presentation on pre-disaster investment and 8 Steps for Local DRR Planning**	Mr. Masaaki Chida (Project Manager of the JICA Project Research for Disaster Prevention in Southern Africa) ・Importance of pre-disaster investment ・Importance of reflecting the local DRR plan planned based on 8 steps into the local development plan
	10:40-10:45	5 min	Photo Session	Photo session for Mauritius and JICA team
	10:45-11:00	15 min	Break	
	11:00-11:25	25 min	(by Presenter from Mauritius) **Contribution of Mauritius Meteorological Services in Disaster Risk Mitigation**	Ms. Vandana Goanjur（Mauritus Meteorological Service）
	11:25-11:35	10 min	Q&A	
	11:35-12:00	25 min	(by Presenter from Mauritius) **Knowledge sharing on the implementation of mainstreaming DRR**	Mr. Mohit and Mr.Bissessur（National Disaster Risk Reduction and Management Centre）
	12:00-12:10	10 min	Q&A	
	12:10-13:10	60 min	Lunch break	
	13:10-13:20	10 min	(by Presenter from Mozambique) **Knowledge sharing on "JICA Cyclone Idai recovery project in Mozambique"**	①Showing Introduction video（Alternative to site visit） -Introduction of Project on Strengthening Resilience in Cyclone Idai Affected Area (ARPOC) (Evacuation drill, DRR WS, Hazard map training etc..) -Damaged infrastructure -Speech of Post Cyclone Idai Reconstruction Cabinet (GREPOC) director（about Build Back Better(BBB), etc..）
	13:20-13:35	15 min		②Project introduction Ms. Ana Paula Felicia Correia (National Institute for Disaster Management: INGD) - Assess for resilient community against residual risk -Importance and contents of the activities with linkage between National level, provincial level, municipal level and Bairro level -Introduce the efforts of strengthen the mechanism.
	13:35-13:45	10 min		Q&A
	13:45-14:00	15 min		③Project introduction Mr. Samuel Zacarias Simango (Municipio da Beira: CMB) - Disaster risk reduction plan (or consideration) in Beira. - Structure measures, Land use plan, measures against Residual risks which are considering or will consdier in Beira - Lesson learned from the experience
	14:00-14:10	10 min		Q&A
	14:10-14:25	15 min	Break	
	14:25-14:40	15 min	(by Presenter from Mozambique) **Knowledge sharing on "JICA Cyclone Idai recovery project in Mozambique"**	④Project introduction Mr. Carlito Dino Nhama (Post Cyclone Idai Reconstruction Cabinet: GREPOC) -Activities for recovery from Cyclone Idai -Achievement and challenges. -How to recover as resilient city based on the experience in Beira -Lesson learnt from the experience
	14:40-14:50	10 min		Q&A
	14:50-15:35	45 min	(Workshop) **Discussion of the Lessons and Knowledges Learned from the Mozambique experience of Cyclone Idai**	Share participant's comments on lessons and knowledge learned from Mozambique, the need for mainstreaming disaster prevention and upfront investment, and the current situation and issues in their own countries based on these.
	15:35-15:45	10 min	(by JICA project team) **Wrap up for Day 1**	Wrap up for Day 1

Source: JICA Study Team

Table 6-3 Workshop program (Day 2)

Date	Time		Program	Contents
DAY2 20th Jan	9:30-10:00	30 min	Reception	
	10:00-10:10	10 min	(by JICA project team) **Resume of Day1 and Agenda for Day 2**	Resume of Day1 and Agenda for Day 2
	10:10-10:35	25 min	(by Presenter from Madagascar) **Evolution of disaster risks in Grand Antananarivo**	Lieutenant-Colonel FALY Aritiana Fabien (National Office for Risk and Disaster Management: BNGRC/ JICA Training Alumni) - Disaster risks in Madagascar - Evolution of disaster risks in Grand Antananarivo - Activities and Challenges in Disaster Risk Assesment
	10:35-10:50	15 min	Q&A	
	10:50-11:05	15 min	Break	
	11:05-11:30	25 min	(by Presenter from South Africa) **Importance of disaster prevention education for mainstreaming disaster prevention**	Ms.FOURIE Kristel (North West University / JICA Training Alumni) - Disasters in Southern Africa - Hazard vs Vulnerability Paradigm - Disaster Education
	11:30-11:45	15 min	Q&A	
	11:45-12:00	15 min	(Connection test for Afternoon program)	(Connection test for the Break out room for each coutry)
	12:00-13:00	60 min	Lunch Break	
	13:00-13:15	15 min	(Workshop) **Discussion on the Regional Cooperation for Disaster Risk Reduction(DRR) in Southern Africa and Indian Ocean**	Ms. Motoyo Araki (JICA Expert from the JICA Project Research for Disaster Prevention in Southern Africa) - Introduction of the theme and goals
	13:15-14:15	60 min		Group Discusstion(Break Out Room) Discuss on the possibility of further regional cooperation (i.g.utilization of the Disaster Risk Reduction Management Regional Platform (DRRMRP)) by each
	14:15-14:30	15 min	Break	
	14:30-15:20	50 min	(Workshop) **Discussion on the Regional Cooperation for Disaster Risk Reduction(DRR) in Southern Africa and Indian Ocean**	Presentation from each group on the results of the group discusstion Theme: How to promote Disaster Risk Reduction (DRR) coorperation within Southern African countries Output: Proposals to promote DRR cooperation within Southern African countries
	15:20-15:25	5 min	(by Mauritius) **Wrap up for the Workshop**	Wrap up for the Day 2 and the overall Workshop
	15:25-15:35	10 min	(by Mauritius) **Certificate Ceremony**	Certificate Giving Ceremony for the Workshop
	15:35-15:45	10 min	(by JICA) **Closing Remarks**	Closing Remarks from Ms. Kaori Tanaka, Chief Representative of JICA Madagascar Office

Source: JICA Study Team

3） Photos from the workshop

The following are snapshots of the workshop.

	
Group photo of online participants	Group photo of participants in Mauritius
	
Participants in Mauritius	Participants in Mozambique
	
Participants in Zimbabwe	Survey team to grant the certificate of participation

Figure 6-1 Snapshots from the workshop

Source: Photographed by JICA Study Team

4) Presentations and discussions

a) Opening speech

The opening remarks were made by the Deputy Director of NDRRMC and the Director of JICA Madagascar Office. The NDRRMC expressed its motivation for the implementation of the Sendai Framework for DRR and realization of the plans for DRR that have already been formulated. They expressed their gratitude to international donors, including JICA, for their support to date, and their hope for continuing support, after mentioning that DRR should be implemented with the involvement of international stakeholders. JICA Madagascar Office stated that the disaster risk in Southern Africa is increasing year by year due to climate change and abnormal weather, and that JICA will continue to be a good partner for DRR to contribute to the sustainable development of the region. Both speakers mentioned the volcanic eruption and tsunami that occurred in Tonga on January 15, 2022, just before the opening of the conference, and emphasized again the difficulty of predicting disasters and the importance of DRR.

b) Presentation by the survey team

As the first program, the JICA survey team shared the importance of pre-investment in DRR and the concept of incorporating the perspective of DRR into regional development planning based on the 8 steps of local DRR planning. The importance of mainstreaming disaster risk management in urban planning was also discussed, based on the Japanese case study and its application to Southern Africa.

Figure 6-2 Presentation by JICA survey team

Source: Photographed by JICA Study Team

c) Presentation by Mauritius disaster management and meteorological officials

Since Mauritius is relatively advanced in DRR among the participating countries of the Platform, their insights in the fields of DRR and meteorology was shared among the participants.

In the first presentation, MMS introduced the existing early warning systems for cyclones, torrential rains, tidal waves, storm surges, and tsunamis, as well as the methods of communication and how to respond to communities during a disaster, and shared the existing issues in DRR. It was also mentioned that the development of a disaster response plan tailored to the characteristics of each community is in progress.

The next presentation from the NDRRMC introduced the characteristics of natural disasters in Mauritius and shared the history of building a disaster management system to respond to them, the current operation and management system, and the introduction of community training and education programs to enhance disaster response capacity. As the Sendai Framework for Disaster Risk Reduction emphasizes the importance of pre-disaster investment, disaster risk reduction and management is being promoted at the national and regional levels. At the local level, relocation of residents from disaster risk areas is an important issue, and various studies and cross-sectoral efforts are being made to promote understanding. The official also mentioned that the participation of many NGOs, such as social welfare councils and the Red Cross Society, is an important factor in actual efforts.

d) Presentation by the officials for Cyclone Idai in Mozambique

From Mozambique, the country's experiences and knowledge/insights on recovery from Cyclone Idai were shared. A video was presented at the beginning of the session, showing the situation of affected infrastructure in Beira City (collapsed roads, seawalls damaged, houses and schools damaged, etc.), "Project on Strengthening Resilience in Cyclone IDAI-Affected Areas (ARPOC)" of JICA (evacuation drills, DRR workshops, hazard map drills, etc.), interviews with participants of the evacuation drills, and an interview with the Director of GREPOC.

This presentation was followed by another by INGD on the importance of coordination of disaster response at the national, provincial, municipal, and community levels and efforts to create a system where all organizations can work together to protect people, and efforts to strengthen mechanisms for building resilient communities in rural areas where residual risk assessment and structural countermeasures are difficult.

Beira City Hall presented lessons learned from the Cyclone Idai recovery experience, as well as the status of efforts in disaster management planning and evacuation planning, land use planning and structural measures, and residual risk measures.

Finally, GREPOC gave a presentation on the results and challenges they have experienced through their restoration activities, including the concept of reconstruction (Build Back Better) from the perspective of persons in charge of implementation and how that is reflected in the actual situation, how reconstruction should be carried out as a resilient city based on the experience of Beira City, and lessons learned on the importance of prior investment in DRR (hard measures) and prior preparation (soft measures).

e) Presentations by JICA ex-participant of Madagascar

The JICA ex-participant, who is at the forefront of disaster response at BNGRC, shared the evolution of disaster risk in Grand Antananarivo and the activities and challenges of disaster risk assessment. The officer explained that Madagascar has a legal system and formal plans for disaster management, and has established a mainstreaming system for disaster management across ministries, national government, municipalities, and communities, and that the BNGRC is working closely with local governments based on risk maps to promote local disaster management. The BNGRC is already working on soft measures, and the next step is to develop infrastructure and other hard measures, but there are still many challenges in mainstreaming DRR, such as lack of budget and difficulty in promoting understanding among the population.

f) Presentations by JICA ex-participant of South Africa

The JICA ex-participant of South Africa shared the importance and efforts of DRR education based on the efforts of the disaster education system in South Africa. She emphasized the needs to integrate disaster education into primary and secondary curriculums, saying that disaster education does not necessarily mean specialized knowledge, but that it is about assessing their vulnerabilities and changing perspectives on disasters.

g) Discussions for wide-area cooperation in Southern Africa

At the workshop, the participants were divided into seven groups and engaged in group discussions and presentations on how to promote regional cooperation for DRR in Southern Africa. The opinions presented by each group are shown below.

Figure 6-3 Snapshots from discussions and presentations

Source: Photographed by JICA Study Team

Table 6-4 Opinions presented in the workshop

Group	Main opinions
Mauritius 1	- A clear Standard Operating Procedure is needed at the onset of a disaster as missions often overlap. - Due to the COVID-19 pandemic, lessons are not shared sufficiently, capacity building activities and training are also insufficient, and there is little communication. Need technical assistance and capacity building for integration of DRR in disaster management education, hazard mapping, early warning and implementation of DRR measures. - Need to provide scholarships for disaster-related degrees and encourage the organization of exchange programs. - Need a platform to share information on response to major weather disasters in the region. Challenges include political interference, funding, health issues such as pandemics, and public motivation. - DRR should not be implemented in isolation. It is in our interest to share experiences and best practices to better prepare for disaster management.
Mauritius 2	- It is important to determine in advance the lead agency for each disaster response (e.g. landslide disaster) for efficient response and predictions. Donors will also find it easier to find appropriate counterparts. When Mauritius experienced its first landslide disaster, it was difficult to come up with countermeasures. - Relocation of residents in landslide hazard areas is a major problem. It is difficult to persuade people to relocate, and they often come back after relocation. Social and economic aspects should be taken into account before relocation. Cooperation is also important to learn from mitigation measures of other developed countries. - Mauritius is good at coping with cyclones and can share well-designed norms and knowledge with other countries. Knowledge sharing is important in order to improve response measures. It is also necessary to know how to receive major monetary assistance in a short period of time when disaster strikes.
Madagascar and Comoros	- In the Comoros, experts who can conduct river surveys are in shortage and models and thematic studies by universities are also not made sufficiently. It is necessary to conduct disaster assessments and formulate a national DRR plan with a time frame. There are many laws and national policies that need to be revised to deal with storm surges and landslides. - Data collection and tools sharing need to be developed for quick assessment of the situation. - More efficient capacity building activities can be achieved if there is good coordination at the local level. Focus should be on DRM research areas such as risk assessment, hazard mapping, etc., and technical support is needed. The establishment of a joint platform would be very useful and we expect JICA to play the role of technical leader.
Mozambique	- Strengthening the communication system including humanitarian organizations and GREPOC is very important to us because of the problems such as inefficient coordination among government agencies and organizations during disasters. - Lack of drinking water and facilities for storing food during disasters is an issue. It can be suggested that the Humanitarian Aid Center be used for multiple functions as an accommodation facility during disasters and as a warehouse at other times. - Information and experience sharing within the region through partnerships with other countries is important; information exchange within SADC should be activated. - There is a need to sensitize people at all levels, including general house

Group	Main opinions
	management, to disaster preparedness. DRM should be introduced in education for this purpose.
Malawi and South Africa	- We are faced with a lack of preparation and personnel. In addition, it is difficult to predict regional damage in the event of a disaster. Currently, the Disaster Management Center is doing all the work, but it lacks support and response from other concerned parties. There is no institution that can initiate and facilitate cooperation among the concerned parties. - It is important for countries to have the same vision for disaster management. It is also necessary to share experiences on what worked and what did not work, and possible interventions in local systems if necessary.
Zimbabwe 1	- We have a weak early warning system and limited knowledge on how to respond to disasters. There is inadequate cooperation among relevant departments, and our information dissemination system is weak. We also have few resources in terms of transportation and equipment. As a result, effective emergency response and monitoring is difficult. - DRM should be incorporated into the education system. - There is a need for collaboration among countries to improve facilities, allocate and share appropriate resources, and mobilize knowledge transfer and capacity building training. - It is suggested that a Memorandum of Understanding be developed among the participating countries to develop and strengthen regional centers for disaster management. There should be regional workshops, exchange programs, joint or regional disaster management exercises. Funding mechanisms should also be considered.
Zimbabwe 2	- I believe that legislation and policies are needed because the current disaster management system in Zimbabwe is weak in terms of cooperation. We also want to establish a ministry responsible for capacity building of key stakeholders and identify key stakeholders in the region to promote community education and installation of resilient communication infrastructure. - Through inter-regional cooperation, we want to get an early warning system. We would also like to see technical cooperation in the form of expert assistance, training workshops, exchange programs, and seminars from various countries. It would also be efficient to create a research center to share strategies and resources. - In disaster-prone countries, disaster management should be a priority. Existing bottlenecks include cultural differences, lack of education, political influence, and instability, but we hope that providing disaster education to the people will change their mindset. Capacity building of government and community leaders is also needed.

Source: compiled by JICA Study Team

6.3 Potential for a Regional DRR Network in Southern Africa

Based on the issues faced by Southern Africa Network for Disaster Reduction and the opinions of the participants obtained at the workshop, the needs of the Regional DRR Network in Southern Africa in the future and the possibility of collaboration were discussed.

6.3.1 Reaffirmation of the Challenges of Disaster Risk in Southern Africa

(1) Disaster risk in Southern Africa

The figure 6-4 shows the paths of cyclones in Southern Africa region over the past 25 years. It indicates the trajectories of cyclones extend not only to islands such as Mauritius and Madagascar, but also to the continent itself. In general, cyclones tend to move from east to west and from island areas to the continent. That being said, the red line in Figure B on the upper right shows the trajectory of Cyclone Idai, which had a complicated trajectory, heading from west to east, changing course without landing in Madagascar, and then heading for the continent. As a result, widespread damage and complex disasters, such as long rains and floods, occur simultaneously. To cope with cyclones, it is necessary to cooperate and take DRR measures in a wide area, such as sending out meteorological observation information from the islands and receiving it on the continental side.

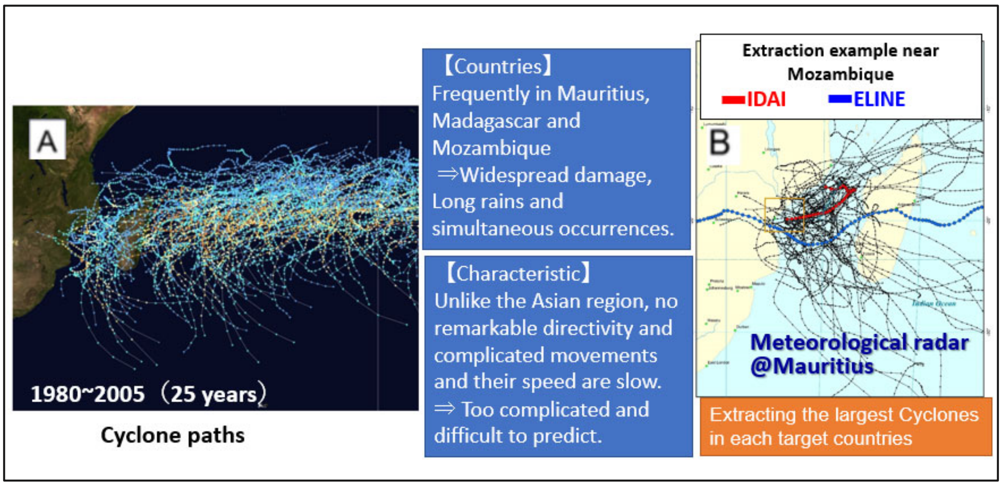


Figure 6-4 Cyclone paths in Southern Africa

Source: Created by JICA Study Team

In addition, from the view point of regional cooperation and geopolitical perspective of disaster risks, it is necessary to promote cooperation by dividing the region into three areas: (1) the island areas of Madagascar, Mauritius, Comoros, and Seychelles; (2) Mozambique, the coastal area of the African continent; and (3) Malawi and Zimbabwe, the inland areas of Africa, addressing issues related to their regional characteristics, disaster characteristics, and lessons learned from previous disasters.

Table 6-5 The priority sectors targeted in this study (repeat)

Category	Disaster characteristics	Target country
Archipelago countries	- It is the first region among the eight target countries to be affected in the event of a cyclone. - As an island nation, all coastal areas are at high risk of being affected by storm surges. - Among the archipelago countries, Madagascar is 1.6 times the size of Japan, and it has the same risks of natural disasters and issues in infrastructure develop ment as continental areas.	Madagascar, Mauritius, the Union of the Comoros, Republic of Seychelles
Continental coastal countries	- In addition to the risk of storm surges as it is locate d at the coastal area, there is also the problem of riv er flooding attributed to its connection to the contine ntal interior. - There is a high need to develop infrastructure such a s ports and roads as a logistics hub and network not only for the country itself but also for inland countri es. - Major cities are located in relatively flat areas with o pen coastal areas.	Mozambique
Continental inland countries	- Although damage from cyclone storms are limited, th ere is a risk of flooding and landslides due to rainfal l. - As a landlocked country, there is no port which is th e key to logistics, logistic infrastructure network such as roads and other from neighboring countries is vit al. - Due to the irregular geographical characteristics with hills and valleys, there is a high risk of flooding and landslides in urban areas and on roads and other cri tical infrastructure. - The country's industry is dependent on agriculture, w hich makes it susceptible.	Malawi, Zimbabwe

Source: compiled by JICA Study Team

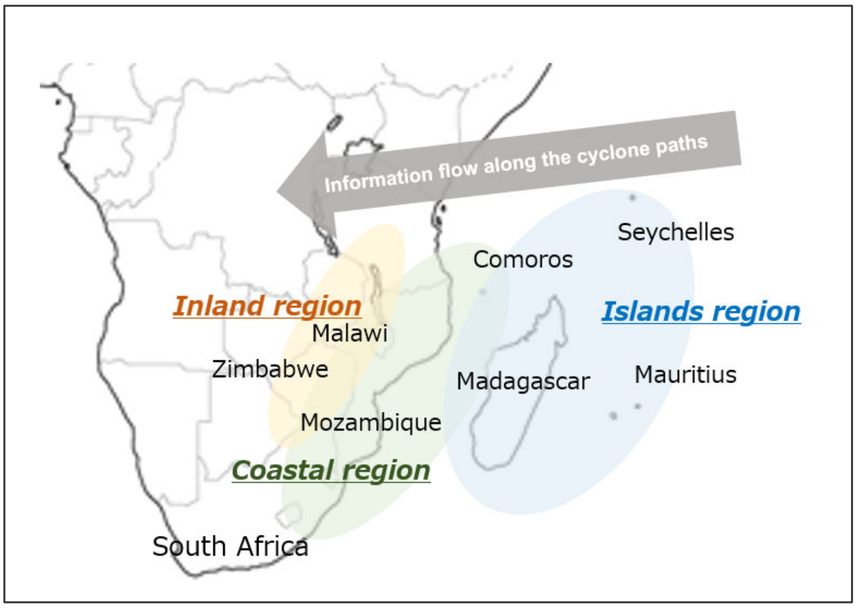


Figure 6-5　Concept of the distribution of the three districts

Source: JICA Study Team

(2)　Lessons learned from the experience Cyclone Idai

Following the damage of Cyclone Idai in 2019, the "Project on Strengthening Resilience in Cyclone IDAI-Affected Areas (ARPOC)" is being implemented in Beira City, Sofala Province, which was the most damaged in Mozambique. As an example of recovery assistance for natural disasters in Southern Africa, the lessons learned from this project are summarized below.

- Due to COVID-19, travel was interrupted, and the survey had to be postponed, making it difficult to provide support for early recovery and reconstruction. Currently, more than three years have passed since the disaster.
- The existence period of GREPOC (Gabinete de Reconstrução Pós-Ciclone Idai / Post Cyclone Reconstruction Cabinet) is limited to five years, and it is necessary to maximize the support within this period.
- The GREPOC was not only located in the capital city of Maputo, but also in the affected city of Beira, where it was able to directly identify and respond to local needs for recovery and restoration, as well as coordinate projects with donors. This contributed significantly for the effective promotion of restoration activities. In the future, when similar disasters occur in other countries and regions, it would be desirable to propose the establishment of an agency like the GREPOC to be in charge of reconstruction in affected areas.
- However, in light of the fact that it took 10 years after the Great East Japan Earthquake for projects to achieve the same level of restoration as before the disaster, it is recommended that

the duration of the GREPOC should be about 10 years.

- While cooperation with local C/Ps is important in recovery assistance, JICA offices in each country do not necessarily have a relationship with local government agencies and departments related to recovery and reconstruction in the course of their normal contacts. For this reason, it is necessary for JICA offices to always be prepared to collaborate with major infrastructure government agencies and other organizations, assuming that they will promote mainstreaming of DRR and advance investment in DRR, so that they will be able to respond to events caused by sudden natural disasters. Fortunately, the Mozambique Office responded quickly and established a pipeline with corresponding government agencies, which led to the rapid initial response of emergency relief assistance.
- The main donor in the African region is the World Bank (WB), which is involved in various infrastructure projects, DRR and assistance. For this reason, it is necessary to constantly check the trends of the World Bank and seek clues for collaboration. Fortunately, in Mozambique, we have been able to collaborate on projects such as hazard simulation, seawall construction, and drainage pumping station construction. Since other countries and regions also want to collaborate with JICA, it would be desirable to continue to build a good relationship and collaborate on DRR assistance in Africa.
- Although COVID-19 has frequently interrupted our travel, we cannot stop our local recovery support activities. In such instances, we believe that we should collaborate with organizations that can always work in the field. Local universities, NGOs, and local consultants are candidates for such activities; NGOs and local consultants are still used for evacuation drills and land use planning as local re-commissioning, but there is no full-scale collaboration with universities. In Mauritius, the University of Mauritius has actively offered to collaborate in field research and support for DRR and human resource development, and we believe that Mozambique should have made efforts to promote collaboration with local universities. However, collaboration should not be limited to just academic endeavors like SATREPS, but rather a mechanism to take practical actions such as recovery support and human resource development through collaboration.
- JICA believes that equal assistance should be provided to the affected areas dominated by rebel groups. As the affected city of Beira has a political system that is opposed to the central government, the citizens of Beira are at a disadvantage when it comes to relief and recovery assistance. JICA should continue to provide necessary support after emergency recovery assistance, despite its relationship with the current government.
- The BBB is mentioned as an objective of recovery assistance, but as mentioned above, has taken more than 10 years to recover from a large-scale disaster in Japan. For this reason, it is necessary to look at the results of the BBB from a somewhat long-term perspective, especially

in areas that take time, such as the recovery of livelihoods, and in many areas that will only occur once recovery and reconstruction projects are in place. In order to achieve true recovery, it is necessary that the input of aid and the manifestation of its effects are not viewed from a short-term perspective, and that decisions are not made to deny aid because it is predicted that it will not produce results in the short term.

- In the pilot project to renovate and build new educational and medical facilities that were damaged by the disaster, the biggest bottleneck was the inability to supervise and instruct construction work locally, but the introduction of 360-degree cameras has enabled remote management from Japan. We believe that this is a model project that will not stop construction or business in other countries or regions even during the COVID-19 pandemic.
- The development and study of the inundation hazard map allowed to be examined the facility development in conjunction with the hazard map simulation, such as changing the originally planned 60cm foundation raise to 100cm, because the newly built Macurungo Elementary School may be flooded according to the worst-case hazard map simulation. This can be presented as a model project.
- When providing support as a JICA project, there is concern about the system and capacity of the C/P of the partner country. In particular, it is often said that Africa lacks such systems, human resources, and capacity, when compared to Asia. However, this is not the case with the C/Ps in Mozambique and Beira, and the large number of highly capable personnel and their sincere responses will make it easy for JICA to proceed with the project.
- ARPOC was the first urgent development study in Africa, and until now there had been no large-scale DRR projects in Africa. In Mozambique, the need for DRR assistance was considered to be low, as there had been no disaster-like event until Idai, although, the country had a cyclone DRR program. However, the frequency of cyclones has been increasing since Idai, and this year's Cyclone Ana caused major damage in Mozambique, in addition to Malawi and Madagascar, where cyclones and flooding due to long rains have become the norm. Compared to Asia, Africa is the only continent that needs to mainstream DRR, as its cities are less dense and have more capacity for development and maintenance. Pre-investment in DRR should be promoted.
- In Mozambique, the frequency of cyclones seems to be high, even north of Beira City. In the three years since ARPOC was launched, the city has experienced several cyclones, and, through the use of hazard maps, evacuation plans, and evacuation drills, Beira has developed a good human resource base for disaster management. In addition, the city has been working with national organizations such as INGD. The effects of support are evident in the fact that the city has been able to avoid serious human casualties during major cyclones after Idai. Therefore, we believe that the personnel in Beira working for DRR are approaching a level

to be able to take the lead in sharing knowledge and guidance on restoration in other regions and countries.

- It was found that invitations to Japan and training in Japan have been very effective in developing human resources for DRR in Mozambique and raising awareness of the need for collaboration and cooperation in DRR. As mentioned above, the government of Mozambique and the city of Beira have had political conflicts that jeopardized the future of cooperation and collaboration in recovery. However, government officials of the countries invited to Japan and those in charge of disaster-stricken areas of Beira City worked together and gained Japanese knowledge, which helped to foster mutual understanding. In this study, the coordination among the ex-participants of training in Japan from each country had done to hold a workshop led by them, who were all highly conscious of and motivated in DRR. Therefore, it would be desirable to continue to actively promote invitations to Japan, training in Japan, and subject-specific training in the development of human resources for DRR.
- Most of the major damage caused by Cyclone Idai in Mozambique was wind damage from the storm, not storm surge damage or flooding. (The tide level was low at the time of Cyclone Idai, and it was simulated that a large storm surge would occur if it coincided with a high tide a few days later.) In Mozambique, large trees destroyed houses and many lives and properties were lost. Therefore, Mozambican DRR personnel wanted to acquire knowledge on storm countermeasures, but there were no lectures on wind damage countermeasures in JICA's Knowledge Co-Creation Program (hereinafter KCCP) training for floods and earthquakes. Therefore, during the training in Japan for ARPOC, it was provided an opportunity for a lecture on Japan's knowledge on wind damage and how to deal with it. The requests for such wind damage prevention measures would be surely requested in the future. In addition, since pre-response as non-structure measures would be required in parallel with structure measures, to share insights of this kind of subject is effective. Therefore, it would be desirable to include at least one session of this kind of lecture in the KCCP of JICA.
- As mentioned above, in addition to the issue of the deadline for the GREPOC support, the basic support work for ARPOC will also end this June. However, for the recovery of the BBB, we believe it is necessary to continue to implement future support.

6.3.2 Challenges of the Regional DRR Network in Southern Africa

From the questions, answers and presentations at the workshop noted above, and the contents of the interviews with University of Mauritius conducted afterwards, challenges related to human resource development in the DRR field pertaining to the formulation of a Southern Africa regional DRR network were confirmed. The following are the specific challenges that could be identified.

- There are already many regional cooperation systems for natural disasters such as cyclones, but no system has been built in consideration of human resource development for disasters.
- Various donors, such as Mauritius and Madagascar are involved in the development of hazard maps and disaster response projects. However, there is a shortage of adequately trained human resources who understand why natural disasters occur and judge how to prevent the damage are in advance.
- The concept of DRR (including pre-disaster investment) that responds to disaster mechanisms is not widespread, and as a national system, there are not many opportunities (employment opportunities) for people with such knowledge and skills. There are also few opportunities to learn such knowledge and skills.
- There is a need to strengthen the early warning system through regional network.
- Technical cooperation in the form of assistance from experts from various countries, training workshops, exchange programs, seminars, etc. is desired.
- It is desirable to establish a research center for sharing strategies and resources.

6.3.3 Needs of the Regional DRR Network in Southern Africa

From the active question and answer sessions and presentations at the workshop, it was able to be understood that, although there are differences in the situation and the level of maturity of DRR systems in each country, there are experiences and issues that can be shared and utilized mutually, and that there is a need to continue to promote the construction of effective regional DRR systems through cooperation. The following is a list of specific needs that were identified.

- Sharing of insights on the establishment of effective DRR efforts: Although there are existing ministries and agencies in each country, they vary in terms of organizational structure, such as personnel, structure, and staff expertise; operational structure, such as budget execution method, size, and resources; and administration structure, such as cooperation with infrastructure authorities, emergency response authorities (police, fire departments, etc.), local governments, and local communities. There were many questions about this matter. Some participants pointed out the difficulties in communication and information transfer between the central government and local governments in their countries, as well as the need to improve the legal system, and felt that there were challenges in building an effective system to ensure a smooth response under emergency conditions in the event of disasters.
- Sharing of best practices: It is believed that countries with similar social and economic situations can learn a great deal from each other by sharing knowledge on how they dealt with challenges they have faced and other factors that led to their success or failure. In the workshop, there were occasions when information was exchanged on the difficulties of

relocating residents in disaster risk areas. Establishing a relationship that allows for casual consultation and exchange of opinions on common issues, besides the purpose of gaining knowledge that can be used in one's own country, would be meaningful to those involved in DRR, who are often faced with difficult situations.

- Information sharing for disaster response: In Southern Africa, where heavy rains and cyclones often cause damage to the entire region, it is important to share disaster information during emergencies. In particular, for countries that do not have advanced weather information systems, information sharing from neighboring countries is very important. Therfore, enhancement of the cooperation in emergency situations, including in the field of meteorology is required. In addition, it is desirable to establish an emergency communication system in advance to ensure smooth sharing of human and material resources for mutual support in the event of a disaster.
- Sharing of insights about financing methods: As mentioned in the challenges section, it is difficult for countries in Southern Africa, where there are many developing countries, to secure sufficient budgets for investment in DRR. Even regional networks such as SADC do not have sufficient funds. Therefore, though it is essential to obtain funds and support from overseas donors, such as international organizations, there is a lack of knowledge about the means and procedures to attract support, and the ability to control overseas support. Therefore, the dissemination of experience by countries and regions with experience in aid from international organizations is considered effective.
- Advanced technical support: Comprehensive risk assessment and analysis methods based on the latest specialized technologies to reduce underlying risk factors, as well as hazard mapping and technical response measures based on these methods, are difficult to implement in Southern Africa which has many developing countries, due to lack of educational institutions and experts. There is a need for capacity building, training and training opportunities to improve technical expertise.
- Joint human resource development and network strengthening: Many respondents expressed a desire to jointly conduct exchange programs, seminars and capacity building trainings in order to continuously develop capacity and strengthen the human network of disaster management officials in their countries.
- Sharing of insights about promotion of DRR education: Many participants recognized the importance of fostering awareness among local communities for smooth implementation of administration of DRR, and many expressed their desire to promote education for DRR. On the other hand, it will take a lot of time and effort to promote DRR education in cooperation with school education, etc., and there is a high need for support from countries in Southern Africa where knowledge is limited.

6.3.4 Proposal for expansion of the Regional DRR Network in Southern Africa

The issues and needs for the establishment of a regional DRR network in Southern Africa are discussed above. However, considering that existing regional networks such as SADC are already active, it is not desirable to establish a new similar network from the viewpoint of difficulty in securing resources. In past workshops and trainings held by JICA in Mauritius, it has been pointed out that there is a lack of experts and human resources, as well as challenges in building information-sharing networks, administrative structures, development regulations, and sustainable support. Here, since it seems that there are some bottlenecks preventing the realization of the project, we propose expansion measures to complement the existing Regional DRR Network in Southern Africa.

One of the biggest challenges of the current regional DRR network is the lack of roles to provide coaching and support for technical issues faced by participating countries. The government officials of Mauritius, which has a relatively developed DRR system among the target countries of this study, also mentioned the lack of expertise of their own engineers as an issue and commented that they need technical cooperation from JICA etc. is needed. Although, SADC and other regional disaster management platforms have functioned as a forum for information sharing, the capabilities of the participating countries are close to the same, and they do not provide in-depth support such as dispatching experts to each other. Even when knowledge is shared, since it is up to the discretion of each country to decide whether or not it can be brought back to their own country and reflected in organizational structures and systems. however, it is difficult to implement due to lack of experts and budget etc.

Therefore, it is necessary to have a system that can provide technical support for the promotion of disaster reduction measures based on the knowledge gained by the participating countries through the network, as well as continuous follow-up for the realization of such measures. It is also necessary for the secretariat to be staffed by people who can take a comprehensive view of the issues and needs in the region and develop effective and meaningful content and programs for each country in terms of knowledge sharing and human resource development, which are frequently requested by participating countries. It will also be necessary to secure resources, such as human resources and funds, for this purpose. Since these efforts will be difficult to realize immediately, it is desirable to strengthen the platform's structure through continuous support from JICA and other organizations and the dispatch of experts until it gets off the ground.

In the future, a regional DRR research center could be established in cooperation with a university (e.g., the University of Mauritius) in a country such as Mauritius that can take a leading position to serve as a base for research on DRR issues in the region and for reagional cooperation. The

Regional DRR Research Center will serve as a hub for the development of human resources for DRR in Southern Africa, accepting and educating engineers from neighbouring countries, with the aim of improving the technological capabilities of the entire region. The training will not be for "disaster response personnel," but for "DRR personnel" with skills in geology, civil engineering, urban planning, disaster engineering, and evacuation action planning. It is assumed that Japanese experts and JICA experts will be dispatched as technical instructors on a year-round basis or on a short-term, continuous basis as specialists with extensive experience in natural DRR worldwide. In addition to the year-round curriculum program, seasonal programs such as summer school are also envisioned. However, training in Japan is also a very important part of the program and it is desirable to create a system in which returned trainees can take role as instructors in place of Japanese nationals for sustainable development in the future.

In the future, a pool of DRR experts may be established with the human resources trained at the Regional DRR Research Center, and it will play a think-tank role in Southern Africa, where there is a shortage of experts. It may aim to provide technical advisory services when DRR issues arise in the region, dispatch experts to government agencies in each country, and serve as a conduit for information dissemination and negotiations with donors.

According to the Interview with NDDRMC, which leads DRRMP, it was confirmed that introduction of DRR curriculum in junior high school (7th to 12th grade) , DRR training for educators, introduction of a DRR exchange program, introduces an early warning system for flood monitoring, DRR exchange program to be enhanced capacity development and inter-reagional netwark, capacity development of program for GIS software which are needed to establish NDRRMC as a central organization to share spatial data and GIS analysis, and technical recovery program. It is conceivable that such workshops and seminars will be held regularly as DRRMP, with the Regional DRR Research Center as the focal point.

Based on the above, the ideas of support could be as follows.

- In the next fiscal year and beyond, continue to support the holding of the Disaster Risk Reduction Platform (DRRMP) for the Indian Ocean and Southern Africa, in collaboration with eight other countries, as part of the third country training program. (Also consider holding this event in each country on a rotating basis.)
- In collaboration with the Government of Mauritius (and the University of Mauritius), support the establishment of base of Regional DRR such as the "regional research center for DRR" and development of their function with install the needed equipment.
- When such a place and function are established, provide support such as dispatch of Japanese engineers, regular human resource and technical capacity development, and DRR education.

- While focusing on Mauritius, support human resource and technical capacity development, DRR education, etc., as needed, in response to the requests of the eight partner countries.
- As part of the mainstreaming of DRR, implement projects while assessing the capacity and preparedness of C/Ps and other governmental organizations in each country with regard to the project of structural and non-structural measures discussed elsewhere in this report.

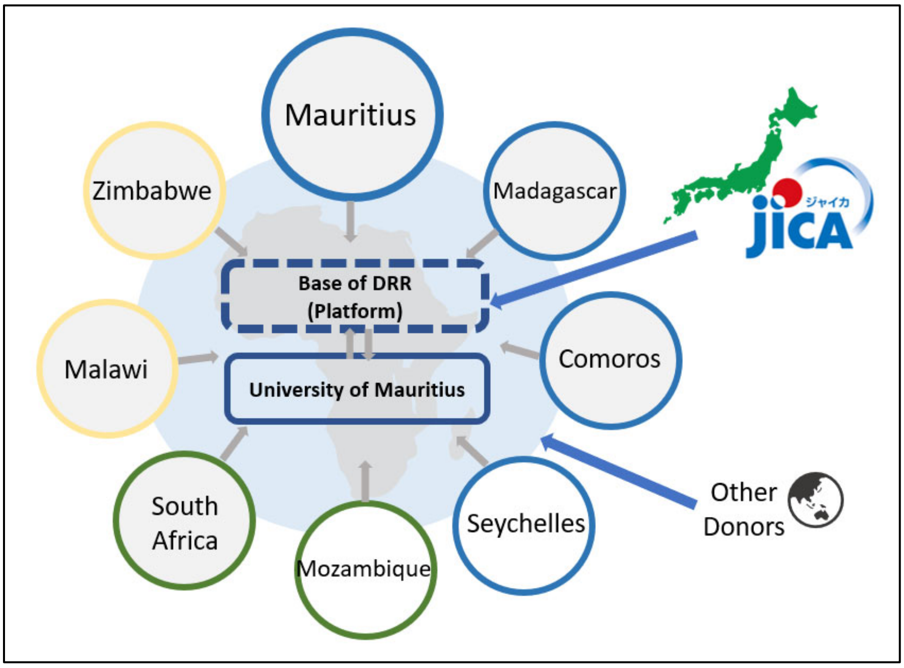


Figure 6-6 Concept of a hub for human resource development for DRR in Southern Africa

Source: JICA Study Team

* The establishment of the "Regional DRR Research Center" here does not mean that new facilities will be established, but that we will utilizes facilities, spaces, and research fields that the University of Mauritius, which is at the center of the framework, is offering to provide.

* In addition, when establishing the "Regional DRR Research Center", we will not support cooperation for the purpose of establishing this center function, but will cooperate and support human resource development as part of training in a third country and it is assumed that the implementation system and implementation framework will be in the form of a "Regional DRR Research Center".

6.3.5 Cooperation with South Africa

As mentioned in Chapter 3, South Africa has an accumulation of research in the field of DRR at higher education institutions. For this reason, it is practical to actively utilize South African university resources for the start-up of the above-mentioned university-centered human resource development system for DRR. In particular, South African universities have a large number of research and projects that cover the entire African continent, and can be expected to provide input that includes conditions unique to Africa.

In addition, South Africa does not yet have enough experience in DRR education and awareness-raising for primary and secondary school students and local residents. So, while introducing Japan's knowledge, workshops will be held in collaboration with universities in South Africa and seven other countries, as well as with participants at the practitioner level. As the outputs of the eight-country platform, it could be expected to create DRR education and awareness programs and the materials.

Furthermore, Rescue SA is an internationally active expert organization in disaster response and training for other countries is a major part of their activities. As mentioned above, the main target of this survey is to develop human resources for DRR. However, in most of the eight target countries, the major role of the organizations engaged in DRR is to respond to disasters. Therefore, the need to develop human resources for disaster response cannot be ignored.

Naturally, in order to improve the country's DRR capacity in a comprehensive manner, it is important to strengthen all capacities (DRR and mitigation, pre-disaster preparation, disaster response, and rehabilitation and recovery) in a balanced manner. Therefore, it is important that the activities of this platform incorporate a good balance of activities in the future to ensure continuity.