Ministry of Public Works and
Ministry of Agriculture and Fishery
Democratic Republic of Timor-Leste

THE POST SITUATION AND DATA COLLECTION SURVEY FOR THE FLOOD COUNTERMEASURES IN DILI

Final Report

IMPORTANT

- The grant aid projects described in this report are based on information as of February 2022. The proposed project contents will be revised according to price and exchange rate fluctuations at the time of cost estimation in a separately conducted preparatory survey.
- None of the proposed projects described in this report are promised to be implemented.

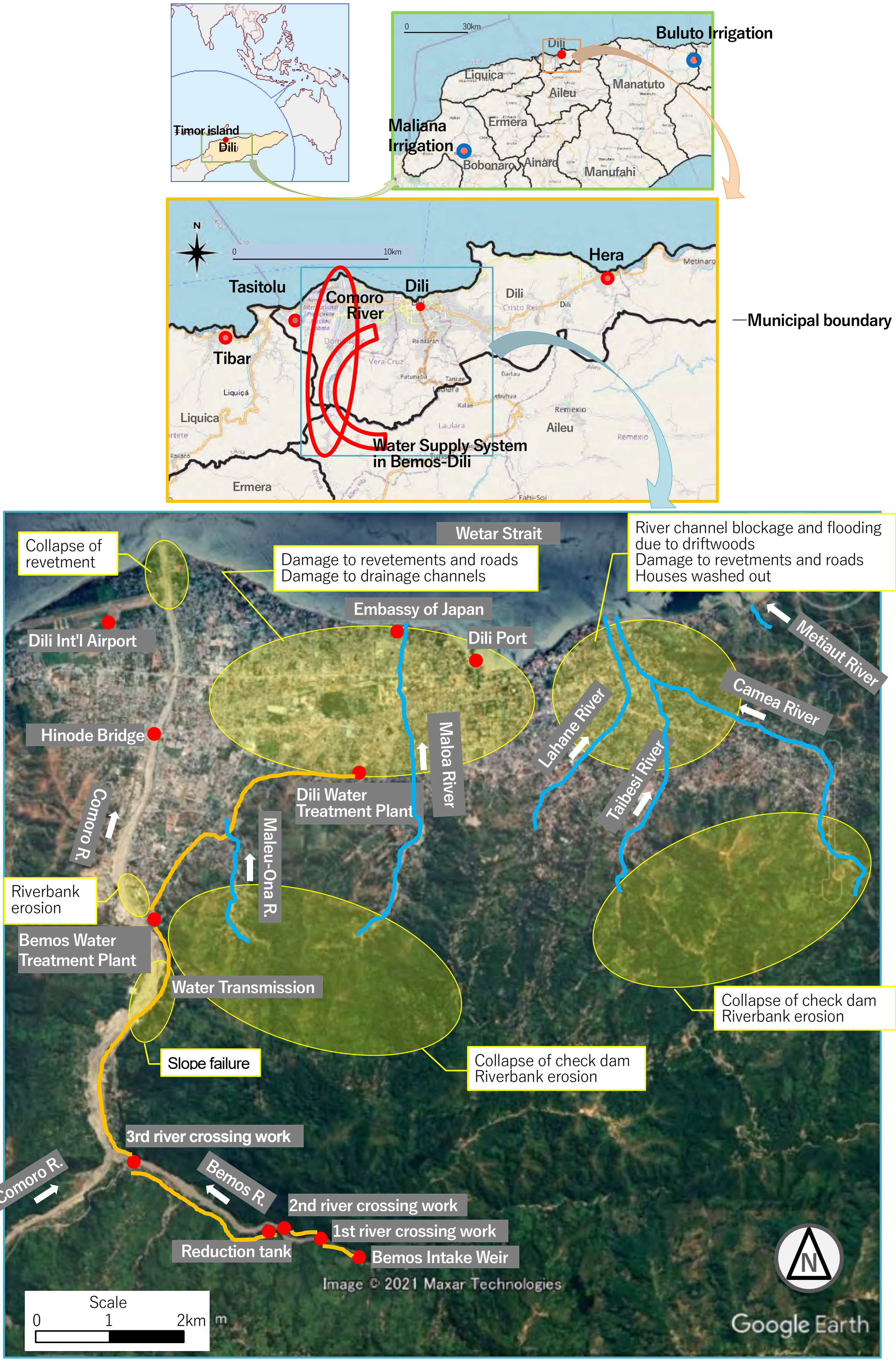
December 2022

JAPAN INTERNATIONAL COOPERTAION AGENCY (JICA)
IDEA Consultants, Inc.
Sanyu Consultants Inc.
INGEROSEC Corporation

Exchange Rate

USD 1 = JPY 115.26

(As of February 2022)



Source: (top left) Ministry of Foreign Affairs website, (top right and middle) OpenStreetMap, (bottom) Google Earth, prepared by JICA Survey Team based on the emergency briefing on flooding in Timor-Leste (May 29, 2021,Yamaguchi University)

Location Map of the Survey

Comoro River

0.9km (Left bank): A part of the damaged section is closed to a runway of the airport.

3.8km (Right bank): Gabion mattress is collapsed and traffic of a road on the bank is affected.

4.1km (R): Retaining wall is collapsed and a part of road is damaged.

5.5km (R): Retaining wall is dropped and a road on the bank is washed out.

6.1km (R): Housed on right bank side is attacked by debris flow.

Bemos Water Supply System

Intake: Falling rocks from the left slope devastated the wall, wing, etc.

River crossing No.1: Catastrophically damaged except left riverbank

River crossing No.2: Flood flow changed the route beyond the right bank and damaged it.

Buluto & Maliana Irrigation System

Buluto irrigation: Retaining wall (wet masonry) fell down and argent recovery was finished.

Maliana irrigation: Steel bars of flushing sluice are exposed by wear.

Photographs

THE POST SITUATION AND DATA COLLECTION SURVEY FOR THE FLOOD COUNTERMEASURES IN DILI, TIMOR-LESTE

Final Report

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Abbreviations

ADB	Asia Development Bank
ADN	National Development Agency
AdP	Aqua de Portuguese
BTL	Bee Timor-Leste
CBDRM	Community-based Disaster Risk Management
CPA	Civil Protection Authority, Ministry of Interior
CVTL	Timor-Leste Red Cross
DDIUP	Dili Drainage Improvement Upgrading Project
DFAT	The Department of Foreign Affairs and Trade, Australia
DGPC	Directorate General of Civil Protection
DNGRD	National Directorate of Disaster Risk Management
DNMG	National Directorate of Meteorology and Geophysics
DNSA	National Directorate of Water Supply (Predecessor of BTL)
DRBFC	Directorate of Road, Bridge and Flood Control
EDTL	National Electricity Company
EU	European Union
EWB	Engineers Without Border (Australia)
EWS	Emergency Warning Signal
FAO	The Food and Agriculture Organization of the United Nations
FB	Facebook
GMNTV	Grupo Media Nacional TV
GoTL	Government of Timor-Leste
GPDRR	Global Platform for Disaster Risk Reduction
GSMaP	Global Satellite Mapping of. Precipitation
ICHARM	International Centre for Water Hazard and Risk Management under the auspices of UNESCO
IFAS	Integrated Flood Analysis System
IPG	Institute of Petroleum and Geology
JMA	Japan Meteorological Agency
JPY	Japanese Yen
KOIKA	Korea International Cooperation Agency
MAF	Ministry of Agriculture and Fishery
MNEC	Ministry of Foreign Affairs and Cooperation (Ministro dos Negócios Estrangeiros e Cooperação)
MoF	Ministry of Finance
MPS	Secretariat for Major Project Service
MPT	Ministry of Planning and Territory
MPW	Ministry of Public Works
NGO	Non-governmental organizations
NOAA	National Oceanic and Atmospheric Administration
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
PDNA	Post Disaster Needs Assessment
SEPC	Secretary of State for Civil Protection
SMS	Short Message Service
UNDP	United Nations Development Programme
UNITAR	The United Nations Institute for Training and Research

UNRCO	The United Nations Resident Coordinator Office
UNTL/ FEST	National University of Timor Lorosae / Faculty of Engineering, Science and Technology
USAID	United States Agency for International Development
USD	United States Dollars

Chapter 1 Background and Objectives of the Survey

1.1 Background of the Survey

The Democratic Republic of Timor-Leste (hereinafter referred to as "Timor-Leste") has a mountainous terrain covering most of the country and a steep topography along the coast, resulting in landslides and flooding disasters every year. Dili Municipality, the capital, has population of about 300,000 people, but its drainage facilities have not caught up with the growing urban population. In recent years, local heavy rains and extreme weather conditions have led to repeated flooding, seriously affecting the region's economic and social activities.

In April 2021, heavy rains that had continued for several days caused small rivers and drainage channels in Dili to overflow predawn morning on April 4, and the overflowed water far exceeded the drainage in Dili. The floods in April 2021 have killed 48 people and more than 10,000 people were displaced.[1]

In addition, landslide disasters occurred in mountainous areas, damaged roads, bridges, and water supply facilities, as well as marked it difficult to travel between local cities. (Hereinafter referred to as "the floods" or "the April 2021 floods.")

The Government of Timor-Leste has sent the Government of Japan and JICA an official letter of technical cooperation to support the government's efforts for Build Back Better. In response to the official letter.

JICA and the Government of Timor-Leste held a series of discussions and exchanged views on the survey and JICA and counterpart agency (Ministry of Public Works, Ministry of Agriculture and Fisheries) signed the Minutes of Meeting on August 12, 2021.

After which, the Post Situation and Data Collection Survey for Flood Countermeasures in Dili (hereinafter referred to as the Survey Team) was dispatched to Timor-Leste.

1.2 Objective of the Survey

The objective of this survey is to collect information necessary for the formulation of future cooperative projects regarding disaster-resistant urban development in Dili. Specifically, the survey will analyze and identify the current damages of flood control, drainage and water supply facilities, the mechanism of flood damage occurrence, and the responses of disaster management organizations. Based on this, information necessary for the formulation of future cooperation projects will be collected and analyzed through the trial studies of flood countermeasures and hazard maps.

1.3 Survey Areas

・ Dili Municipality (Dili*, Hera, Tasitolu, Comoro River, Bemos Water Supply System) *"Dili" indicates the center of Dili Municipality.
・ Liquica Municipality（Tibar）
・ Aileu Municipality（Comoro River, Water Supply System in Bemos-Dili）
・ Manatuto Municipality（Buluto Irrigation Facilities）
・ Bobonaro Municipality（Maliana Irrigation Facilities）

1.4 Counterparts and Related Organizations of Timor-Leste

1.4.1 Counterparts

(1) Ministry of Public Works: MPW

1) Directorate of Road, Bridge and Flood Control: DRBFC
2) Bee Timor-Leste: BTL

[1] UNEP/GCF Proposal "Enhancing Early Warning Systems to build greater resilience to hydro-meteorological hazards in Timor-Leste" (2021/07)

(2) Ministry of Agriculture and Fishery: MAF

1) Department of Irrigation and Water Management: DIWM

1.4.2 Partner Organization

National University of Timor Leste: UNTL, Faculty of Engineering, Science and Technology: FEST

1.4.3 Related Organizations

(1) Ministry of Finance: MoF
(2) Ministry of Foreign Affairs and Cooperation: MNEC
(3) Secretariat for Major Project Service: MPS
(4) Civil Protection Authority: CPA (successor of Directorate General of Civil Protection (DGPC))
(5) National Authority for Water and Sanitation: ANAS
(6) National Directorate of Meteorology and Geophysics: DNMG
(7) Institute of Petroleum and Geology: IPG
(8) National Electricity Company: EDTL
(9) Municipality of Dili

1.4.4 International Organizations

(1) UN Resident Coordinator Office: UNRCO
(2) Asia Development Bank: ADB
(3) World Bank: WB
(4) United Nations Development Programme: UNDP

1.4.5 Other Doners

(1) Aqua de Portuguese: AdP
(2) Engineers Without Border (Austraria): EWB
(3) United States Agency for International Development: USAID

1.4.6 NGO/NPO

Mercy Corps

1.5 Members of the Survey Team

Table 1.5-1 Members of the Survey Team

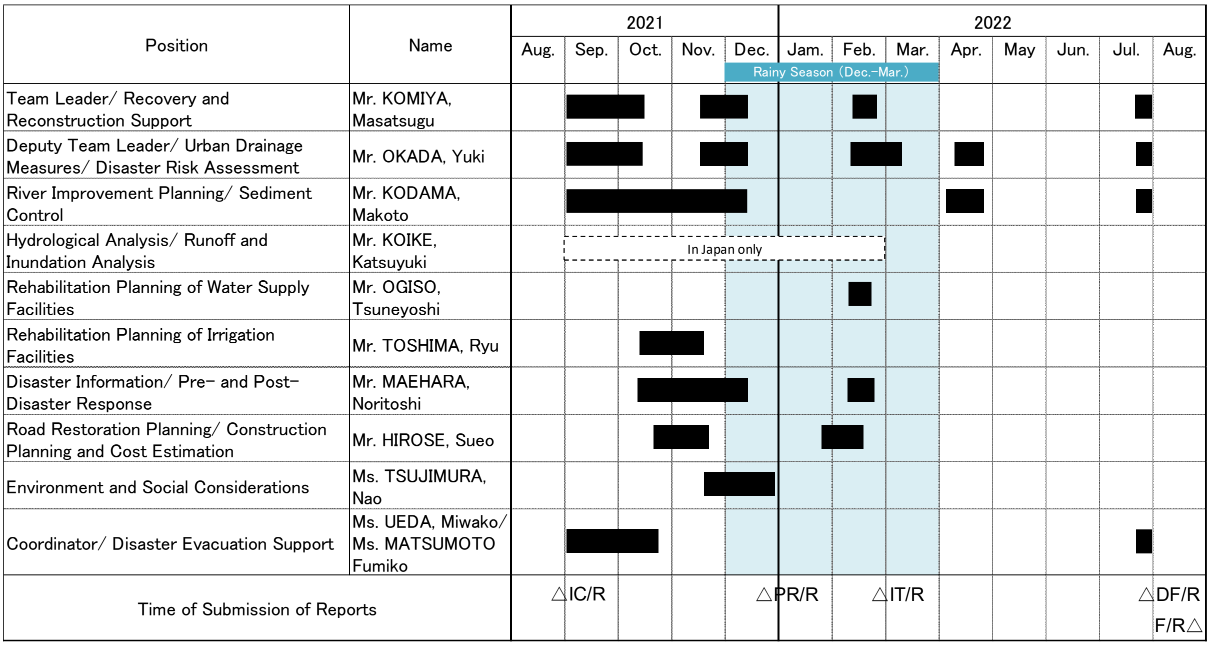
Job Role	Name	Company*
1. Team Leader/ Recovery and Reconstruction Support	Mr. KOMIYA Masatsugu	IDEA
2. Deputy Team Leader/ Urban Drainage Measures/ Disaster Risk Assessment	Mr. OKADA Yuki	IDEA
3. River Improvement Planning/ Sediment Control	Mr. KODAMA Makoto	IDEA
4. Hydrological Analysis/ Runoff and Inundation Analysis	Mr. KOIKE Katsuyuki **	IDEA
5. Rehabilitation Planning of Water Supply Facilities	Mr. OGISO Tsuneyoshi	SCI
6. Rehabilitation Planning of Irrigation Facilities	Mr. TOSHIMA Ryu	SCI
7. Disaster Information/ Pre- and Post-Disaster Response	Mr. MAEHARA Noritoshi	IDEA
8. Road Restoration Planning/ Construction Planning and Cost Estimation	Mr. HIROSE Sueo	ISEC
9. Environment and Social Considerations	Ms. TSUJIMURA Nao	IDEA (KEI)
10. Coordinator/ Disaster Evacuation Support	Ms. UEDA Miwako/ Ms. MATSUMOTO Fumiko	IDEA

(*) IDEA：IDEA Consultants, Inc., SCI：Sanyu Consultants Inc., ISEC：INGEROSEC Corporation , KEI：Katahira & Engineers International

(**) Mr. Koike (Hydrological Analysis/ Runoff and Inundation Analysis) is only assigned the works in Japan, will not be scheduled to travel.

1.6 Travel and Onsite Work Schedule

Below figure shows travel and onsite works schedule of each team member. The survey team will change travel date/periods and/or limit a number of travel members to work flexibly on flight schedule change and entrance limitation due to Covid-19 pandemic.



Note: IC/R: Inception Report, PR/R: Progress Report, IT/R: Interim Report, DF/R: Draft Final Report, F/R: Final Report
Source: JICA Survey Team

Figure 1.6-1 Tentative Travel and Onsite Work Schedule

Chapter 2. Overview of Target Country

2.1 Key socioeconomic conditions

2.1.1 Overview

Timor-Leste is located on Timor Island in the Lesser Sunda Islands in eastern Indonesia, about 300 km north of Darwin, Australia. Timor-Leste consists of the eastern half of Timor Island, where the capital Dili is located, the islands of Atauro and Jaco, and the enclave of Oecussi, located on the west side of Timor Island. The country has a land area of about 14,900 km2 (almost the same as the total area of Tokyo, Chiba, Saitama, and Kanagawa), but is surrounded by oceans rich in biodiversity, including coral reefs.

The population of Timor-Leste is about 1.27 million, and the population density is about 89 / km2 (Japan: 345 / km2). Most of the ethnic composition is of Melanesian and Polynesian descent, and of others, Malay descent, Chinese descent, European descent mainly of Portuguese descent and their mixed races. 99.1% of the people are Christian (mostly Catholic) and 0.79% are Muslim.

GNI per capita is a low middle-income country of USD 1,800 (World Bank, 2020). The main industry is oil and natural gas income, and 80% to 90% of the national budget comes from resource income. Oil and gas revenues are managed and operated by the Oil Fund, and although the short-term impact is small, the decline in natural gas and crude oil prices may affect national finances in the medium to long term. Other major industries are agriculture (coffee, rice, potatoes, etc.), and 90% of export items account for coffee exports. The economic growth rate has fallen to -10.5% (World Bank, 2020) due to the impact of the spread of Covid-19 infection, and the inflation rate is 1% (World Bank, 2019).

The political system is a republic, with a unicameral system (term of office: 5 years) and a national parliament with 65 seats (June 2020). The head of state is President Jose Ramos-Horta (term of office: 5 years from May 20, 2022).

After the colonial rule by Portugal, the occupation by Japan, and the military invasion and annexation by Indonesia from the first half of the 16th century, Timor-Leste tried to restore security through the intervention of the international community and the United Nations against the deterioration of domestic security, and recovered independent in 2002. Played. Even after independence recovery, security deteriorated sharply and 150,000 residents were evacuated domestically, triggered by demonstrations by military soldiers from the west requesting improvement in discrimination treatment. In response to this situation, at the request of Timor-Leste, an international security force from Australia, Portugal, etc., and an OKA (UNMIT) were established by the UN Security Council. In February 2008, the president and the prime minister were attacked by armed groups, causing serious injuries to the president. There was concern that security would deteriorate again, and a state of emergency was declared, but security was maintained and peace is still maintained.

As mentioned in the historical background above, domestic government facilities and infrastructure have been attacked and destroyed for a long time until the restoration of public security in 2008, and the current infrastructure development is inadequate, and accumulated experience in management and operation. There is no one with. The Timor-Leste government has set up an "infrastructure fund" as infrastructure development is indispensable for economic development, and allocates about USD 300 to 400 million annually, accounting for about 25% of the total national budget every year.

2.1.2 Social conditions and major economic indicators

Table 2.1-1 shows the general situation and the political system / domestic affairs, and Table 2.1-2 shows the economic situation and the trade situation with Japan.

Table 2.1-1 General circumstances and political system / domestic affairs in Timor-Leste

General affairs		Political system / internal affairs	
Area	14,900 square kilometers (almost the same as the total area of Tokyo, Chiba, Saitama, and Kanagawa)	Political System	Republic
Population	1.27 million (World Bank, 2020)	President	Jose Ramos-Horta (term of office: 5 years from May 20, 2022)
Capital	Dili	Parliament	Unicameral (term of office 5 years) (65 seats)
Ethnic groups	Most of the ethnic groups, such as the Tetum, are of Melanesian descent. Others Malays, Chinese, etc., Europeans, mainly Portuguese, and their mixed races.	Government	・ Prime Minister Taur Matan Ruak (June 2018-) ・ Minister of Foreign Affairs Adalziza Albertina Xavier Wraith Magno (June 2020-)
Languages	Official languages are Tetum and Portuguese. Actual languages are Indonesian and English. Many other local languages are used.	Military power	(1) Budget: Approximately USD 20.61 million (Source: Budget amount to the Ministry of Defense in the 2018 budget document published by the Ministry of Finance of Timor-Leste) (2) Military service: Volunteer system (3) Force: In September 2000, the Timor-Leste Interim Cabinet decided to establish the Timor-Leste Army, consisting of 1500 regular soldiers and 1500 reserves, within five years. Established the 1st Battalion in October 2001. (4) Major General: Domingos Raul (from January 28, 2022)
Religion	Christianity 99.1% (mostly Catholic), Islam 0.79%		

Source: Created by JICA Survey team based on the Ministry of Foreign Affairs Japan website

Table 2.1-2 Economic situation and trade situation with Japan in Timor-Leste

Economic indicators		Trade with Japan	
Main industry	Agriculture is the main industry (mostly micro-agriculture. Rice, corn, potatoes, coconuts, etc. are cultivated). As an export crop, they are particularly focusing on coffee cultivation. The development of oil and natural gas is being promoted as a valuable national financial resource.	Trade amount (2020, Ministry of Finance)	
		Export	JPY 1.91 billion
		Import	JPY 700 million
		Major items (2020, Ministry of Finance)	
GDP (Including natural resource income)	USD 2.59 billion (2019, World Bank)	Export	coffee
GNI per capita	USD 1,800 (2020, World Bank)	Import	automobiles and machinery
Economic growth rate	-10.5%(2020, World Bank)		
Price increase rate	1%(2019, World Bank)		
Unemployment rate	10.4%(2016, ILO)		
Export	USD 110 million		
Import	USD 540 million		
Major trade items (2018, Ministry of Finance, Timor-Leste)			
Export	coffee		
Import	Imported mineral fuels, automobiles and parts, electrical equipment, grains, machinery		
Major trading partners (2019, OEC)			
Export	Singapore, China, Japan, Indonesia, USA		
Import	Indonesia, China, Singapore, Malaysia, Australia		
currency	USD, but for less than USD1, use own “centavo” currency.		

Source: Created by JICA Survey team based on the Ministry of Foreign Affairs Japan website

2.1.3 Natural conditions (climate, terrain, biodiversity, protected areas)

(1) Climate

Detailed meteorological data and precipitation for the climate of Timor-Leste will be described in the following chapters. The general climate of Timor-Leste belongs to the tropical savanna climate, and there is a distinction between the rainy season and the dry season. The maximum daytime temperature is in the 30°C range throughout the year, except in mountainous areas. The rainy season is from December to April, the dry season is from June to October, and May and November are transitional periods. Most rivers have no water flow in the dry season, but flood damage occurs in various parts of the country in the rainy season. Due to insufficient installation and management of drainage channels in Dili, the roads are likely to be flooded during precipitation.

(2) Topography / Geographical Features

Timor-Leste is located at 123-127 degrees east longitude and 8-10 degrees south latitude, with a length of 265 km and a width of 92 km. The Lamerau Mountains line up in the center of the island, and the highest peak is Tatamailau (elevation 2,963m). The slopes of this mountain range are often approaching to the north-south coastline. In the northern part of the island, there are many terrains where the steep slopes of the mountainous areas are the coastline of the cliffs that are in contact with the sea. There are also lowlands.

(3) Biodiversity

Timor-Leste is located within a biogeographical division called Warresia, which has never been connected to the continent in its long history, and is home to many endemic species that contribute to biodiversity. On the other hand, in Timor Island and Timor-Leste, the implementation of census and checklists by modern flora methods have not been reported, and the loss of ecosystems due to deforestation, hunting and development is accelerating.

According to the Convention on Biological Diversity, there are 983 species on Timor Island, with 15 to 20 amphibian species and more than 40 insect species. In particular, 50% of frogs, 25% of lizards, and 25% of geckos are endemic to Timor Island. 34 species of bats have been identified, including 12 fruit bats. In addition, there are at least 7 species of Muridae and 5 species of Shrews.

In addition, Timor-Leste is located in an area called the Coral Triangle, which is important for ecosystem conservation and biodiversity, where about 76% of the world's coral reef species gather, and there is also abundant biodiversity in the sea area. The coastline of Timor-Leste consists of more than 700 km and has a potential exclusive economic zone of 75,000 km2. According to a joint study of giant marine animals by the Ministry of Agriculture and Fisheries of Timor-Leste and the Australian Institute of Marine Science (2012), more than 1000 species of giant marine animals exist in the waters around Timor-Leste.

The Constitutional Government of Timor-Leste established Decree No. 6/2020 in February 2020 for the purpose of biodiversity and ecosystem conservation, under the jurisdiction of relevant ministries and agencies regarding ecosystem conservation, establishment of Biodiversity Advisory Committee, establishment of protected species, and protection. It stipulates management and monitoring of the ward.

(4) Protected area

A list of nature reserves in Timor-Leste is shown in Table 2.1-3. Decree No. 5/2016 defines two ocean protected areas and 44 land protected areas. Among the protected areas, Nino Konis Santana and Kay Rala Xanana Gusmao Two places (Kai Lara Shanana Gusman) are designated as national parks.

Table 2.1-3 List of Protected Area in Timor-Leste

	Name	Area (ha)
Territorial Protected Area		
1	Parque Nacional Nino Konis Santana	123,600
2	Monte Legumau	35,967
3	Lagao Maurei	500
4	Be Matan Irabere	No description
5	Monte Matebian	24,000
6	Monte Mundo Perdido	25,000
7	Monte Laretame	16,429
8	Monte Builo	8,000
9	Monte Burabo’o	18,500
10	Monte Aitana	17,000
11	Monte Bibileo	19,000
12	Monte Diatuto	15,000
13	Monte Kuri	No description
14	Parque Nacional Kay Rala Xanana Gusmao	18,000
15	Ribeira de Clere	30,000
16	Lagoa Modomahut	22
17	Lagoa Welenas	20
18	Monte Manucoco	4,000
19	Cristo Rei	1,558
20	Lagoa Tasitolu	No description
21	Monte Fatumasin	4,000
22	Monte Guguleur	13,159
23	Lagoa Maubara	No description
24	Monte Tatamailau	20,000

25	Monte Talobu/Laumeta	15,000
26	Monte Loelako	4,700
27	Monte Tapo/Saburai	5,000
28	Lagoa BeMalae	No description
29	Korluli	No description
30	Monte Lakus/Sabi	No description
31	Monte Taroman	19,155
32	Reserva Tilomar	7,000
33	Cutete	13,300
34	Monte Manoleu	20,000
35	Area Mangal Citrana	1,000
36	Oebatan	400
37	Ek Oni	700
38	Us Metan	200
39	Makfahik	No description
40	Area Mangal Metinaro	No description
41	Area Mangal Hera	No description
42	Lagoa Hasan Foun & Onu Bot	12
43	Lagoa Bikan Tidi	110
44	Samik Saron	No description
Marine Protected Area		
1	Reserva Natural Aquatica (Balibo, Bobonaro)	112,59
2	Reserva Natural Aquatica (Atauro, Dili)	50,85

Source: Decree No. 5/2016

2.2 Overview of related organizations

2.2.1 Current Disaster Management System

(1) Laws and Policies Related to Disaster Risk Management

Currently, Timor-Leste has a National Disaster Risk Management Policy 2008-2012 and the newly approved Civil Protection Law No. 12/2020. An overview of these policies and laws and the major issues are described below.

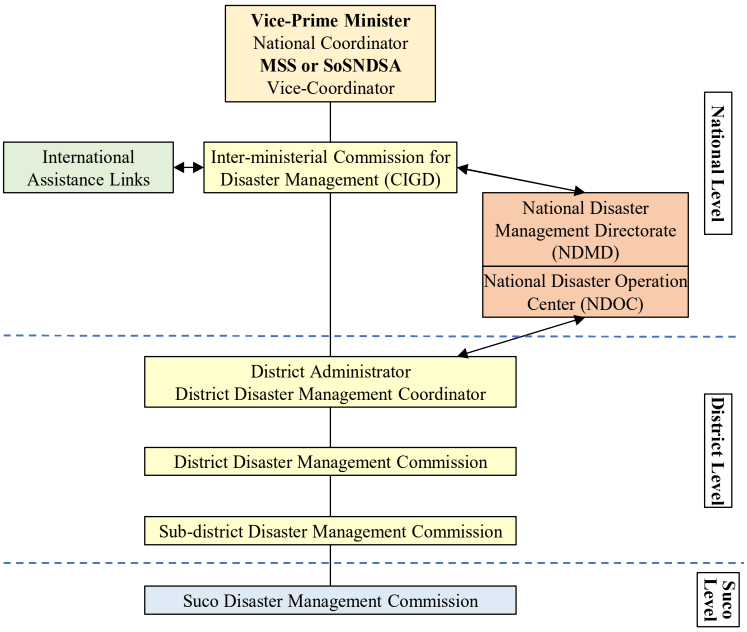
1) National Disaster Risk Management Policy (NDRMP)

The National Disaster Risk Management Policy (NDRMP) 2008-2012 was formulated in 2008 based on the Hyogo Framework for Action (2005-2015). This Policy aims to respond to the constitutional mandate to identify priorities to guide Government objectives and strategies in order to guarantee the security and safety of citizens and their property and to safeguard natural resources against natural or human-induced disasters. The policy lays out the government's vision for disaster management from the national level to the village (suco) level. It outlines a series of activities for disaster risk management, including vulnerability assessment, risk analysis, early warning system, crisis management, post-disaster survey and review, recovery and reconstruction, and disaster risk awareness.

The policy states that evacuation planning should be based on the following principles. "Suco committees, as part of their preparedness for disasters and major emergencies, should identify safe emergency shelters from floods and other hazards and safe routes to these shelters". The interviews with residents on flood disasters in this study revealed that the emergency shelters and routes to them have not been identified in Dili Municipality. Also, no one was aware that this was the role of Suco. This is an issue that needs to be addressed as soon as possible to prepare for the next flood season.

The National Disaster Management System in the Policy is shown in Figure 2.1-1. Under the policy, the National Disaster Management Directorate (NDMD, current National Directorate of Disaster Risk Management: DNGRD) was organized under the Ministry of Social Solidarity (MSS) and was responsible for coordinating and providing technical assistance for disaster risk management in Timor-Leste.

In March 2019, the government reorganized the NDMD into the National Directorate of Disaster Risk Management (DNGRD), which is under the Directorate General of Civil Protection (DGPC), Ministry of Interior (MOI) .



Source: National Disaster Risk Management Policy 2008-2012

Figure 2.2-1 National Disaster Management Structure

An Inter-Ministerial Commission for Prevention of Natural Disasters was established by Prime Minister's Office as a government response to the public fear of earthquakes/ tsunamis after the Asian tsunamis of 26 December 2004. As this policy uses the all-hazards approach, it is necessary to expand the Commission and elevate into an Inter-Ministerial Commission for Disaster Risk Management (CIGD). The role of the CIGD includes annual review of national disaster risk reduction policies and strategic developments, recommendations to the Prime Minister on priorities for the coming year, and providing technical and policy advice and resource support to the National Disaster Coordinator (NDC) and the National Disaster Operation Center (DOC).

Under the policy, the heads of District (now Municipality), Sub-District (now Administrative Post) and Suco levels form the Disaster Management Committee, which is responsible for emergency and disaster risk reduction activities within its area of responsibility.

4.3 "Responsibilities of Departments and Agencies" describes the responsibilities of all ministries, agencies and institutions involved in disaster risk management. It also requires the concerned ministries and agencies to prepare their own sub-plans.

As mentioned above, the policy is based on the Hyogo Framework for Action (2005), which makes it a comprehensive disaster risk management policy. However, it is a bottom-up policy, with emphasis on community-based disaster risk management and expansion of early warning, viewing disaster risk reduction as a humanitarian issue. This is different from the current perspectives of disaster risk reduction (the direction of the Sendai Framework for Disaster Risk Reduction), which sees disaster risk reduction as a development issue and emphasizes prevention of economic loss and the importance of prior investment in disaster risk reduction. In addition, although the roles of relevant ministries and agencies are described, they do not match the current governmental and local organizations due to reorganization, and their roles and responsibilities are unclear. In order to implement efforts in line with the Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR), there is an urgent need to update the National Disaster Risk Management Policy.

2) Civil Protection Law No. 12/2020

The Civil Protection Law No. 12/2020, enacted on December 2, 2020, is the current basic law on civil protection in Timor-Leste. The objectives of the Civil Protection Law are stated as follows:

a) To prevent collective risks and the occurrence of serious accidents or disasters;
b) To diminish collective risks and limit potential effects in the event of a major accident or catastrophe
c) To rescue and assist people and animals in danger and to protect property and cultural, environmental, and high public interest values

d) To support the restoration of normal life for people in areas affected by a serious accident or catastrophe.

Articles 8 and 9 provide for three levels of declarations depending on the disaster event: Alert declarations, Contingency declarations, and Calamity declarations. Alert declarations stipulate the obligation of the media and telecommunications providers to cooperate.

Article 5, Principal b) the principle of prevention, states that "according to which the risks of major accidents or disasters must be considered in advance so as to eliminate their probable causes or, when this is not possible, to diminish their effects". It stipulates disaster risk reduction. Furthermore, emergency declarations provide for access to private property, temporary demands for goods and services, and mobilization of public officials.

Chapter 3, Articles 25 to 28 provide for the organization of the management of the civil protection policy, with the Prime Minister as the primary person responsible for directing the civil protection policy.

Article 28 stipulates that the head of the municipality is responsible for the civil protection policy of the municipality and is obliged to take preventive, rescue, supportive and restorative actions according to the situation when a major disaster is imminent or occurs. The municipality head is also supposed to be supported by the municipal civil protection services and agencies.

The National Civil Protection Council is to be represented by ranks of heads nominated by government members from the fields of defense, internal affairs, justice, finance, trade and industry, environment, public works, transportation and communication, agriculture, forest and fishery, social solidarity, health, education, and national administration. The fire service, the national defense forces, the national police, and the immigration service are also members. The Council of State may convene municipal administrators and experts in technical and scientific fields as needed. One of the duties of the Council of State is to propose standards and technical norms for the formulation and operation of the Civil Protection Emergency Plan, but it is limited to the formulation of the emergency plan. The formulation of the disaster risk reduction investment plan is not included in the mandate.

Article 36 states that the Municipal Civil Protection Council is the coordinating body for civil protection in the municipality. The Municipal Civil Protection Council has as its members the Governor of the municipality, the Commander of the Municipal Civil Protection Command, the relevant ministries of the State at the level of decentralized services in the municipality, and representatives of the defense, security, medical emergency services, and fire departments. Among the duties of the municipal council are to give opinions on the municipal civil protection plan and to monitor the implementation of the civil protection emergency plan, but it does not play a role in formulating disaster risk reduction investment plans.

As seen above, one of the objectives of the Law on Civil Protection is to "prevent the occurrence of serious accidents and disasters," but the content of the Law is mainly focused on post-disaster emergency response, with little reference to disaster risk reduction. In addition, the National Civil Protection Council is supposed to have chief ranks from the ministries of defense, interior, justice, finance, trade and industry, environment, public works, transportation and communications, agriculture, forestry and fisheries, social solidarity, health, education, and national administration as members, but there is no mention of the role of each ministry in implementing disaster risk reduction policies or coordinated efforts.

In order to implement efforts in line with the Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR), there is an urgent need to update the National Disaster Risk Management Policy and to formulate a more specific National Disaster Risk Reduction Investment Plan that meets the global target (e) of the SFDRR.

3) Current Status of Investment in Disaster Risk Reduction

In Timor-Leste, the Infrastructure Fund (IF) was established by the government in 2011 (Law No. 1/2011, February 14, 2011) to finance core infrastructure and important capital development projects to support the implementation of the Strategic Development Plan of Timor-Leste (SDP). The SDP sets out the priorities for the infrastructure sector as a central pillar of the social and economic development of the country. The main target of the IF is to build and maintain essential infrastructure, including roads and bridges, ports and airports, provide reliable electricity across the country, improve water and sanitation, public facilities, and other strategic sectors. Following the Law № 1/2016 of 14 January on the State Budget 2016 the IF was transformed into the autonomous fund and the scope of IF investments is to provide the financial support for the capital development in the following sectors:

1) Transport infrastructure including roads, bridges, ports, and airports;
2) Social infrastructure, including hospitals, schools, and universities;
3) **Flood control and landslide protection infrastructure**;
4) Water treatment and sanitation facilities;
5) Power generators and distribution lines;
6) Telecommunications;
7) Logistic facilities, including storage infrastructure;
8) Public buildings and public facilities;
9) Other infrastructure that promotes strategic development.

One of the nine sectors includes investments in "flood control and landslide prevention infrastructure," but the above sectoral disaggregation is not made on the budget document.

Table 2.2-1 shows budget and execution of the IF for the past six years and of which for the maintenance and rehabilitation of the disaster-affected infrastructure. It can be seen that the budget for maintenance and rehabilitation of the affected infrastructure in 2021 has been significantly increased due to the impact of the 2021 flood damage. It is important to systematically promote "disaster risk reduction investments".

Table 2.2-1 Infrastructure Fund Budget and Maintenance and Rehabilitation Budget for Disaster Affected Infrastructure (USD million)

Year	Infrastructure Fund (IF) Total			Maintenance and rehabilitation of disaster-affected infrastructure within IF		
	Budget	Execution	Execution rate	Budget	Execution	Execution rate
2016	784.47	549.64	70%	4.67	0.63	14%
2017	325.62	231.95	71%	7.06	4.57	65%
2018	386.01	331.23	86%	10.62	9.47	89%
2019	367.54	276.90	75%	6.15	4.39	71%
2020	184.93	138.74	75%	2.91	1.97	68%
2021	280.89	32.49	12%	63.21	0.87	1%
Total	2,329.46	1,560.95	67%	94.62	21.89	23%

Note: The execution and execution rate of the IF for 2021 is the figure at the end of the second quarter (2Q).
The execution rate of the budget for the maintenance and rehabilitation of damaged infrastructure in 2021 is the figure at the end of the third quarter (3Q).
Source: State Budget 2022, Book 3A Infrastructure Fund, Ministry of Finance

(2) Status of Existing Disaster Management System in Dili Municipality

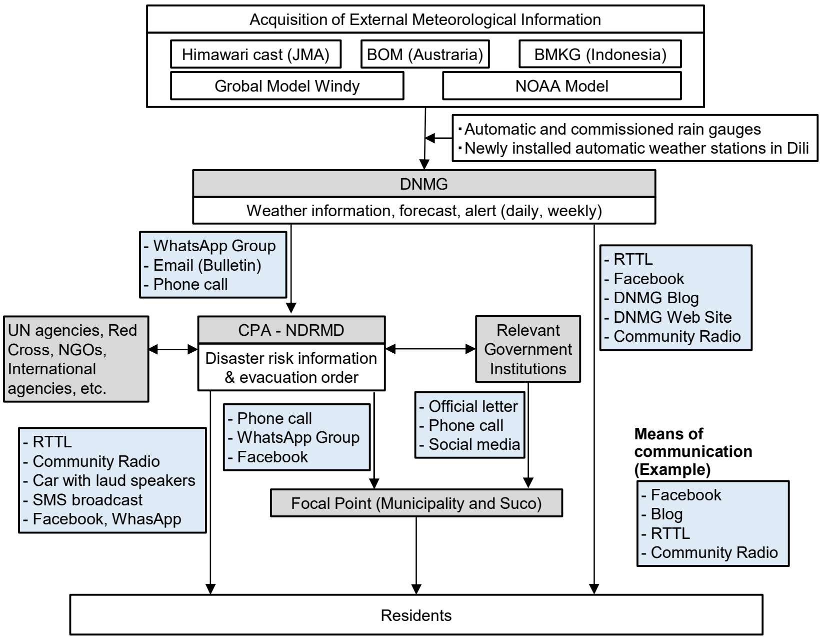
1) Disaster Response

a) Disaster Information Communication

At present, Dili's disaster management efforts are limited. There is no department in charge of disaster management in Dili, but there is a Focal Point for the Civil Protection Service in the municipal government building, where a total of five staff members are working. The staff dispatched from the Civil Protection Authority (CPA) play a coordinating role between the municipality and CPA, and are paid by CPA.

Meteorological information from the Department of Meteorology and Geophysics (DNMG) is sent to CPA, which analyzes the need for emergency evacuation and transmits the information to relevant ministries and agencies. DNMG's weather information is also directly disseminated to the public through TV, radio, and social media. In addition, disaster risk information such as evacuation orders is issued by CPA based on the Article 4 of the Civil Protection Law No. 12/2020 directly to the contact points (Focal Points: in the case of municipality, the staff dispatched by CPA; in the case of villages, the head of the Suco) in the municipalities and villages.

The municipal government communicates disaster risk information to the sub-district head (head of the Administrative Post), village head (head of Suco), and sub-village head (head of Aldeia) via telephone and social media. Figure 2.2-2 shows the current flow of disaster risk information and means of communication.



Source: Prepared by JICA Survey Team based on interview survey.

Figure 2.2-2 Flow of disaster risk information and means of communication

It is desirable that multiple means of communication are available for dissemination of disaster risk information and that redundancy is ensured. In addition, a major step forward since the April 2021 flood disaster is the agreement with three mobile carriers in Timor-Leste to distribute disaster risk information via SMS broadcast. SMS broadcasts are ideal for issuing warnings because they do not require an internet connection like social media, and even older cell phones can be used to receive push-type information.

In interviews with residents, they commented that they had heard weather information about the cyclones via television, but thought it was the same as usual. Depending on the scale of the approaching hazard, messages that convey the potential for impact may be necessary. In Japan, expressions such as "never experienced before" or "comparable to torrential rains in 20xx" are sometimes used, but expressions that match Timor-Leste are needed to convey a sense of urgency.

b) Emergency response to disasters

According to the Dili Municipality, the role of disaster risk management has not yet been transferred from CPA, and the municipality will assume the role of disaster risk management from 2022, but at present no organization or team has been formed, and there is no clarity on the plan or role. Some staff have been trained as facilitators of community-based disaster risk management (CBDRM), but no activities have been launched yet. Emergency evacuation shelters have not been designated in the municipality and there have been delays in response.

In the aftermath of the April 2021 floods, due to budgetary constraints, the municipality was only able to provide food, water, and blankets to the victims. Based on this experience, for the next fiscal year of 2022, a budget of USD 1 million was proposed by the assembly for disaster response, but it was not approved.

Currently, the role of all municipalities, including Dili, in disaster management is limited and dependent on CPA. This is due to the delay in the implementation of the Civil Protection Law No. 12/2020. It is hoped that a disaster management system in line with the Civil Protection Law will be established soon.

2) Investment in disaster risk reduction

The municipalities are not in charge of infrastructure development, such as river rehabilitation, to reduce disaster risks, which is the task of the Ministry of Public Works (MPW). Infrastructure projects that can be handled by the municipality are those with a value of less than USD 500,000 (Decree Law N.º 54 /2020). The budget for Suco and Aldeia will also be evaluated and implemented based on the proposals from the heads of Suco and Aldeia, and cannot be implemented by the municipality itself. Therefore, after the April 2021 flood disaster, the removal of sediment deposited in rivers and roads was carried out with the cooperation of the Institute of Equipment Management (IGE).

Under the current law, due to this division of roles between the national government and the municipal government, it is not possible to implement large-scale river improvement projects, but cleaning of drainage ditches and excavation of small-scale deposited sediment with the participation of local residents may be possible with the city's budget. In addition, river channel monitoring and channel management in cooperation with IGE will be essential to reduce flood risks in the capital city.

2.2.2 Main Counterpart Organizations

(1) Ministry of Public Works (MPW)

The Ministry of Public Works (hereinafter referred to as "MPW") is a government agency involved in business planning, policy formulation, implementation, and management of public services such as water supply and drainage services, power supply, and transportation. The organization chart of MPW is shown in Figure 2.2-3. MPW's overall budget for 2021 is USD 23.45 million, but in addition to this, there is a budget allocation for each project from the infrastructure fund of the Major Project Secretariat, which will be described later.

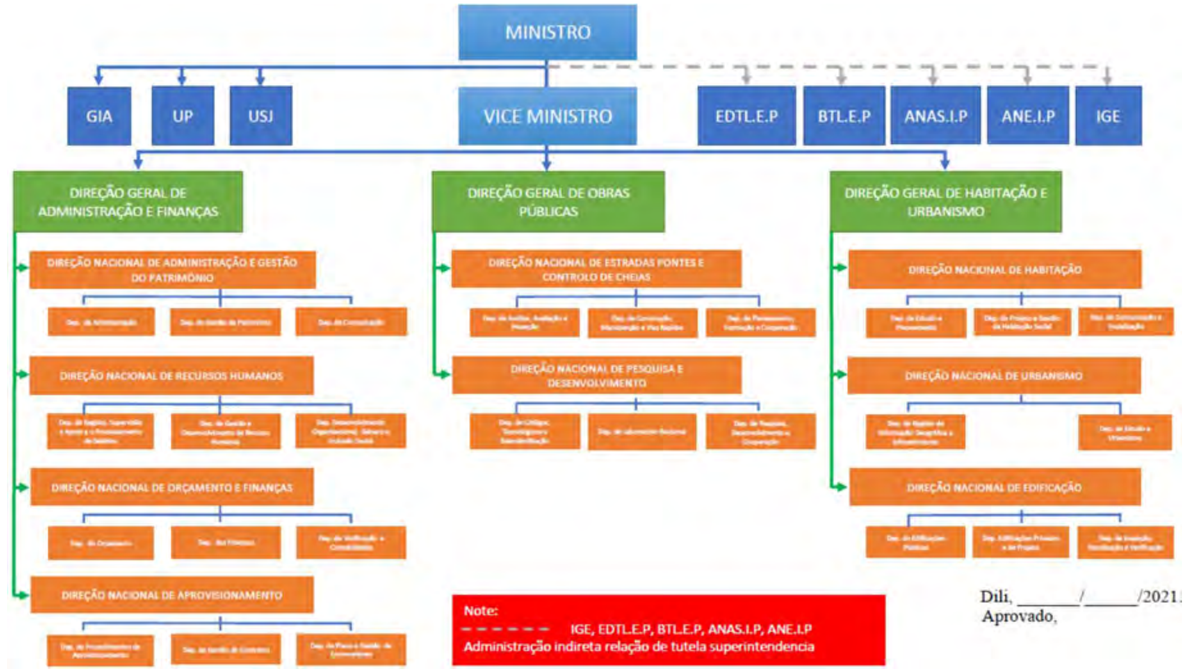


Figure 2.2-3 MPW Organization Chart

1) Directorate of Road, Bridge and Flood Control (DRBFC)

The responsibility of the Directorate of Roads, Bridges and Flood Control (DRBFC) is presented in Table 2.2-2 based on Article 5 of the 2013 MPW No. 25 (Ministerial Diploma 25 / MOP / 2013). DRBFC is the main department in charge of practical flood control measures mainly by infrastructure (structural measures). DRBFC is the main counterpart of the Project for the Capacity Development of Road Services in Timor-Leste (CDRS) and the Project for Construction of Upriver Comoro Bridge, etc., and many staff members have received training through the JICA support projects. The organization chart of DRBFC is shown in Figure 2.2-4.

Table 2.2-2 DRBFC Responsibility

No.	Responsibility
1	a) Elaborate, or to promote the elaboration of construction works projects, expansion and remodeling of roads, bridges and other infrastructures;
2	b) Ensure the construction, conservation and maintenance of the roads and bridges of the national network, including other works for the protection and control of floods and water of any other nature;

3	c) To prepare, in collaboration with other services and competent public entities, legislative and regulatory projects for the public works sector, including for the improvement of the safety conditions of roads and other means of communication;
4	d) Keep the record up-to-date on the state of conservation of roads, bridges and other means of communication;
5	e) To promote, with other services and competent public entities, the articulation between the national plan of the national road network and the road transport networks;
6	f) Any others assigned to it by law.

Source: Ministerial Diploma 25 / MOP / 2013

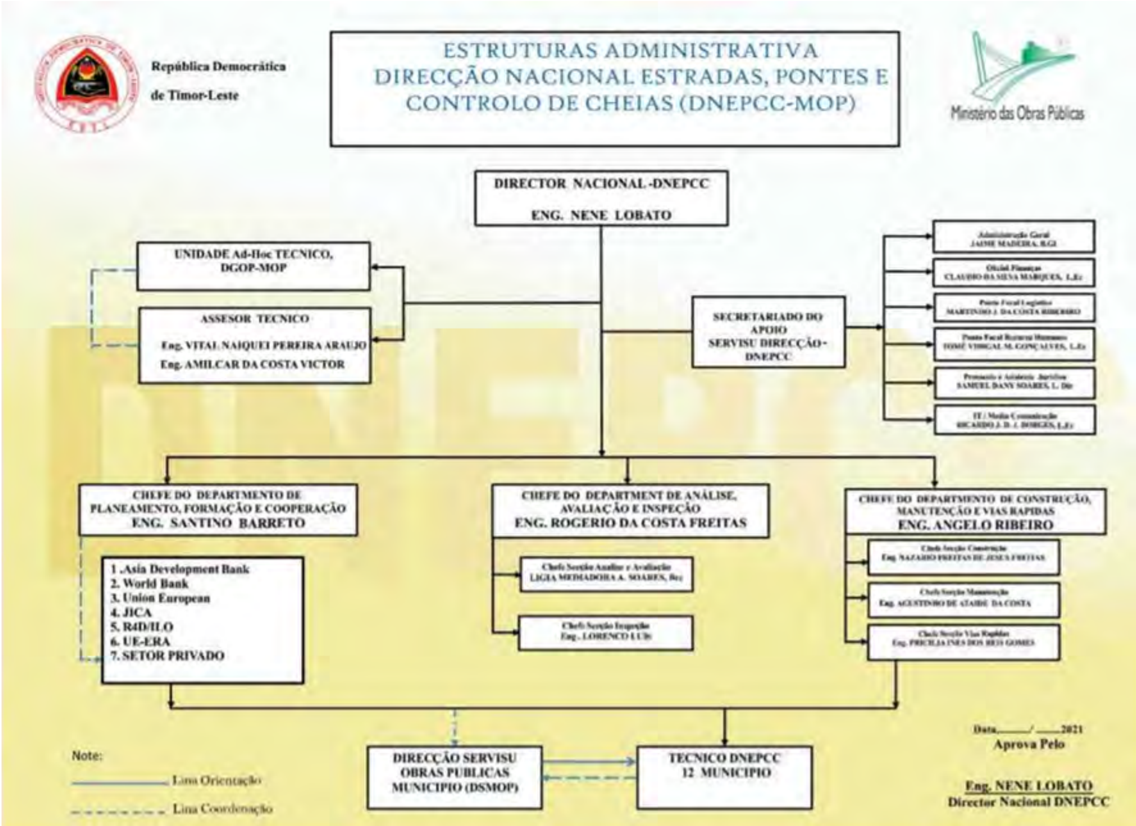


Figure 2.2-4 DRBFC Organization Chart

2) Bee Timor-Leste (BTL)

Bee Timor-Leste ("BTL") was converted into a public corporation and reorganized in January 2021, and based on Decree No. 41/2018, DNSA to the Timor-Leste Water Services Corporation (Bee Timor-Leste, hereinafter BTL). The water supply business was transferred to.

The jurisdiction of BTL is the implementation department of operations and management related to water supply and drainage in Timor-Leste. As a specific example, in the water supply field in Dili, he is in charge of the management and operation of the Bemos intake weir and the Bemos water purification plant, as well as the management and operation of water pipes and other ancillary equipment. The water pipe to the Bemos intake weir and water purification plant, which was destroyed immediately after the flood in April, was temporarily restored with the cooperation of the Australian Borderless Engineers.

On the other hand, regarding operations in the drainage field, the current situation is that only maintenance is being carried out within Dili, but a drainage facility renewal plan within Dili is being promoted with the cooperation of the Portuguese Water Services Corporation. The plan is to expand the drainage channel in Dili, develop a reservoir and construct a drainage channel (tunnel) with a national budget of USD 16.5 million.

(2) Ministry of Agriculture and Fishery (MAF)

The organizational chart of the Ministry of Agriculture, Forestry and Fisheries (hereinafter referred to as “MAF”) is shown in Figure 2.2-5. The MAF is organized under Decree No. 14 of 2015 and is a policy-making, implementation and coordinating agency for agriculture, forestry, fisheries and livestock. In addition, it is also in charge of local development planning and policy formulation.

The average annual budget for the entire MAF is USD 29.5 million, which includes the disaster recovery and emergency response budget of USD 15,000.

Under local legislation, the department in charge of natural disasters in the MAF is The National Directorate of Rain Catchment and Mangrove Areas (Direção Nacioanal das Bacias Hidrográ ficas e Áreas Mangais). There is no record of reconstruction measures. In reality, the department in charge of managing damaged structures and systems adjusts the annual budget and procures from other departments for reconstruction measures. Due to the damage to the irrigation facilities during the April flood, the irrigation department adjusted about USD 150,000 within the ministry and took measures for reconstruction.

With the support of FAO, MAF has organized a disaster risk management unit consisting of directors of the irrigation, fisheries, livestock and forestry sectors, but the National Protection Agency has positioned the measures to be taken by the MAF's disaster countermeasures. There is no policy / response policy for this.

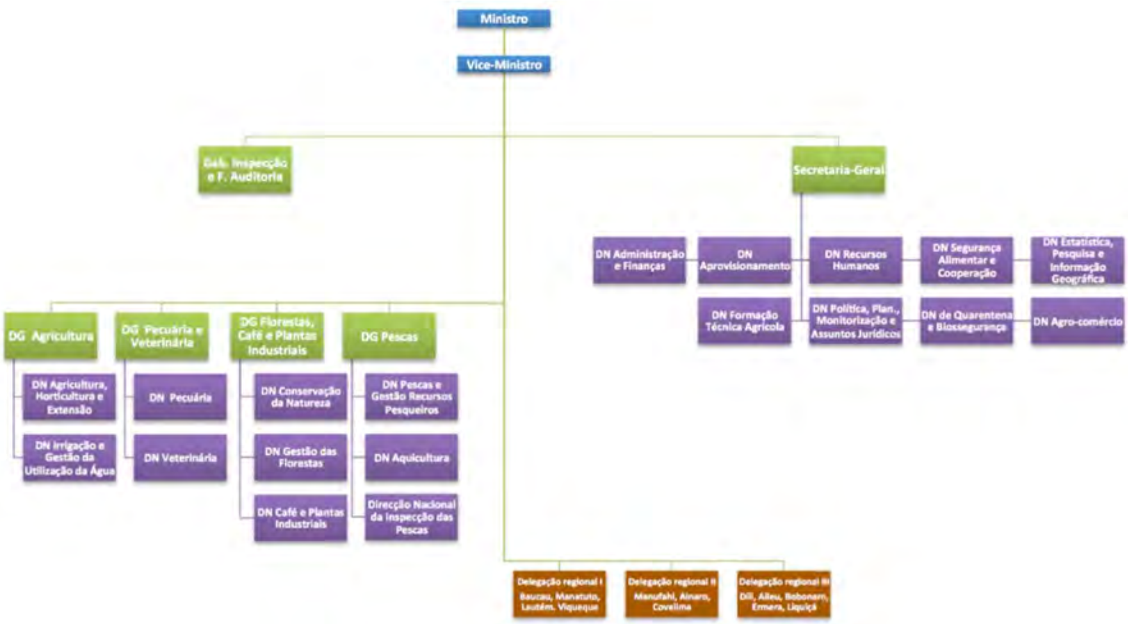


Figure 2.2-5 MAF Organization chart

2.2.3 Government Related Organizations

Table 2.2-3 shows the establishment basis law that describes the budget and jurisdiction of related organizations.

Table 2.2-3 Budget and Establishment Basis Law of the Related Organizations

Related Organizations	Budget[1]（USD million）	Establishing Grounds Decree
MAF	31.8	Decree No.41/2012
MNEC	26.3	-
MPS	339.6（Infrastructure Fund）	Decree No.8/2011
Civil Protection	13.5	Decree No.12/2020
ANAS		Decree No.38/2020
IPG	11.8 (Ministry of Transport and Communications)	
DNMG	2.9[2]	Decree No.33/2012
EDTL	157	
Dili Municipality	8.6	Decree No.11/2009
UNTL	19.1(University in total ）	-

(1) Ministry of Finance (MoF)

The Ministry of Finance (MoF) is in charge of annual budget planning, monitoring, finance, etc. based on 2012 Decree No. 41. The jurisdiction of the Ministry of Finance is as shown in the table below. The relationship with this survey will be responsible for adjusting the handling of taxes when forming future projects.

Table 2.2-4 Contents of MoF jurisdiction

No.	Jurisdiction
1	Propose macroeconomic, monetary and exchange-rate policies, together with the central bank
2	Put forward policies and draft laws and regulations on revenues, budgetary framework, procurement, public accounting, public finance, auditing and control of the State treasury, issuing and management of the public debt
3	Administer the petroleum fund of Timor-Leste
4	Work, in cooperation with the Ministry of Foreign Affairs, to coordinate the relationship of Timor-Leste with the donors
5	Manage the external public debt, the State's stakes in companies, and external assistance – coordinating and defining its financial and tax aspects
6	Manage the State's assets
7	Compiles and publishes official statistics
8	Oversee implementation of the budget allocated from the State General Budget, and
9	Look after the good management of the funds transferred from the State Budget to bodies that are indirectly administered by the State and by the local government bodies, through audits and monitoring.

Source: Created by JICA survey team from MoF HP

(2) Ministry of Foreign Affairs and Cooperation (MNEC)

The Ministry of Foreign Affairs and International Cooperation (MNEC) is an organization that formulates foreign policies, concludes treaties, and coordinates international organizations and the support of governments of other countries. The relationship with this survey is the adjustment of acceptance of the survey team and the adjustment when forming future projects.

(3) Secretariat for Major Project Service (MPS)

The Major Business Secretariat ("MPS") was established in 2011 based on Government Ordinance No. 8 to provide business and technical support to the Infrastructure Fund Administration Council.

[1] Includes 2021 supplementary budget. Source: MOF HP and consultation results
[2] 2020 budget. Source: IPG Annual Report 2020

Table 2.2-5 Contents of the jurisdiction of MPS

No.	Jurisdiction
1	Carry out the preliminary and formal appreciation concerning the remission of projects to be funded by the Infrastructure Fund, from a technical and financial perspective;
2	Determine the scheduling or returning of projects;
3	Perform secretary duties in the meetings of the Infrastructure Fund Administration Council, drafting the respective minutes;
4	Draft the releases by the Infrastructure Fund Administration Council and report its activities to the Council of Ministers every month.

Source: Created by JICA survey team from MOF HP

(4) Civil Protection Authority (CPA)

Civil protection organization was under the umbrella of the Ministry of Social Solidarity until 2019, but was reorganized under the Ministry of Interior in 2019. Based on the Ministerial Diploma No. 28/2021 dated May 7, 2021, the Directorate-General of Civil Protection (DGPC) has been established under the Ministry of Interior. Thereafter, based on the Decree-Law No.11/2022 of March 9, 2022, the government established the structure of the entire civil protection system headed by Civil Protection Authority: CPA (Autoridade de Proteção Civil) as the executive entity of national scope regulating all civil protection activities. CPA is headed by a President as a focal point of liaison at the political level and which will make the operational, administrative, logistic and financial management of the entire civil protection system. The regional and municipal civil protection systems will be the existing deconcentrated and in the future decentralized structures in the Special Administrative Region of Oe-Cusse Ambeno (SAROA) and in each of the 13 municipalities. CPA has the following national directorates:

1) National Directorate of Firefighters
2) National Directorate of Disaster Risk Management
3) National Directorate of Security and Protection of Public Property
4) National Directorate for the Prevention of Community Conflicts
5) National Directorate of Resource Management Directorate

According to the Decree-Law No.11/2022, CPA will create Standard Operation Procedures and the National Civil Emergency Planning System within one year from the effective date of the Decree-Law.

The newly established CPA is expected to perform overall coordination of all the concerned organizations for implementation of disaster risk reduction policies of Timor-Leste.

The National Directorate of Disaster Risk Management formulates public policies on disaster risk management from the perspective of civil protection and coordinates the activities of government departments within the country. Table 2.2-6 below shows the jurisdiction stipulated in Decree No. 12 of 2020 (Civil Protection Law).

Table 2.2-6 Contents of the jurisdiction of the Civil Protection

No.	Jurisdiction
1	a) Survey, forecast, monitoring, evaluation and prevention of collective risks;
2	b) Continuous analysis of vulnerability to risk;
3	c) Information and training of the population;
4	d) Planning of emergency actions, aiming at the search, rescue and provision of relief and assistance, as well as evacuation, accommodation and supplies of the affected populations;
5	e) Inventory of available resources and means and/or deployable at the municipal, regional and national level;
6	f) Study and dissemination of adequate forms of protection infrastructure and buildings in general, monuments and other cultural assets, as well as the natural and environmental resources;
7	g) Forecasting and planning of actions for the replacement of communications in case of isolation of affected areas by serious accidents or catastrophes.

Source: Art. 4, Law No. 12/2020

CPA has a central office in Dili, and each municipality office has a branch office of the Civil Protection Services, with a total of 14 offices. The central office has a National disaster operation center with four drones, radios, and control monitors. In addition, they have only 8 vehicles (including motorcycles) for staff movement and 2 trucks for disaster prevention equipment. They do not own tents to accommodate evacuees nor stockpile supplies for evacuation, and are currently relying on the support of the development partners.

(5) National Authority for Water and Sanitation (ANAS)

In September 2020, the Water Resources Regulation Authority ("ANAS") was under the jurisdiction of its predecessor, the National Directorate of Water Supply (DNSA), in accordance with Decree No. 38 of 2020. Legal regulation planning / enforcement / monitoring functions have been transferred. The jurisdiction of ANAS is as follows.

Table 2.2-7 Contents of the jurisdiction of ANAS

No.	Jurisdiction
1	support the Government in the definition of the water resources management, water supply and sanitation policy;
2	prepare proposals for water resources management plans to be submitted to the tutelage;
3	support the work of the Coordination Council for Integrated Water Resources Management; promote the rational use of water through Water Resources Management Planning;
4	propose the creation of areas in the public water domain;
5	coordinate, at the national level, the adoption of exceptional measures in extreme drought or flood situations;
6	ensure the monitoring, inspection and licensing of the use of water resources in accordance with the law and water resource management plans;
7	propose to the Government the approval of regulatory norms related to the water resources sector, water supply and sanitation;
8	regulate water supply and urban wastewater sanitation services and the quality of the service provided to users by management entities;
9	ensure the monitoring, inspection and licensing of the activity of entities managing water supply and sanitation systems, in accordance with the law;
10	control the correct use of water supply and sanitation systems by consumers, etc.

Source: 2020 Decree No. 38

(6) National Directorate of Meteorology and Geophysics (DNMG)

The Meteorological and Geophysical Bureau ("DNMG") is under the umbrella of the Ministry of Transport and Communications, and is an organization that conducts meteorological monitoring, manages, and provides meteorological and geological information in Timor-Leste. The jurisdiction of DNMG is as follows. For meteorological monitoring, internationally released data such as observation data of sunflowers, which are Japanese meteorological satellites, are used, and DNMG itself does not make meteorological forecasts.

Table 2.2-8 Contents of the jurisdiction of DNMG

No.	Jurisdiction
1	Prepare and develop , in collaboration with other departments and public bodies responsible for the preparation and implementation of national information systems and meteorological monitoring, climatology and seismology , as well as the national civil protection plan , to be approved superiorly ;
2	Ensure the provision of meteorological information , climatological and seismological autonomous entities to civil aviation and shipping services as well as other public and private entities ;

Source: Article 14, Organic Law No.20 / 2016

(7) Institute of Petroleum and Geology (IPG)

The Petroleum Geological Research Institute (hereinafter referred to as "IPG") was established under the Ministry of Petroleum and Natural Resources as a geological research institute for natural resources such as oil and natural gas, based on Decree No. 33 of 2012. As a project related to this survey, they are creating a hazard map for landslides and landslides. Table 2.2-9 shows a part of the jurisdiction of IPG.

Table 2.2-9 Contents of IPG jurisdiction

No.	Jurisdiction
1	To compile, select, process, update and reproduce inventories that enable the dissemination of information related to geology, petroleum resources and minerals, including information submitted to it by any public or private entities, whether enterprise or not, including the Authority National Petroleum and Minerals and Timor GAP;
2	Produce and distribute geological maps and other thematic maps, as well as related literature, covering the national territory or maritime zones where Timor-Leste exercises sovereign rights;
3	Promote, support and execute research and developments in the areas of pure of and applied geology, including in the field of petroleum research, mineral resources and groundwater resources, in order to obtain systematic geological knowledge of the national territory and maritime areas on which sovereign rights area applied, with a view to optimizing the exploitation and use of resources, and in order to promote, from a scientific perspective, social welfare and national economic development; Manage and develop the National Geology Laboratory;
4	Support and advise public bodies and institutions on matters or processes related to access to geological information, including engineering, environmental planning and management, mineral and groundwater resources management, civil protection, including terms of reference and procedures related to the granting of rights to research and exploitation of national mineral and water resources;
5	Accompany the scientific or technical work necessary to the process of preparing draft laws and regulations within the ambit of the IPG mission, advising the supervisory body in the exercise of this competence;
6	Provide geology or related services to public and private entities that request it;
7	Develop all activities that allow it to carry out the mission for which it was created.

Source: Decree-Law No. 33/2012

(8) National Electricity Company (EDTL)

The Electric Power Corporation (hereinafter referred to as "EDTL") is a public corporation responsible for power generation, distribution, and power supply in Timor-Leste. The power plants currently in operation in Timor-Leste are two diesel power plants located in Hera and Betamos, which supply the entire country. The electrification rate in Dili is about 85%, but the power grid is being expanded and strengthened toward electrification.

EDTL's 2021 budget is USD 157 million, most of which is fuel costs for diesel generation. Since domestically produced natural gas and oil are exported, they are not used for domestic power generation. According to President Dr. Paulo da Silva, the introduction of natural gas-fired power plants and solar power plants is being considered as a future plan. In addition, electricity theft has become a problem nationwide, and meters are being installed. In addition, EDTL has not been able to draw a nationwide power grid due to the lack of information on electricity theft and the colonial era. Therefore, to maintenance of the power grid, they have to go to sites to look for the part needed to be repaired. There are plans to digitize the power grid in the future.

The impact of the April flood on the power supply, etc., did not damage the two power plants, but the 16 transmission towers were tilted, the connecting wires were cut, and the power supply to 34 locations was cut off. .. On the day of the flood on April 4th, the central of Dili was blacked out for about 9 hours, but it was restored after that. The repair work for the 16 transmission towers and the disconnected electric wires was completed one to one and a half months after the disaster, and the power supply was resumed.

(9) Municipality of Dili

For 13 prefectures in Timor-Leste, administrative divisions, prefectural borders and prefectural office locations were clarified by Decree No. 11 of 2009. At present, the central government of Timor-Leste is the policy-making and legislative body, while the prefectural office is the enforcement body for such policies and decree. According to the Dili Prefectural Office, although it is possible to formulate laws and regulations and formulate prefectural policies, the actual situation is that administrative management and procedures are in charge. In addition, if the central government evaluates the autonomy ability and obtains a permit, the autonomy of each prefectural office including the drafting of laws and regulations will be recognized. The Dili Prefectural Office is under evaluation as of 2021, and if a permit is obtained, autonomy will be recognized from next year onwards.

In addition, the annual budget of Dili Prefectural Office is covered by the allocation from the national budget, and there is no prefectural office tax revenue.

In addition, hygiene management in Dili is under the jurisdiction of Dili, and public areas such as roads are cleaned by Dili. On the other hand, MPW is in charge of cleaning drainage ditches along roads and in residential areas, and the Dili Prefectural Office recognizes that cleaning by the domestic government is not possible except for cleaning projects by NGOs and donors (UNDP, KOICA, etc.). There was an explanation from the Dili Prefectural Office that it was not recognized.

(10) National University of Timor-Leste (UNTL), Faculty of Engineering, Science and Technology (FEST)

Timor-Leste National University ("UNTL") was established in 2000 and has nine faculties (Faculty of Engineering, Faculty of Agriculture, Faculty of Science, Faculty of Sociology, Faculty of Law, Faculty of Economics and Business Administration, Faculty of Education and Art Interrogation Science, Faculty of Philosophy and Human Sciences, and Faculty of Health Sciences).

There are five engineering departments: Mechanical Engineering, Civil Engineering, Electrical and Electronic Engineering, Information Engineering, and Geology / Petroleum Engineering. There are 19 lecturers, including EDTL President Dr. Paulo da Silva in the Civil Engineering Department. Since the establishment of the Faculty of Engineering in 2001, JICA has continued to support curriculum formulation, facility reconstruction, equipment provision, technical cooperation, etc. for the purpose of supporting industrial human resource development.

Dr. Benjamin Hopffer Martins, who belongs to UNTL, was appointed as the coordinator of the Post disaster infrastructure restoration committee by the presidential order after the flood in April and is investigating the flood damage.

2.2.4 International Organizations

(1) UN Resident Coordinator Office (UNRCO)

The UN Resident Coordinator Office of Timor-Leste (UNRCO) is an organization established for the purpose of coordinating and managing projects of UN organizations and organizations in Timor-Leste. There are a total of 5 UN organizations that support the disaster prevention field in Timor-Leste. The United Nations Environment Program (FAO) supports disaster-affected farmers, the United Nations Development Program (UNDP) provides community-based disaster risk reduction education, the International Monetary Fund (IMF) supports local businesses, and the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the United Nations Environment Program (UNEP) are supporting the construction of an early warning system.

In addition, UNRCO does not have a United Nations Office for the Coordination of Humanitarian Affairs (OCHA) in Timor-Leste, so UNRCO is also in charge of supporting humanitarian issues. Therefore, UNRCO compiled and published the April flood damage report. Information was collected through an inter-organizational collaborative coordination system (network) organized by domestic government-affiliated organizations, UN organizations, and NGOs when preparing flood reports. The government is conducting two types of damage investigations: humanitarian (victims, evacuees, housing damage) damage and infrastructure damage. In addition, UNDP collects data such as the number of victims and evacuees by installing shelters and providing emergency support to evacuees. In addition, in the field of water and sanitation (Water, Sanitation and Hygiene, WASH), UNICEF plays a central role in providing support, mainly quantifying housing damage and prioritizing reconstruction measures. Based on the above and information from other organizations, UNRCO issues a disaster status report. In addition, the Post Disaster Needs Assessment (hereinafter referred to as "PDNA"), which summarizes the disaster situation and necessary support in the future, will be issued.

In addition to the above, we are cooperating with NGOs to improve the capacity of the National Protection Agency, capacity building of staff, and formulate disaster preparedness plans as the support status of UN-related organizations in the field of disaster prevention. Immediately after the disaster, UN organizations have been providing simple evacuation shelters, setting up temporary rescue and evacuation tents, and supporting disaster victims through support for the National Protection Agency. There are 40 evacuation centers in operation in Dili prefecture. Detailed data will be posted on PDNA. In the field of early warning system construction, urgent installation is required and priority is high, so other donors such as the United States and South Korea are also conducting similar projects, but at present there is no location map etc. with the support of each donor, and warnings are given. The integrated support situation in the system field has not been organized.

(2) Asia Development Bank (ADB)

As of December 31, 2021, ADB's cumulative commitments amounted to US$358.9 billion toward realizing its vision of a poverty-free Asia-Pacific region.

ADB has so far agreed to a USD 619 million loan, grant and technical assistance project procurement agreement with Timor-Leste. Specifically, it includes national highway reconstruction support, power supply capacity enhancement, and urban water supply projects in Manatuto prefecture.

According to ADB, there are two types of disaster emergency financing and project contract methods for ADB: a loan from Savings Loan at the request of the government, or adding disaster countermeasures and repair work to projects for which a loan has been agreed or contracted. Following the April floods, the first government request has never been received. Regarding the second, Road Network Upgrading Project is currently active, but no plan changes have occurred due to the April flood. On the other hand, the plan of the national highway project also includes a disaster occurrence detection system such as the installation of river water level observation sensors.

2.2.5 Other Doners

(1) Aqua de Portuguese (AdP)

The Portuguese Water Authority ("AdP") has traditionally continued to support the water sector in Timor-Leste. AdP is in charge of the detailed design of the drainage facility renewal plan of Dili with a total amount of USD 200 million, and BTL is currently in the process of procuring drainage channel collection and new construction.

The project involves different donors in each phase, and in the first phase, an Australian company surveys the existing infrastructure. In the second phase, AdP was in charge of the detailed design. At this stage, they were conducting hydraulic analysis, LiDAR surveys, collection and organization of rainfall data, and information on necessary permits and licenses. According to AdP, the plan is currently being adjusted for procurement procedures for renovation and new construction. The construction period is assumed to be 5 years.

(2) Engineers Without Border (Australia) (EWB)

The Engineer Without Borders Australia (EWB) is an organization established by engineers in Melbourne, Australia in 2003, and has been financed by the Australian government and other countries around the world in the fields of technical cooperation, water and sanitation management, etc. they provide hardware and software support.

EWB provided emergency reconstruction assistance for the water supply system destroyed by the April floods. Specifically, it is an intake weir, its ancillary equipment, and a water pipe. Since the purpose was temporary emergency recovery, the useful life is expected to be about 3 years. Some of the intake weirs and water pipes are funded by the Australian Government, designed and procured by EWD and are currently bidding. Hydrological model analysis has already been carried out at the time of design, and information can be shared as soon as bid information disclosure is completed, but it has not been disclosed yet at this time. According to EWD, the risk of landslides and landslides is extremely high through on-site reconnaissance and analysis during detailed design, and the countermeasures have not yet been started.

(3) United States Agency for International Development (USAID)

The United States Agency for International Development ("USAID") is a government-affiliated international development and humanitarian agency. USAID has been providing support in Timor-Leste mainly in the fields of strengthening the political system such as election implementation support, the field of market / community economic development, and the medical field.

Following the April flood, USAID contributed US $ 100,000 for emergency disaster relief through the International Organization for Migration ("IOM"), a United Nations agency. The main uses of funds are sediment removal / cleaning, shelter installation, education of government agencies in charge of disasters and rescue agencies, etc.

In addition, as part of the existing project to improve the income of local farmers, as part of the reconstruction support for the April disaster, they provided support for rebuilding the value chain for farmers whose income was affected by the flood. USAID does not provide support for the restoration of irrigation facilities in the agricultural sector in Timor-Leste.

In addition, emergency disaster response education for government-related organizations is more effective and efficient than US experts for about 20 personnel such as the Incident Command System (ICS), the Ministry of the Interior, the National Protection Agency, and the police. They regularly hold training on disaster management and response systems. According to USAID, disaster prevention field support flexibly forms support projects in response to government requests and needs through IOM.

2.2.6 NGO/NPO

(1) Mercy Corps

Mercy Corps was established in Portland, Oregon, USA, and provides support in the fields of agriculture, economic development, health such as Covid-19 infection prevention, and disaster countermeasures around the world. In Timor-Leste, nutrition improvement, agriculture and disaster countermeasures, and local government support projects are in operation. There are three disaster recovery support projects underway: Preparadu, Maloa River Landscape Project, and Managing Risk through Economic Development. The early alarm system construction project is being implemented as part of Preparadu. The Early Warning System project is being carried out in collaboration with a local company called Similie with the financial support of the EU and KOICA. The counterpart is the city of Dili. Currently, the warning system is in the design and installation stage. Those that can be produced domestically are procured domestically, and the others are planned to be procured from overseas.

2.3 Legal system on environment and social consideration (EIA) of Timor-Leste

The main laws related to environmental and social considerations in Timor-Leste and the legislative bills currently under draft are as follows.

【Environment related】

- Constitution of the Democratic Republic of Timor-Leste
- Laws of the National Parliament No.10/2011 15th September, Approves the Civil Code
- Government Decree Law No. 26/2012 4th July, Basic Law on Environment
- Government Decree Law No.5/2011 9th February, Environmental Licensing

The Environmental License Law stipulates the procedure for environmental impact assessment in Timor-Leste.

According to this law, regarding categorizing of impacts of the projects, there are three categories that similar with the JICA guidelines. Category A is one of classification of impacts for projects that will be expected to have a significant negative impact on the environment and society, and Category B is middle classification for projects that are expected to have a certain negative impact. And projects that are expected to have little impact will be classified Category C (Table 2.3-1).

Table 2.3-1 Criteria and classification of EIA of TL

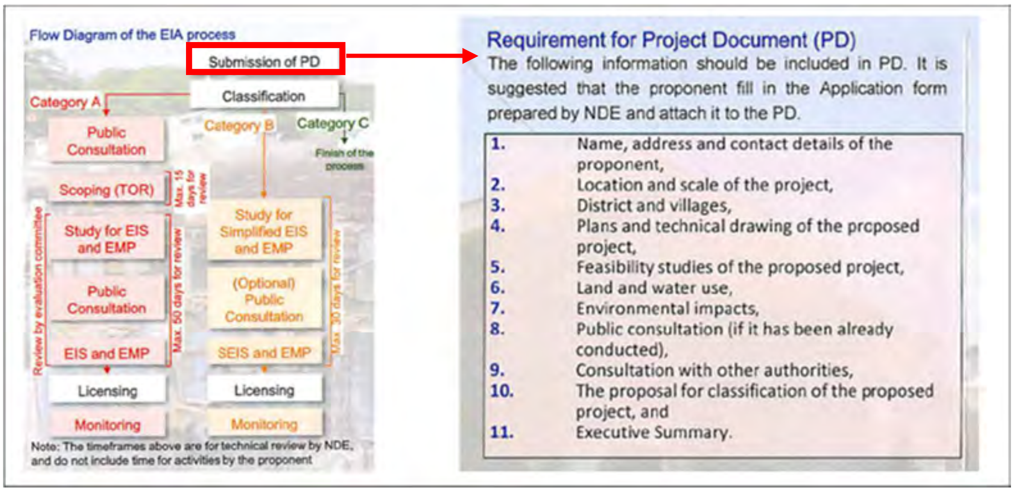
Categorizing of impacts of the projects	Criteria of project impact assessment
Category A	Projects could have a significant negative impact
Category B	Projects could have a certain negative impact
Category C	Projects could have a negligible slight negative impact

Source: JICA expert team

Regarding existence of "significant negative impact" in the definition of the category will be determined by comprehensive evaluation such as the scale of the project site, the presence or absence of involuntary relocation of residents, and whether or not target project includes socio-economic impact. All development project planners are required to submit a project document describing the project plan to the National Directorate of Environment of the Secretary of State of Environment before implementing the project, in order to obtain an environmental license.

As shown figure below, the required contents for the project document do not differ depending on the category classification.

Regarding the license expiration date can be extended up to twice the original period. However, license that has been exceeded maximum extension period or license that expiration of a term will be lost its effect, and even for continuation same project, project should have a new category evaluation process (Environmental License Law, Article 22 and 41).



Source: Brochure of Ministry of Commerce, Industry and Environment, National Directorate for Environment

Figure 2.3-1 Flow of EIA of TL and Requirement for Project Document

【Social consideration related】

- Constitution of the Democratic Republic of Timor-Leste
- Laws of the National Parliament No.10/2011 15th September, Approves the Civil Code
- Laws of the National Parliament No.13/2017 5th June, Special Regime for the Definition of Ownership of Real Estate
- Laws of the National Parliament No.8/2017 26th April, Expropriation for Public Utility
- Draft of the Government Decree Law No./2018, Legal Regime of Real Estate in the Private Domain of the State
- Draft of the Government Decree Law No./2018, Legal Regime of Real Estate in the Public Domain of the State
- Draft of the Government Decree Law No./2021, Land Registry Code

In addition, the Government ordinance stipulates compensation targets such as plants and their acquisition prices. The replacement price of TL Government was based on market price, and it includes income tax and bank remittance fee, it is the same as the compensation level based on the JICA Environmental and Social Consideration Guidelines.

Currently, the government of Timor-Leste is developing a Land Registry Code for the purpose of granting real estate ownership to the people, and land will be covered by compensation in the future. For this reason, the expropriation of real estate on private land or the acquisition of them that will be occurred after implementation of Land Registry Code, have to be carried out based on close consultation in order to obtain consensus with the residents who are the right holders.

Table 2.3-2 below shows the subjects to be indemnified and replacement price determination bodies in TL.

Table 2.3-2 Subject of compensation and price determination bodies

Subject of compensation	Price determination bodies
Houses Others (constructions)	Project Management Unit and ND Buildings will determine based on Market price
Lands	N/A
Trees Plants Crops	MAF relevant ND will determine based on Market price
Utility poles Electric cables	EDTL will determine

Source: JICA Survey Team

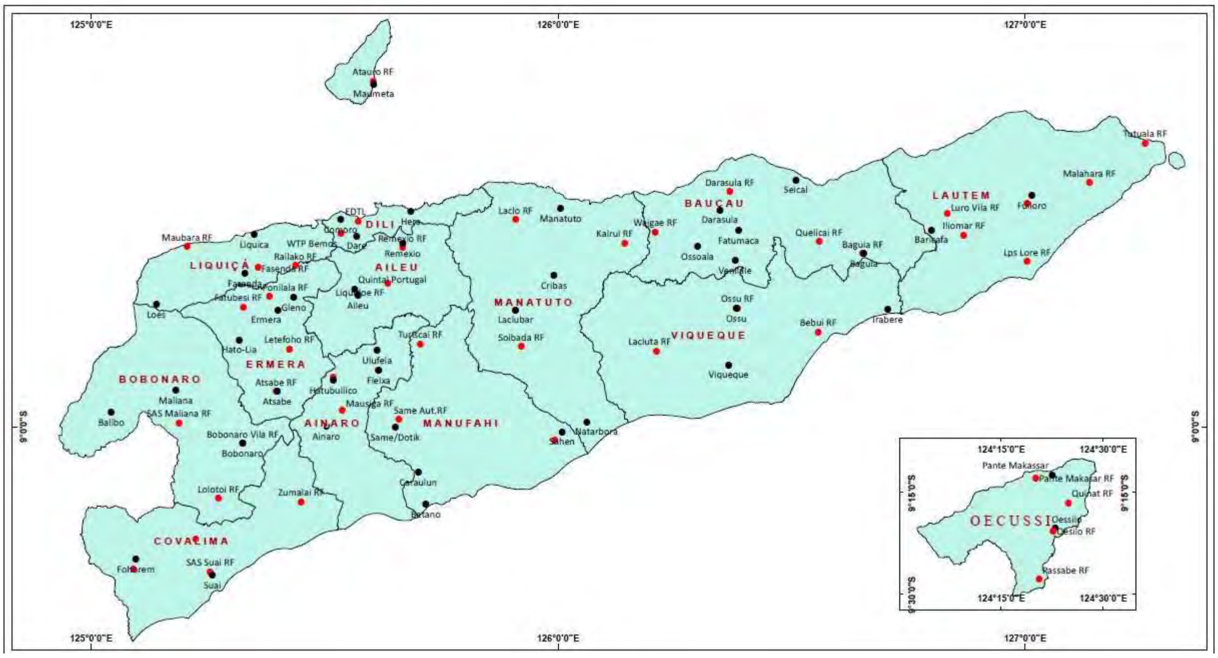
Chapter 3 Survey Result

3.1 Understanding the mechanism of disaster occurrence (April 2021) and disaster risk assessment

3.1.1 Present monitoring system for rainfall and water level

(1) Outline of rainfall observation in Timor-Leste

Figure 3.1-1 shows the rainfall observation stations managed by ANAS and ALGIS.



Source: UNTL

Figure 3.1-1 Rain gauge stations managed by ANAS and ALGIS

Automatic observation is carried out at WTP Bemos in Dili, but daily rainfall data is manually recorded at the other ANAS's station, and ANAS's hydrological team manage the daily rainfall data by manually inputting the amount of daily rainfall reported from all over the country into the system.

Meteorological stations in Dili Airport and Dare are managed by DNMG.

Basically, rainfall data is stored on a daily basis, but data obtained during Indonesian colonial period is stored on a monthly basis.

Source：JICA Survey Team (Taken Photos at ANAS)

Figure 3.1-2 An example of ANAS manual rain gauge instrument

At Dili Airport, which is managed by DNMG, observations are conducted by ANATL using the instruments shown in Figure 3.1-3. Meteorological Data, including daily rainfall data from 2003 to date are recorded in this station.

Meteorological Instruments

Rain Gauge

Source: Material provided by DNMG

Figure 3.1-3 Meteorological instruments installed in Dili airport

(2) Outline of water level observation

On land, ANAS conducts manual river water level observations at 13 stations as shown in Figure 3.1-4. Currently, no automatic observations have been carried out.

Source: JICA survery team based on the material provided by ANAS

Figure 3.1-4 Rain gauge and river water level stations managed by ANAS

In the sea area, Administração dos Portos de Timor-Leste (hereinafter referred to as "APORTIL") conducted the water level observation in Dili port.

3.1.2 Evaluation on rainfall /river water level, and estimation of hourly rain fall

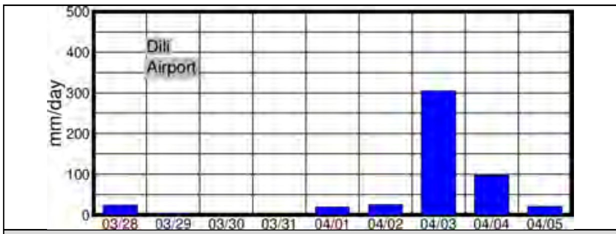
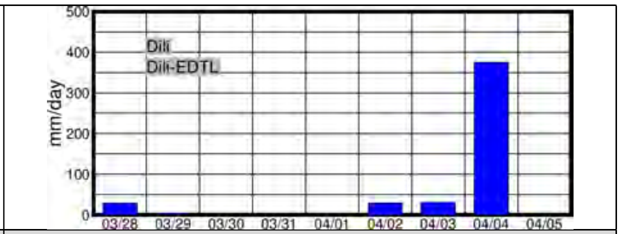
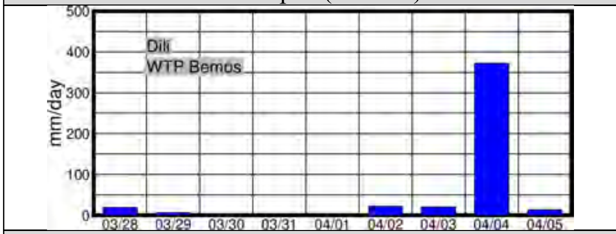
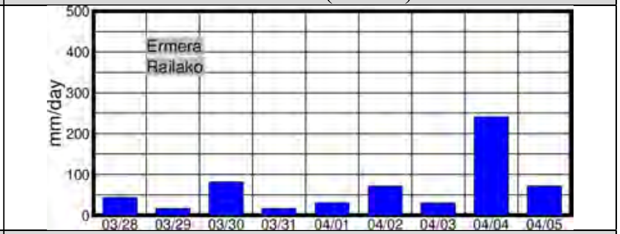
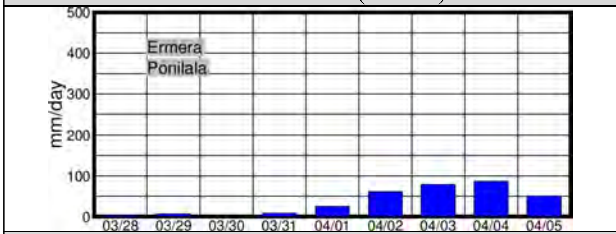
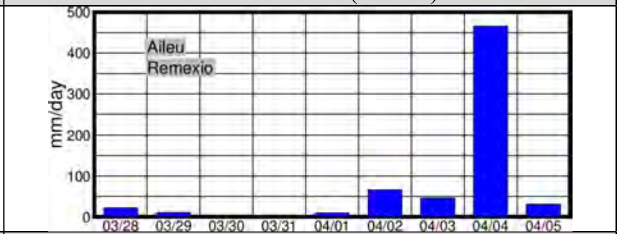
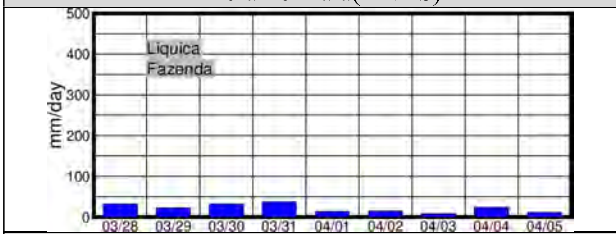
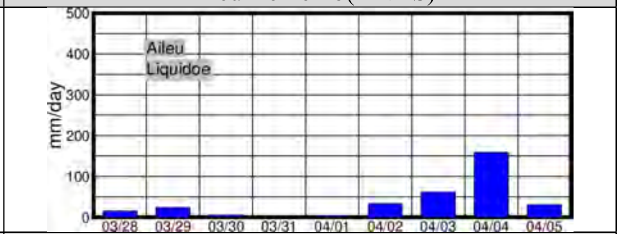
(1) Rainfall and water level of April 2021 flood based on observation data

1) Daily rainfall data from DNMG, ANAS

Figure 3.1-5 shows the rain gauge stations in and around Dili Municipality and the Comoro River basin, and Figure 3.1-6 shows their daily rainfall during March 28th to April 5th. Dili Airport records daily rainfall of 305mm on April 3rd, while other rain gauge stations managed by ANAS record peak daily rainfall on April 4th.

Source: JICA Survey Team Based on materials provided by ANAS and DNMG

Figure 3.1-5 Rain gauge stations in and around Dili municipality and the Comoro River basin

	
Dili Airport(DNMG)	Dili-EDTL(ANAS)
	
Dili WTP Bemos(ANAS)	Ermera Railako(ANAS)
	
Ermera Ponilala(ANAS)	Aileu Remexio(ANAS)
	
Liquica Fazenda(ANAS)	Aileu Liquidoe(ANAS)

Source: JICA Survey Team Based on materials provided by ANAS)

Figure 3.1-6 Daily rainfall around Dili (March 28th ー April 5th)

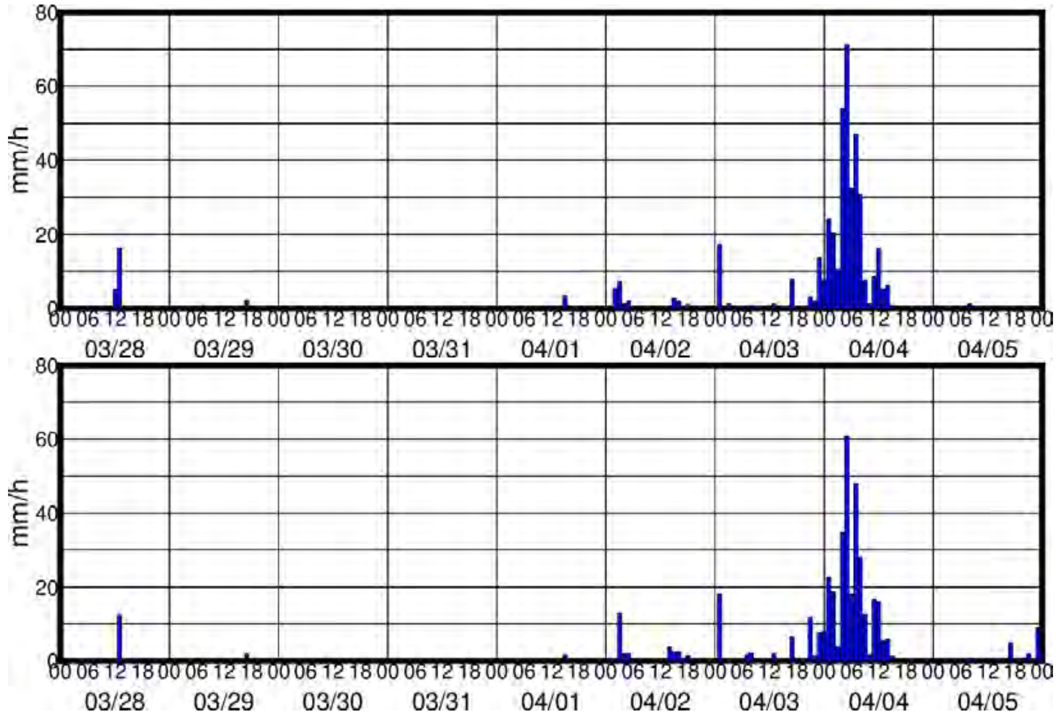
2) Hourly rainfall data

UNTL conducted rainfall observations at two stations in Dili shown in Figure 3.1-7 for research purpose. Onset's Rain Gauge Smart Sensor (S-RGB-M002) are used at these two stations, and rainfall data is recorded every 0.2mm.

Source: UNTL

Figure 3.1-7 Sub-daily rainfall gauge stations in Center area of Dili Municipality

Figure 3.1-8 shows the hourly rainfall amount in center area of Dili Municipality during April 2021 flood (hereinafter referred to as "***This Flood***"). The two-day rainfall amount during April 3rd to 4th, when heavy rain occurred, was 359.6mm for Beto Leste and 338.4 mm for Bairo Formosa.



Source: JICA Survey Team Based on materials provided by Dr.Benjamim, UNTL)

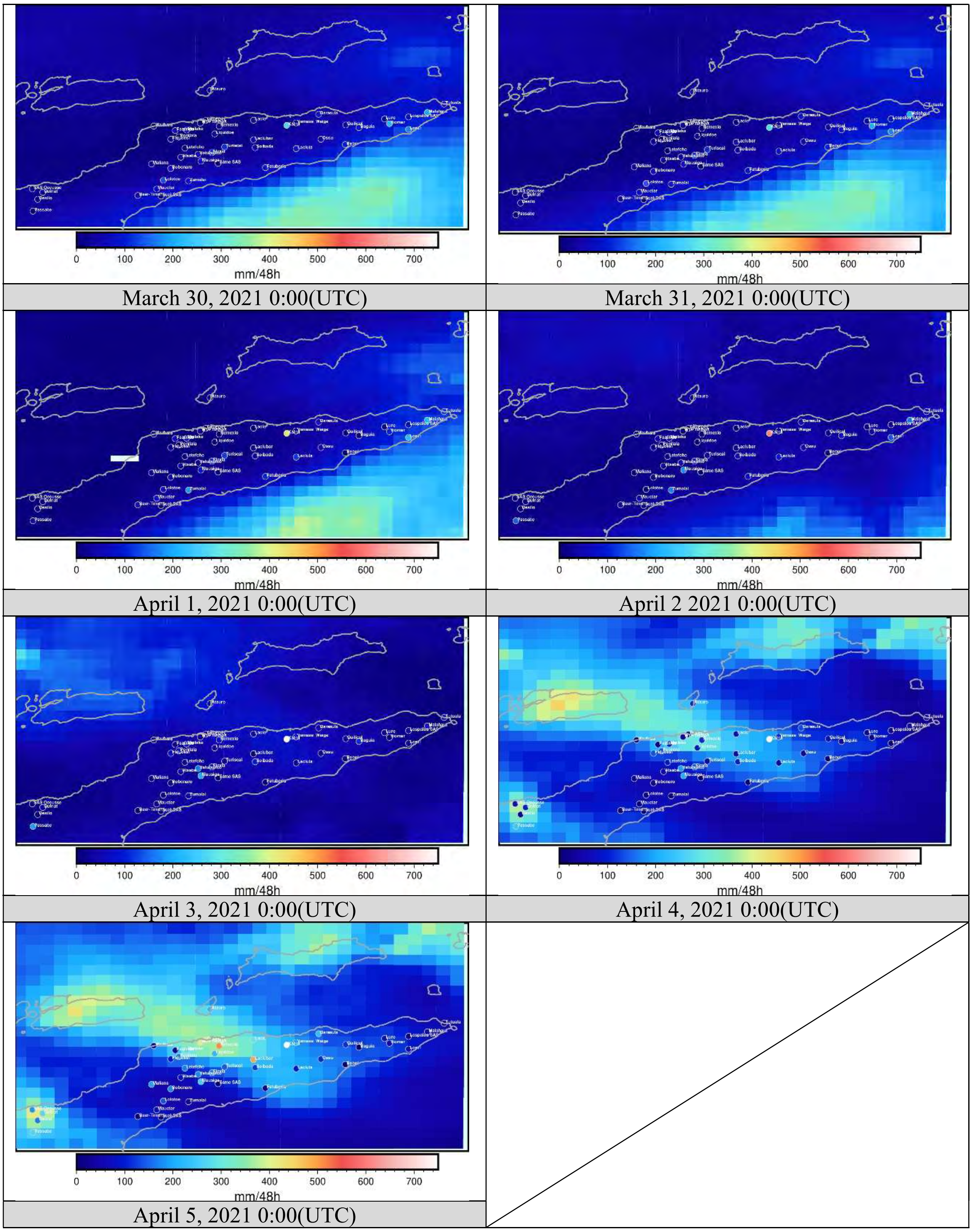
Figure 3.1-8 Hourly rainfall records in Dili Municipality during *This Flood*
Upper :Beto Leste, Lower:Bairro Formosa

3) GSMaP

GSMaP has multi-satellite global precipitation map under Global Precipitation Measurement (GPM) mission, by using Dual-frequency Precipitation Radar (DPR) onboard GPM core satellites, other GPM constellation satellites, and Geostationary satellites. The main feature of the GSMaP algorithm is utilization of various attributes derived from the spaceborne precipitation radar, TRMM/PR and GPM/PR.

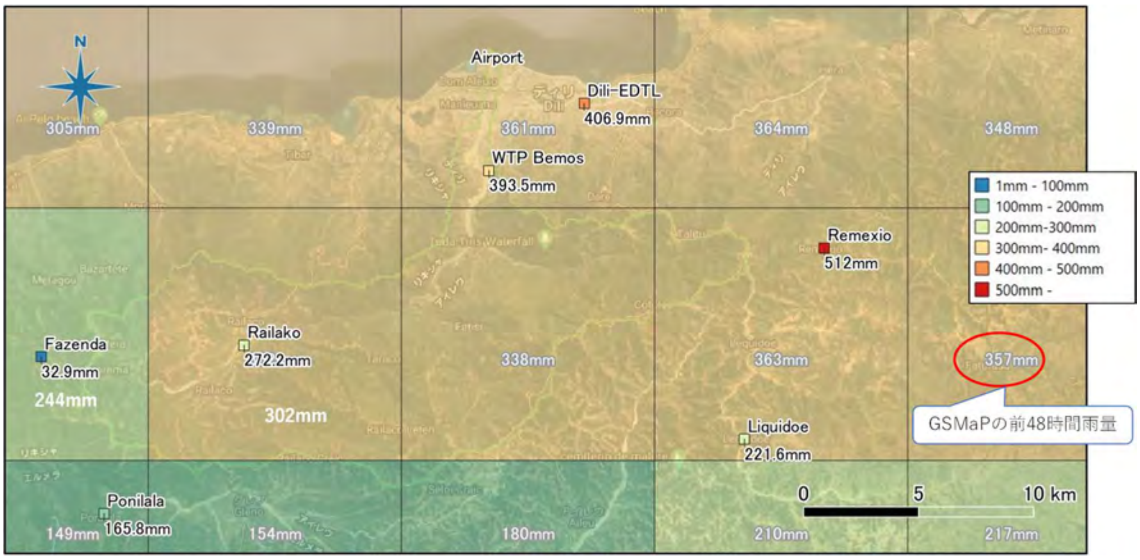
Figure 3.1-9 shows the comparison diagram of GSMaP and 48hr rainfall data at stations managed by ANAS. It can be confirmed there is a correlation between the strength and weakness of the rainfall distribution over a wide range of both rainfall amounts.

Figure 3.1-10 shows the accumulated rainfall during April 3rd to 4th around the Comoro River basin including Dili Municipality. Although GSMaP provide rainfall distribution information on an hourly basis, there is a difference from rain-gauge rainfall. In addition, it is hard to say that the GSMaP can accurately represent rainfall distribution in the Comoro River basin, because there are only 7 grids within there.



Source: JICA Survey Team Based on materials opened by JAXA and provided by ANAS)

Figure 3.1-9 Comparison diagram of GSMaP and 48hr rainfall data at stations managed by ANAS



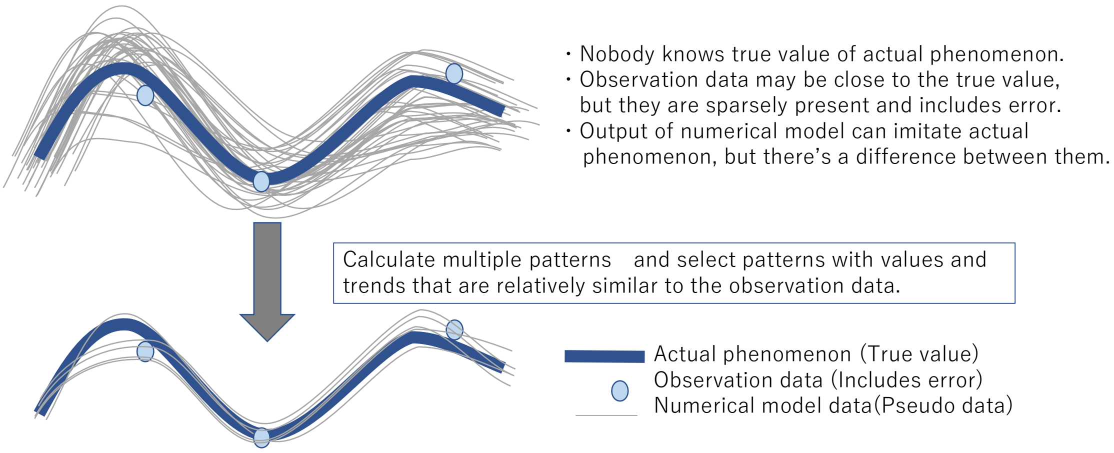
Source: JICA Survey Team Based on materials opened by JAXA and provided by ANAS

Figure 3.1-10 48hr (April 3rd-4th) Rainfall distribution around Dili Municipality

(2) Estimation of hourly rainfall by mesoscale numerical weather prediction system WRF

Although GSMaP provide hourly rainfall data around Timor-Leste, its horizontal resolution is 0.1°×0.1°. Higher resolution rainfall data is required for run-off and flood inundation analysis in the Comoro River basin with about 200km^2, and small and middle size river watershed within Dili Municipality. High-resolution rainfall information can be calculated by mesoscale meteorological model, but it is pseudo data that’s imitates the actual phenomenon by considering thermodynamical and dynamical process of meteorological phenomenon and there’s a difference from actual phenomenon.

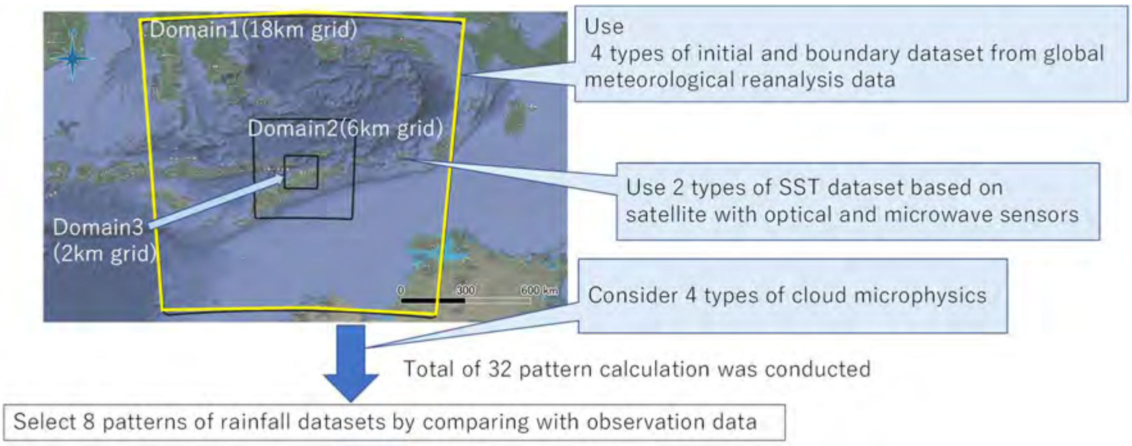
In light of the above, the survey team create multiple patterns of high-resolution rainfall dataset and evaluate them by comparing with observation data based on the concept as shown in Figure 3.1-11.



Source: JICA Survey Team

Figure 3.1-11 Concept of high-resolution rainfall information extraction

Figure 3.1-12 shows the procedure of creating high resolution data from global meteorological reanalysis data. With respect to initial and boundary condition, the survey team create 4 types of initial and boundary dataset for domain01(18km grid area) using global meteorological reanalysis data, which modified forecast data based on observation data by using Data Assimilation method. In addition, the team prepare 2 types of Sea surface Temperature (SST) dataset from the open data as shown Table 3.1-1 as lower boundary condition. Then the team conduct a double-nested dynamical downscaling, by considering 4 patterns of cloud microphysics schemes and create the total of 32 patterns of 2km grid(domain3) rainfall datasets around Dili Municipality. Finally, the team selected 8 patterns of rainfall datasets by comparing with observation data.



Source: JICA Survey Team

Figure 3.1-12 Procedure for creating high-resolution rainfall data from global meteorological reanalysis data etc.

Table 3.1-1 Reanalysis data and SST data used in the approach

Reanalysis data, etc.	SST data
NCEP GDAS Final Analysis(ds083.3)	RSS Optimally Interpolated Microwave and Infrared Daily Sea Surface Temperature Analysis ds277.8
ERA5 Reanalysis(ds633.0)	
GFS Analysis	
GSM、NCEP GDAS Final Analysis(ds083.3)	
NCEP GDAS Final Analysis(ds083.3)	NOAA OISST v2[1]
ERA5 Reanalysis(ds633.0)	
GFS Analysis	
GSM、NCEP GDAS Final Analysis(ds083.3)	

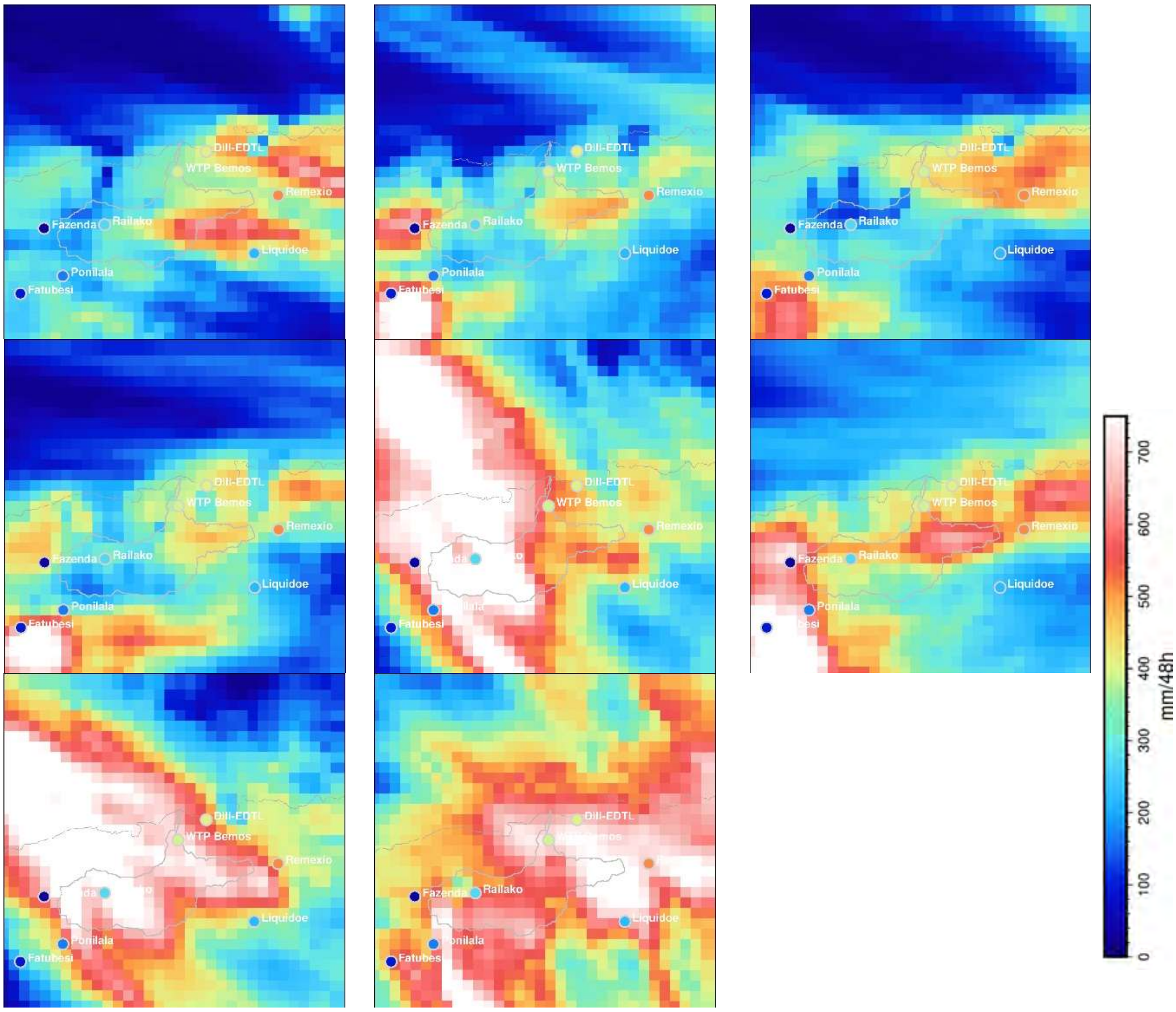
Source: JICA Survey Team

Figure 3.1-13 shows the comparison results between daily rainfall data from ANAS and 8 patterns of WRF output in the 2-day rainfall from April 3rd-4th and Figure 3.1.14 shows the comparison results between hourly rainfall data from UNTL and 8 patterns of WRF output during March 28th to April 5th.

The rainfall during the ***This Flood*** around Dili is due to the convective rainfall by the spiral band of the tropical depression Seroja, and it is speculated that rainfall amount varies greatly depending on the position and intensity of the depression including spiral band.

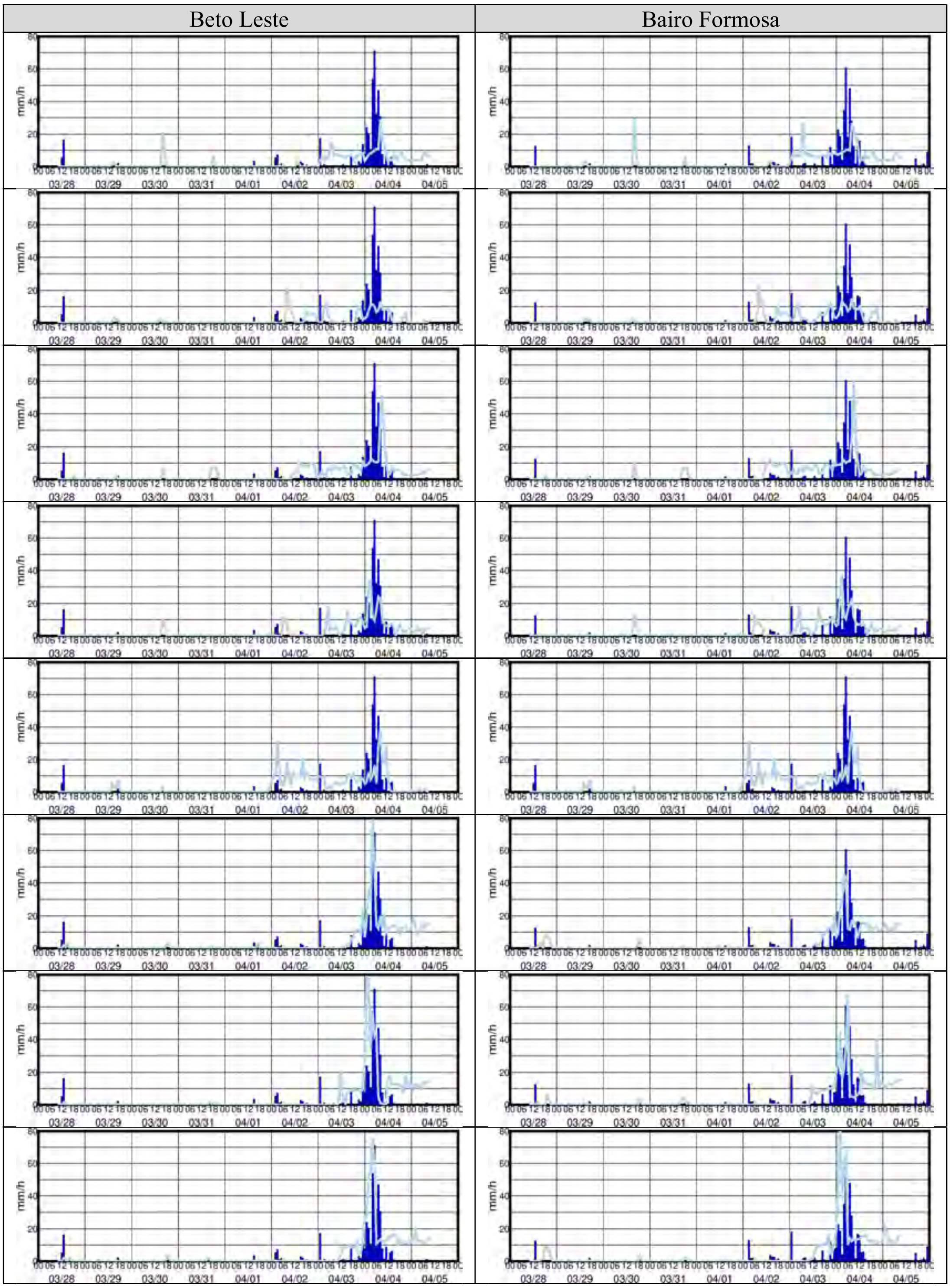
Regarding the comparison results, there are still some differences between observation data and WRF output depending on the time and location. The team think there are some methods for improving the accuracy of WRF output such as shortening the calculation period and/or applying data assimilation etc. Various trials and errors are needed to achieve it, but improvement in accuracy is not necessarily guaranteed. Therefore, the team conducted various studies and evaluations by using the extracted 8 patterns of rainfall data sets in this survey.

[1] https://psl.noaa.gov/data/gridded/data.noaa.oisst.v2.highres.html



Source: JICA Survey Team

Figure 3.1-13 Comparison results between observation data from ANAS and 8 patterns of WRF in the 2-day rainfall from April 3rd-4th

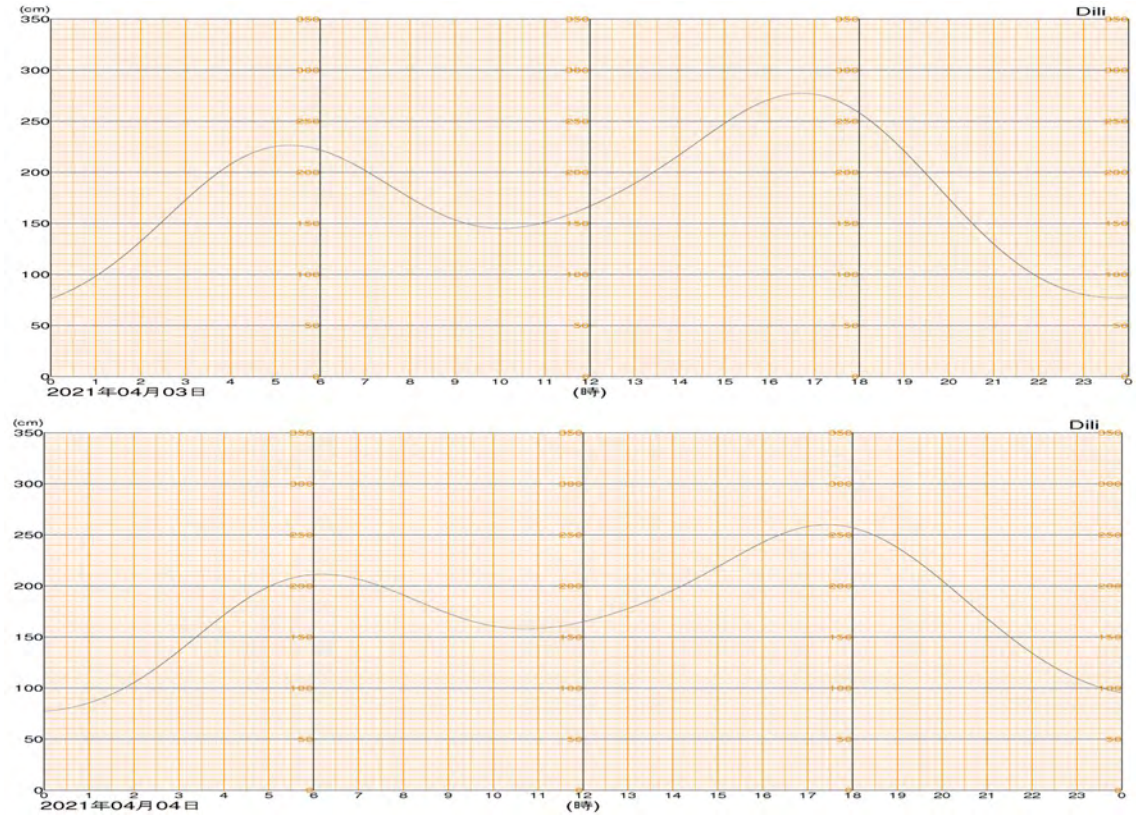


Source: JICA Survey team

Figure 3.1-14 Comparison results between hourly rainfall data from UNTL and 8patterns of WRF output during March 28th to April 5th.

(3) Estimation of tide level during *This Flood*

There's no tide level observation data during ***This Flood***, but the survey team conduct harmonic analysis based on the data for two years from the tide level data from May 19th, 2018 to June 31st, 2019 provided by APORTIL, and calculated astronomical tide level of Dili during ***This Flood***.



Source: JICA suvery team based on the material provided by APORTIL

Figure 3.1-15 Astronomical tide level at the time of *This Flood* at Dili Port

It is confirmed that heavy rain occurred in the early morning of April 4th in Dili, and the astronomical tide of this period was bout 203-215cm, which was considered to be 29-41cm by converting to elevation.

Furthermore, the actual tide level was expected to be higher than the water level shown in Figure 3.1-15 due to the blowdown effect of Tropical cyclone Seroja.

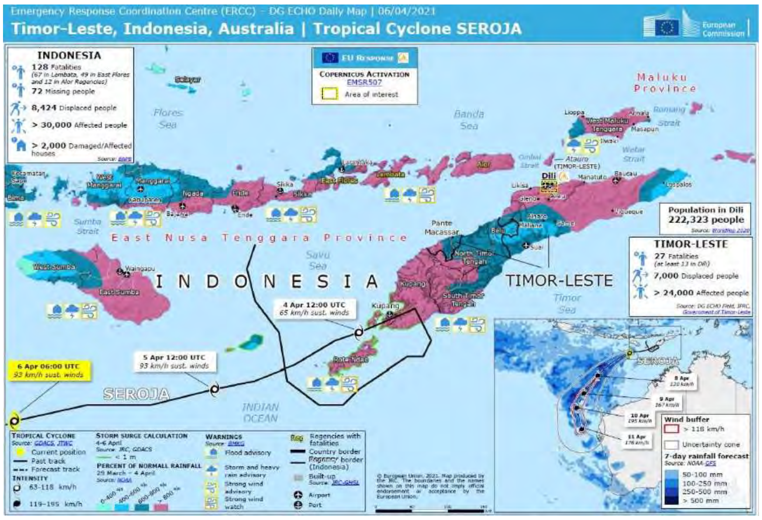
3.1.3 Understanding the mechanisms of disaster occurrence (April 2021)

(4) Situation of Severe Tropical Cyclone Seroja

According to the DNMG report, the tropical cyclone Seroja, the cause of ***This Flood*** was formed on March 29th in the southern part of Timor Sea.

On April 1st to 3rd, the winds grew stronger with moderate intensity rain in the southern part of Timor-Leste. By the early morning of April 4th, the tropical low got intensified and moved very slowly with continuous spiral convection bands occupying storm circulation, resulting in strong winds and heavy rainfall in Timor-Leste up to April 4th. The heavy rainfall hit around Dili before the depression was named as Seroja.

Seroja moved southwest on April 5th, and went away from Timor-Leste.



Source：Emergency Response Coordination Center／Tropical Cyclone Seroj

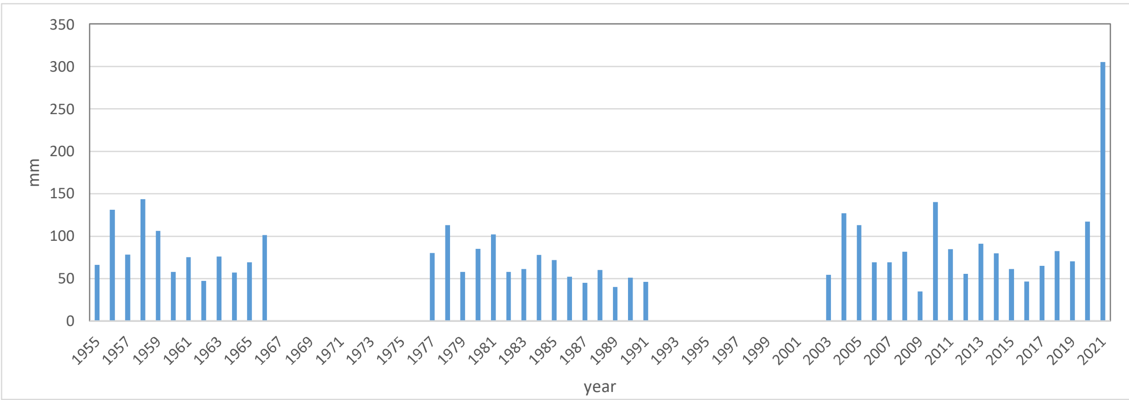
Figure 3.1-16 Track of Tropical Cyclone Seroja around Timor-Leste

Heavy rainfall from Seroja during April 1st to 4th caused enormous damage in various area of Timor-Leste. These heavy rainfalls are thought to be due not only to the formation of low depression systems but also to meteorological phenomena on various spatiotemporal scales such as the La Nina phenomena, Madden-Julian Oscillation and local weather systems.

(5) Heavy rainfall occurrences in the survey area

1) Dili

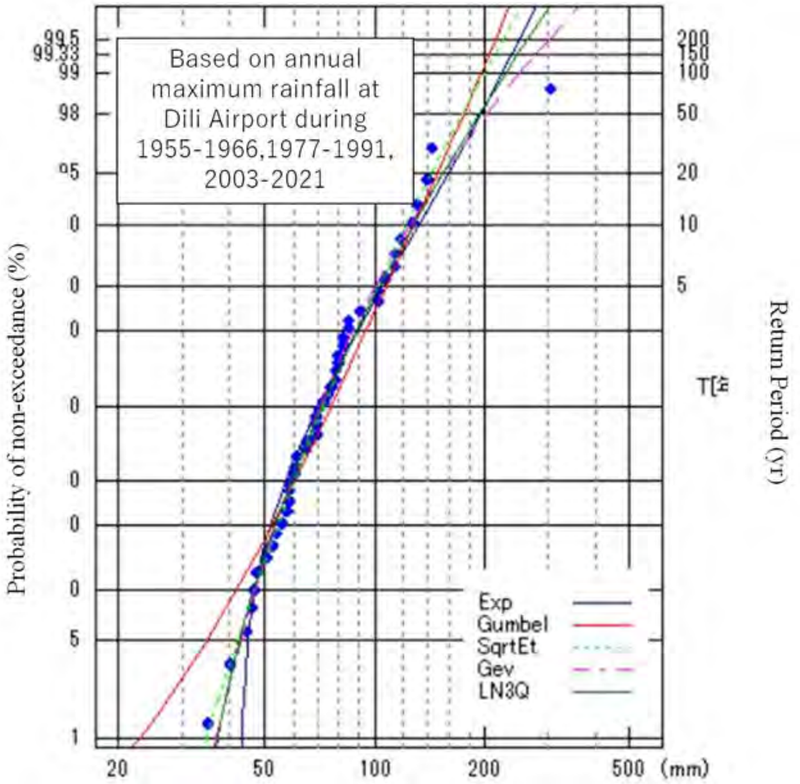
At Dili airport station, there was 305mm of rainfall for 24 hours by 6:00 AM on April 4th.On the other hand, meteorological station in Dili airport has daily rainfall data from 2003 to today. Besides, there are annual maximum daily rainfall records from 1955 to 1966 and from 1977 to 1991.



Source: JICA Survey Team based on materials provided by BTL and DNMG

Figure 3.1-17 Annual maximum daily rainfall record in Dili airport (1955-2021)

Figure 3.1-18 shows probable rainfall by using these data. According to the figure, it is confirmed that the probability rainfall in the ***This Flood*** corresponds to the 210-year return period in the generalized extreme value (hereinafter referred to as “GEV”) distribution.



Source: JICA Survey Team based on materials provided by BTL and DNMG

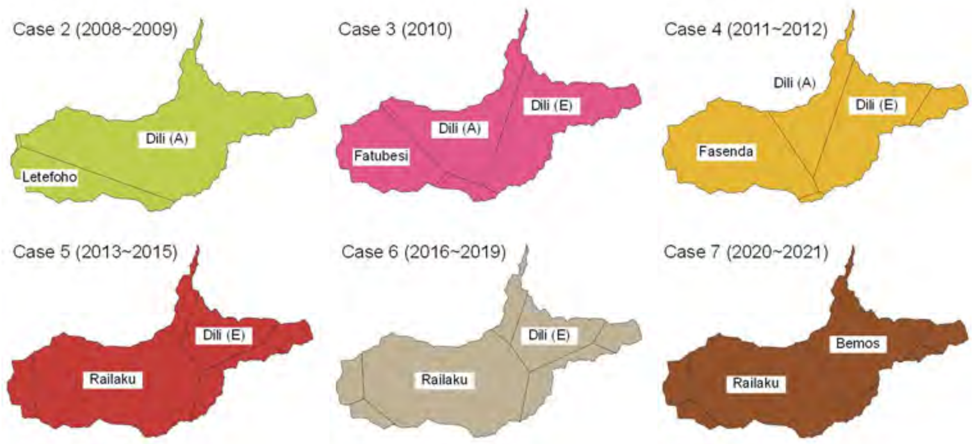
Figure 3.1-18 Probable rainfall in Dili airport

On the other hand, it should be noted that the results may differ significantly if the annual maximum rainfall for the years of 1967-1976 and 1992-2001, for which no annual maximum rainfall values are available so far, are included in the calculation of probable rainfall.

2) The Comoro River Basin

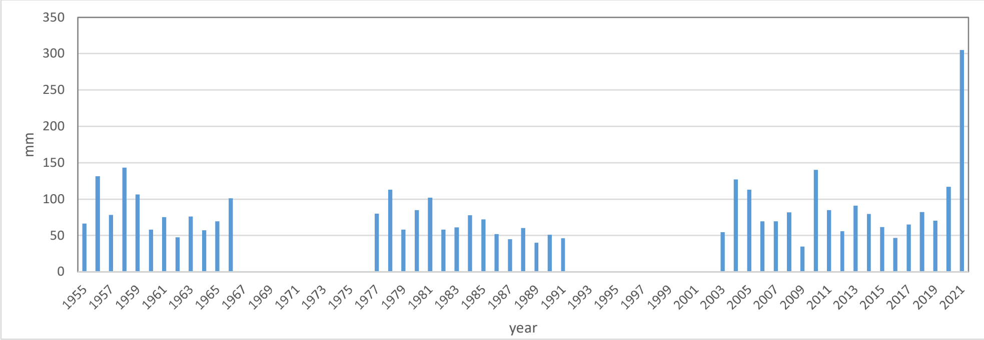
In the Comoro River basin, there are daily rainfall records of several rain gauge station managed by ANAS since 2008, but before that, only records at Dili airport exist. Therefore, JICA Survey Team created different type of Thiessen polygon delineation for each period, and estimate mean areal rainfall for the catchment area for total of 46 years. Furthermore, the annual maximum rainfall and the probability rainfall of the basin rainfall were calculated based on these Thiessen polygons(Figure 3.1-20 and Figure 3.1-21).

According to this calculation method, the daily rainfall on April 4th in the Comoro River basin was 279mm, and it corresponds to the 172 years return period rainfall for GEV, which has the best fit in the extreme value distribution based on SLSC criterion.



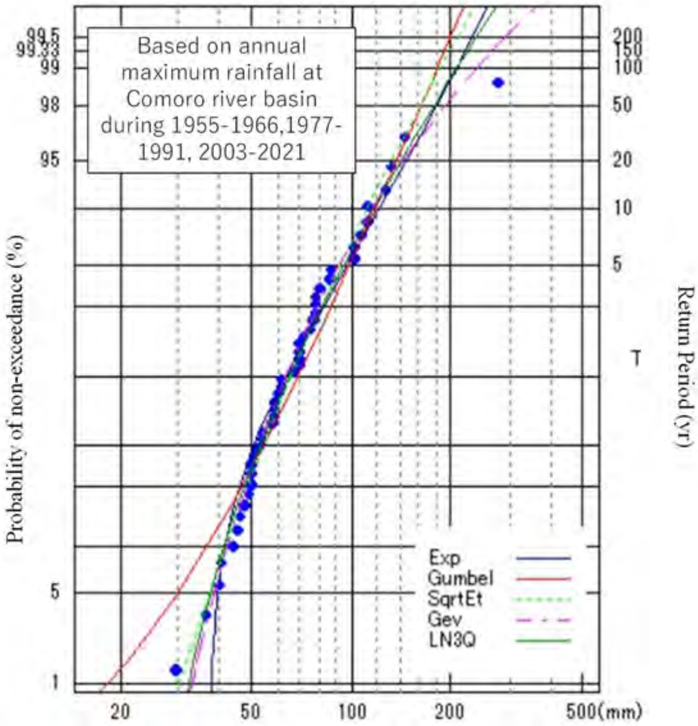
Source: JICA Survey Team

Figure 3.1-19 Thiessen delineation in the Comoro River basin (case2-case7)



Source: JICA Survey Team based on the materials provided by BTL and DNMG

Figure 3.1-20 Annual maximum rainfall in the Comoro River basin (basin averaged rainfall)



Source: JICA Survey Team based on materials provided by BTL and DNMG

Figure 3.1-21 Probable rainfall in the Comoro River basin (by Thiessen method)

Table 3.1-2 Goodness-of-fit evaluation by SLSC for hydrologic frequency models of the Comoro River basin

	Exp (Exponential D※)	Gumbel (Gumbel D※)	Sqrt-Et (SQRT-ETmax D※)	GEV (Generalized Extreme value D)	LN3Q (Log-normal D)
SLSC	0.077	0.101	0.069	0.028	0.036
50 year	181.7mm	162.8mm	161.7mm	191.8mm	177.7mm
100 year	207.3mm	191.4mm	185.1mm	236.9mm	207.1mm
150 year	222.2mm	192.2mm	199.4mm	267.7mm	225.4mm
200 year	232.8mm	199.9mm	212.0mm	291.8mm	238.9mm

Source: JICA Survey Team

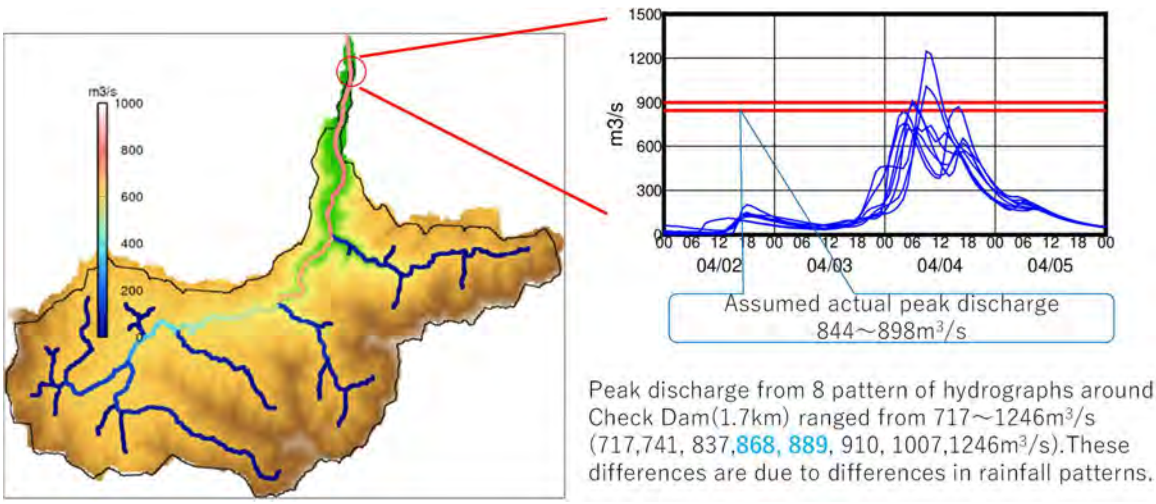
※D: Distribution

According to interviews with local residents in the vicinity of the No.1 Check Dam, the Comoro River did not overflow during ***This Flood***, but water level was almost as high as the top of the revetment. On-site survey indicate that the peak water level of ***This Flood*** reached 2.5m-2.6m(Figure 3.1-22). This depth corresponds to a flow rate of 848-898 m^3/s from the weir formula, which is applicable to backward-facing step like this location based on hydraulic property.

Source: JICA Survey Team

Figure 3.1-22 Peak Water Level during *This Flood*

The rainfall in the meso-scale meteorological model WRF shown in 3.1.2(2) was corrected so that the 24-hour rainfall on April 4th was 279 mm, and runoff analysis was conducted using eight patterns of rainfall datasets. There were large differences in peak discharge, ranged from 717-1,246 m^3/s at the location due to differences in rainfall patterns, though the daily rainfall was the same (Figure3.1-23).

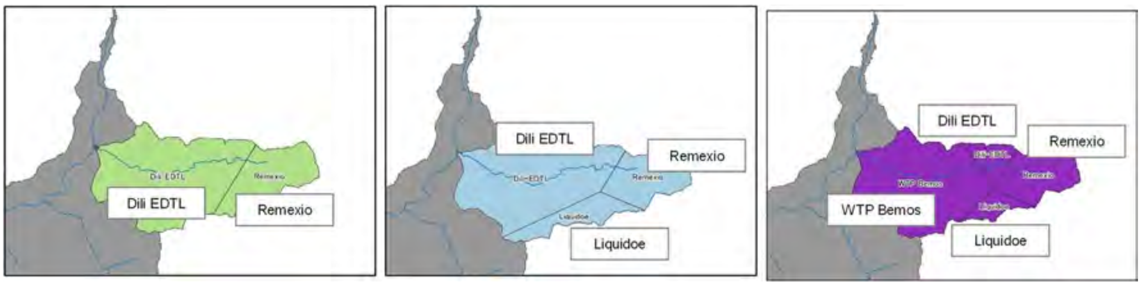


Source: JICA Survey Team

Figure 3.1-23 Peak discharge during *This Flood* by using 8 rainfall datasets

3) Bemos sub-watershed in the Comoro River Basin

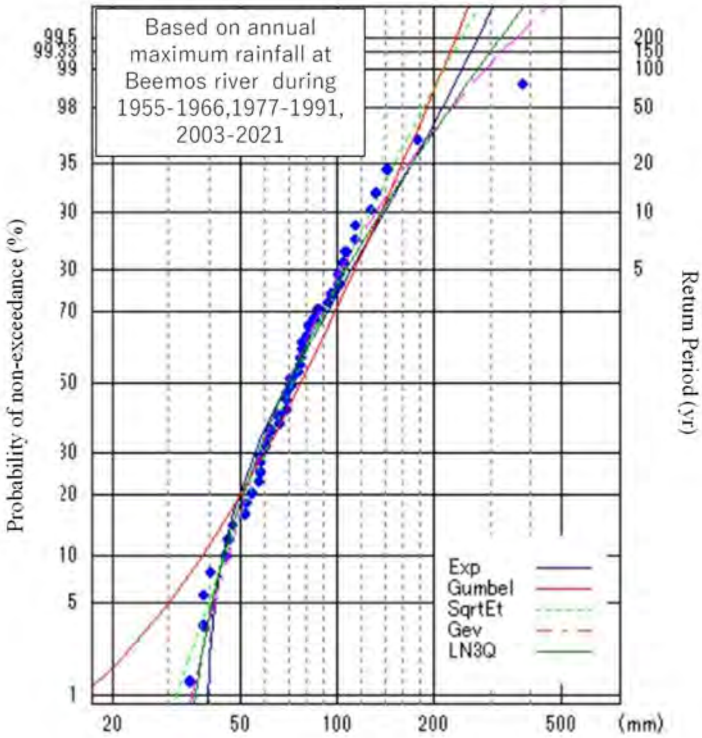
The areal rainfall of Bemos River was calculated by Thiessen method in the same way as the Comoro River basin, and annual maximum areal rainfall was extracted. Calculated daily rainfall during ***This Flood*** was 379mm, which correspond to 233 return period rainfall for GEV, which has the best fit in the extreme value distribution based on SLSC criterion.



Case3 Case4 Case5

Source: JICA Survey Team

Figure 3.1-24 Thiessen polygon delineations of Bemos River for each period



Source: JICA Survey Team

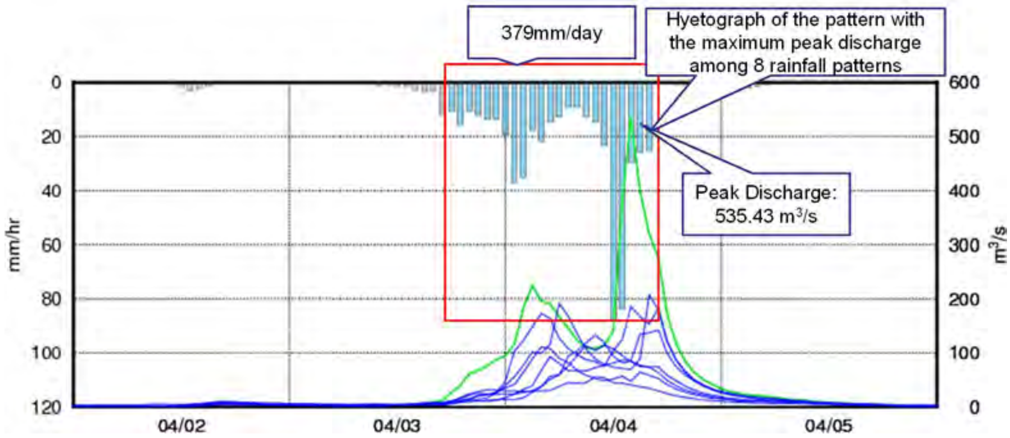
Figure 3.1-25 Probable rainfall in Bemos River basin (by Thiessen method)

Table 3.1-3 Goodness-of-fit evaluation by SLSC for hydrologic frequency models of Bemos River

	Exp (Exponential D※)	Gumbel (Gumbel D※)	Sqrt-Et (SQRT-ETmax D※)	GEV (Generalized Extreme value D)	LN3Q (Log-normal D)
SLSC	0.112	0.138	0.091	0.034	0.038
20 year	172.5 mm	160.5 mm	151.8 mm	168.3 mm	173.0mm
50 year	213.3 mm	190.4 mm	186.2 mm	228.7 mm	226.3 mm
100 year	244.2 mm	212.9 mm	214.1 mm	287.5 mm	272.54mm

Source: JICA Survey Team

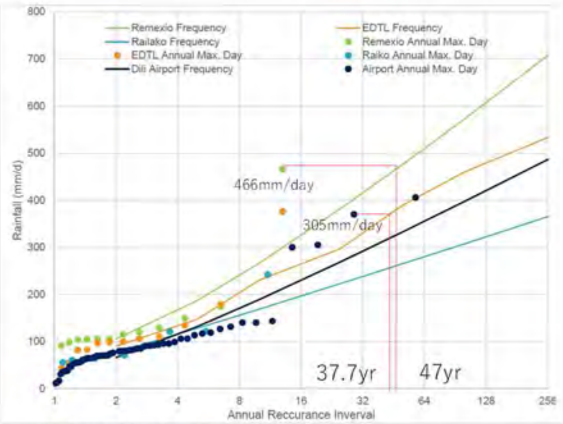
Using the rainfall data from the meso-meteorological model WRF shown in 3.1.2(2), a runoff analysis using the storage routing model showed that the peak flow near the Bemos River intake weir reached a maximum of 535 m^3/s for the rainfall of 233 Return period(Figure 3.1-26).



Source: JICA Survey Team

Figure 3.1-26 Estimation of the discharge of Bemos River by Storage Routing Method

On the other hand, analysis conducted by Engineers Without Borders (hereinafter referred to as "EWB") evaluates that the probability of ***This Flood*** is correspond to 37.7 year return period event at Dili Airport and 47 year return period at Aileu/Remexio.



Source: Materials provided by BTL

Figure 3.1-27 Recorded and inferred Max Daily Rainfall Frequencies

The evaluation results on the JICA survey team side and EWB side are significantly different, this mainly due to the fact that EWB evaluates only the short-term period of rainfall of about 10 years for each rain gauge stations whereas JICA Survey Team use 46 years rainfall data. Highly accurate probable rainfall cannot be calculated from short term rainfall sample, and the plotting position and the extreme value distribution (Log Pearson III distribution) are far apart.

(6) Damage of April flood and mechanisms of disaster occurrence

1) Disaster of April flood

Regarding the April flood, damage occurred in various places around Dili Municipality as shown in Figure 3.1-28.

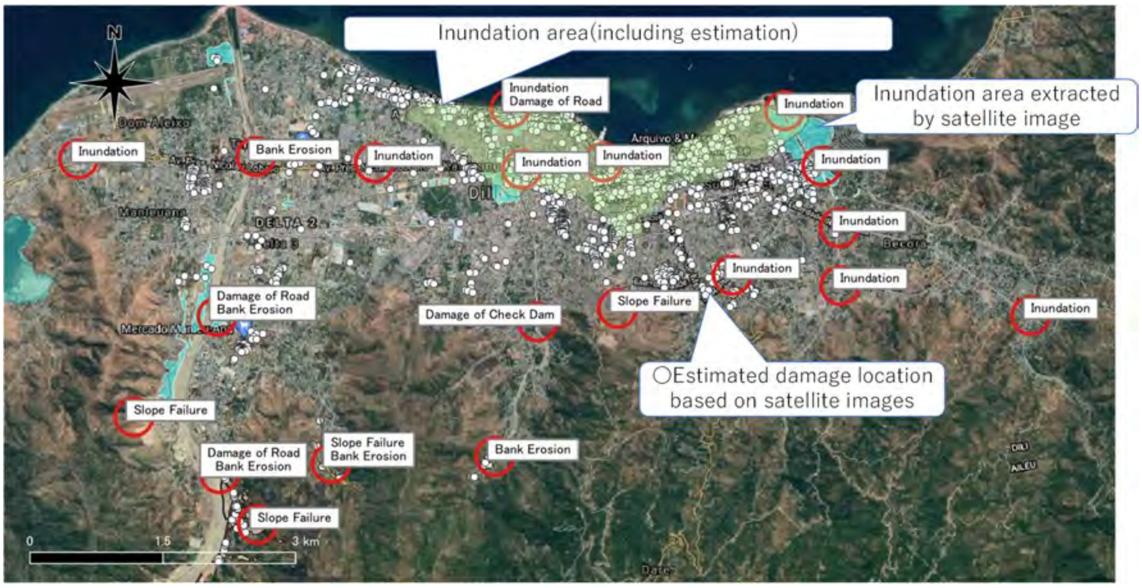
Source: JICA Survey Team based on the materials provided by several Institutions

Figure 3.1-28 Damage situation around Dili Municipality caused by April flood

① Dili

Figure 3.1-29 shows the damage in the center area of Dili caused by April flood. Damage has occurred in various places from upstream to downstream of the River and low-lying area.

Sediment disasters occurred in the upstream area and River channels is blocked in the middle reach due to the sediment accumulation at the intersection of road bridges and urban streams. In the downstream low-lying area, the possibility of flood damage due to storm surge and insufficient drainage capacity has been reported.



Source: JICA Survey Team based on the materials provided by several Institutions

Figure 3.1-29 Damage situation in the center area of Dili during April flood

a) Eastern part of Dili

According to the Flood Damage Assessment Report[2], in the vicinity of My Friend bridge on the Lahane River, riverbed rose by about 1 to 2m due to sediment and overflow occurred. It is reported mud flow reached 50-70cm.

[2] 08 April 2021, Materials provided from MPS

Source：JICA Survey Team based on the materials provided by MPS

Figure 3.1-30 Situation of sediment deposits a few days after flooding near the My Friend Bridge of Lahane River

It is reported that Sediment accumulation in the Taibeshi River channel reached 1-2m and overflow occurred near the Bekushi Bridge on the Taibesi River. It is supposed that the box culvert, which does not have sufficient height, accumulated driftwoods and rocks, caused the blockage of river channel.

Source: JICA Survey Team based on the materials provided by MPS, UNTL

Figure 3.1-31 Damage situation at Bekusi Bridge, Taibesi River

At the Maufelu bridge on the Taibesi River, it is reported that sediment accumulation in the river channel reached 1-2m and flooding occurred, and the mud flow reached 50-70cm.

Source: JICA Survey Team based on the materials provided by MPS, UNTL

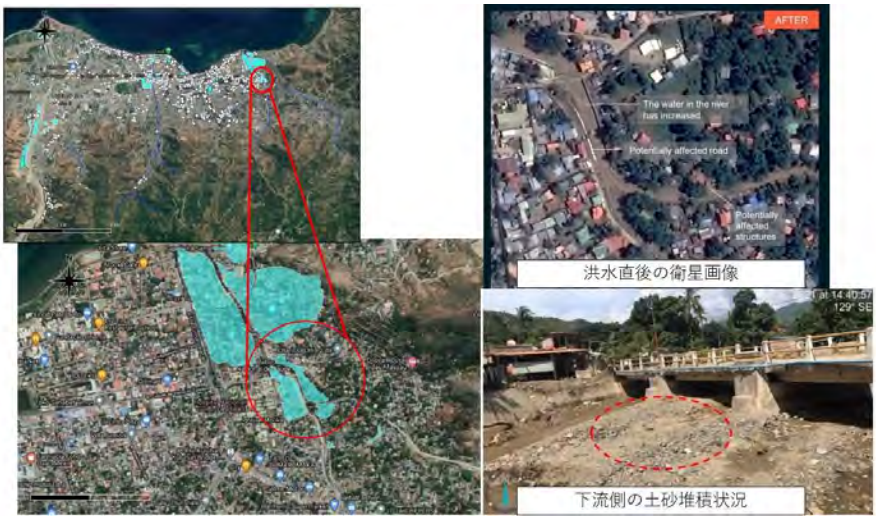
Figure 3.1-32 Damage situation near Maufelu Bridge, Taibesi River

In the vicinity of the bus terminal along the Becora River, the riverbed rose 1-2m due to the sediment accumulation and driftwoods in the channel, which caused flooding. It is reported that mudflow reached 50-70cm.

Source: JICA Survey Team based on the materials provided by UNTL

Figure 3.1-33 Damage situation near bus terminal along Becora River

No major damage was reported downstream from the vicinity of the bus terminal, Becora River. On the other hand, near Bidau Massaur bridge on the Santana River, where the Taibesi and Becora River merged, sediment accumulation in the river channel reached 1.5-2.0m and overflow was occurred. It is reported that mud thickness is range from 50cm to 70cm. In addition, it is reported that seven houses were washed away and several locations of roads and retaining walls were damaged.



Source: JICA Survey Team based on the materials provided by UNTL

Figure 3.1-34 Damage situation near Bidau bridge, Santana River

At the mouth of Santana River, sediment accumulation in the river channel reached 1.5m-2m and overflow was occurred. The mud thickness of the overflow water is reported to range from 50cm to 70cm. It is also reported that several points of road along the river and retaining walls were damaged.

Source: JICA Survey Team based on the materials provided by UNTL and released by UNOSAT

Figure 3.1-35 Damage situation of mouth of Kuluhun and Santana River

b) Center area of Dili

According to the material provided by UNTL, it is reported that dwellings along the banks of Maloa River were damaged due to the erosion of banks in the upstream of Maloa River. It is also reported that the check dam, which located in the middle reach of Maloa River, was partially damaged by mud flow.

The downstream of Maloa River flow through the low-lying area of central Dili, but as shown in Figure 3.1-36, it is reported that the river channel was blocked by sediment and waste, causing enormous inundation damage.

Source: JICA Survey Team based on the materials provided by UNTL and released by UNOSAT

Figure 3.1-36 Damage around the downstream of Maloa River

Figure 3.1-37 shows the damage of the Japanese embassy located near the mouth of Maloa River. Road on Portugal Street had been reported to be damaged.

Source: JICA Survey Team based on the materials provided by UNTL

Figure 3.1-37 Damage of the Japanese Embassy

c) Western part of Dili

It is reported that a debris flow occurred in the upstream of Manleu-ana River, which is located between the Comoro and the Maloa River, which caused riverbank erosion and some dwellings were outflowed.

Source: Materials provided by UNTL

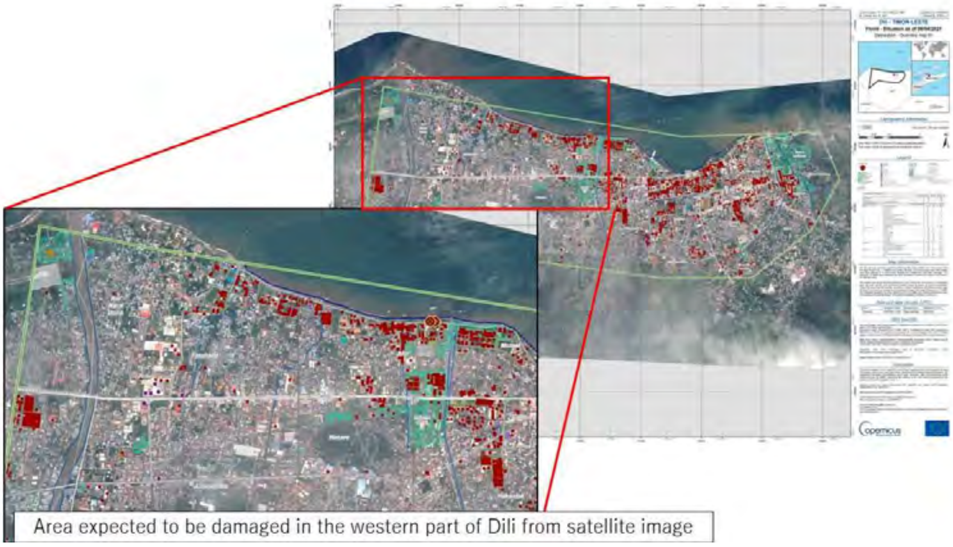
Figure 3.1-38 Damage situation at the upstream of Manleu-ana River

The drainage of Manleu-ana River is suddenly narrowed across the road, and it is reported that excessive sediment accumulation in the channel caused the flood damage.

Source: Materials provided by UNTL

Figure 3.1-39 Damage situation at the midstream of Manleu-ana River

In the low-lying area western part of Maloa River damage is assumed based on satellite image, though there is almost no specific description in various materials.



Source: JICA Survey Team based on the materials released by Copernicus

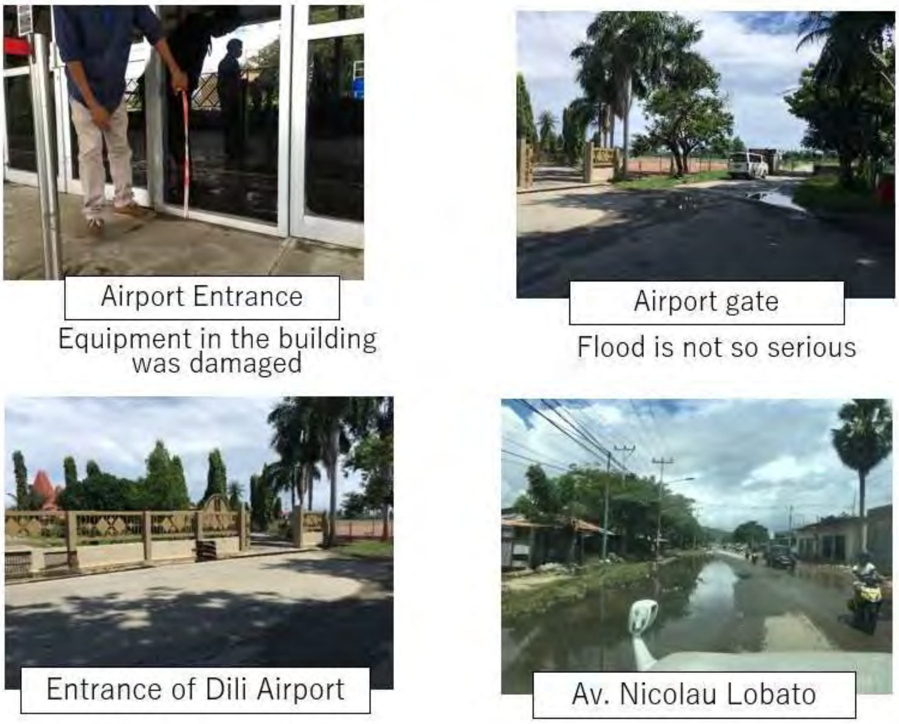
Figure 3.1-40 Area expected to be damaged in the western part of Dili by satellite image

It is reported that the retaining wall of the drainage channel collapsed near Fatuhada, causing damage to an inundation depth of about 40-50cm.

Source: JICA Survey Team based on the materials provided by MPS

Figure 3.1-41 Damage situation near Fatuhada

In the vicinity of Dili airport, it has been confirmed that flood damage occurred on the road in the south side of the airport and airport building located in a lower area than the surrounding area.



Source: Materials provided by MPS

Figure 3.1-42 Damage situation around Dili airport

② Downstream of the Comoro River basin

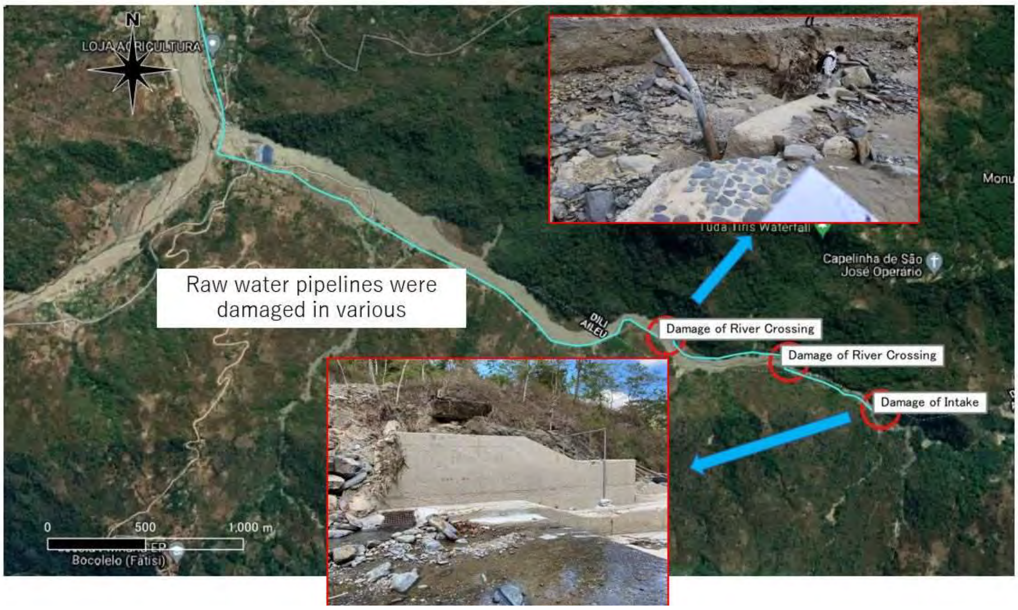
Major damages have been confirmed at the locations as shown in Figure 3.1-43. It is presumed slope failure occurred in the high risk area, because the right bank near the confluence point is a steep slope. In addition, scouring and sucking out due to floodwater are considered to be the causes of the damage, because inundation has not occurred though the road damage and riverbank erosion have been confirmed at several points.

Source: JICA survey team based on the materials from MPS

Figure 3.1-43 Major damage situation around downstream of the Comoro River basin

③ Dili water supply facility

Damage has been confirmed at the locations shown in Figure 3.1-44. The Bemos River, which is the main disaster area, is surrounded by steep slopes and is considered to be vulnerable to floods. The raw water pipeline had been buried to prevent flood damage, but it was exposed and damaged in various places due to the unexpected heavy rain.

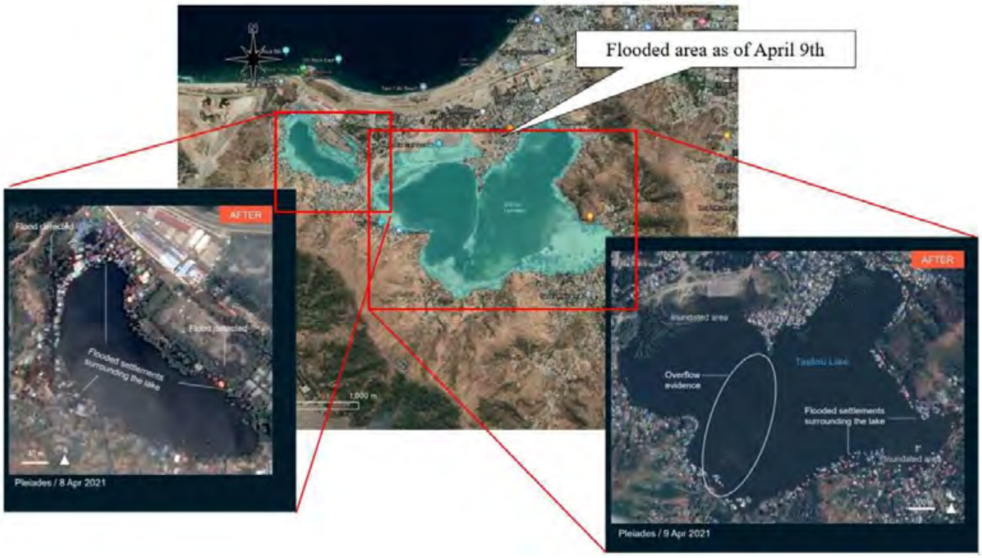


Source: JICA survey team

Figure 3.1-44 Major damage situation around Dili water supply facility

④ Tasitolu

Figure 3.1-45 shows the damage situation around Lake Tasitolu during April flood. It has been reported that the water level of Lake Tasitolu has risen and which caused the inundation damage to the extent that the inundation depth in the surrounding dwellings reaches about 1m. Local people say the flood damage lasted for about one month.



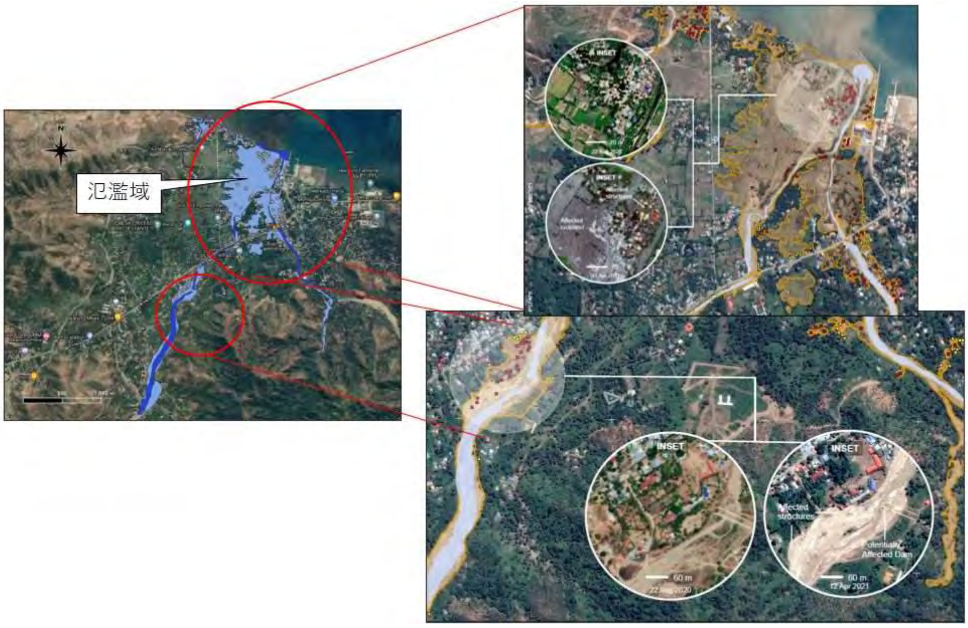
Source: JICA Survey Team based on the UNOSAT material

Figure 3.1-45 Damage situation around Lake Tasitolu

⑤ Hera

Figure 3.1-46 shows the flood damage in Hera. According to the FAO material3, crop land near the mouth of Mota-Kiik was washed away by flash flood. Other reports says that large-scale riverbank erosion occurred in the area about 1km south of UNTL Hera Campus, which washed away several houses.

[3] SPECIAL REPORT 2021 FAO CROP AND FOOD SUPPLY ASSESSMENT MISSION(CFSAM) TO THE DEMOCRATIC REPUBLIC OF TIMOR-LESTE, 16 JUN2021

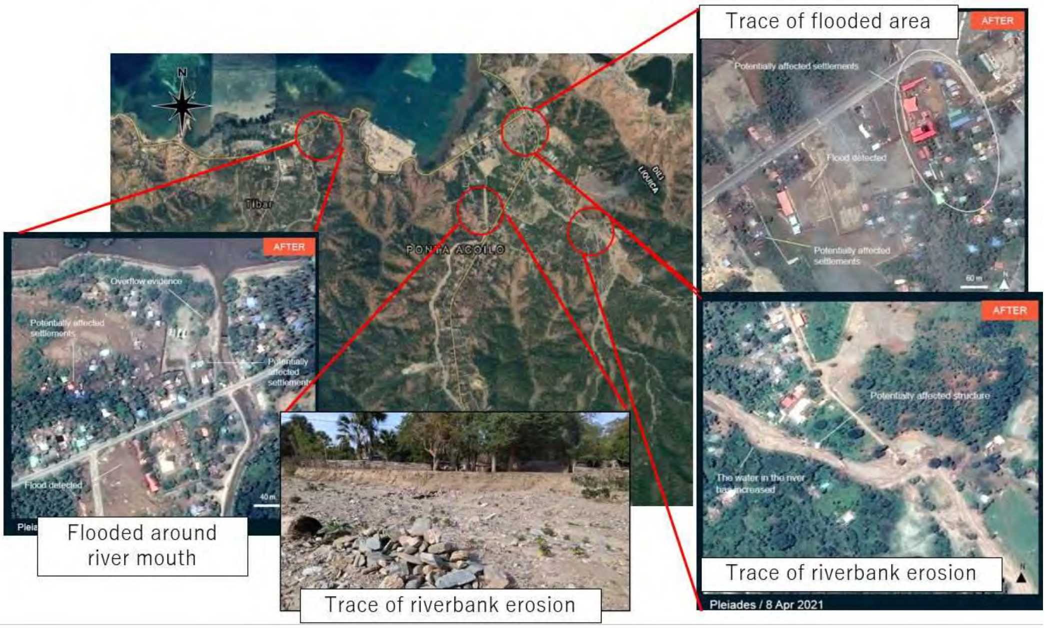


Source: JICA Survey Team based on the UNOSAT material

Figure 3.1-46 Damage situation in Hera

⑥ Tibar

Figure 3.1-47 shows the flood damage in Tibar. From the satellite images, it was confirmed that flood damage occurred near the intersection of channels and the road, and the near the river mouth. Traces of riverbank erosion were also confirmed at several locations.

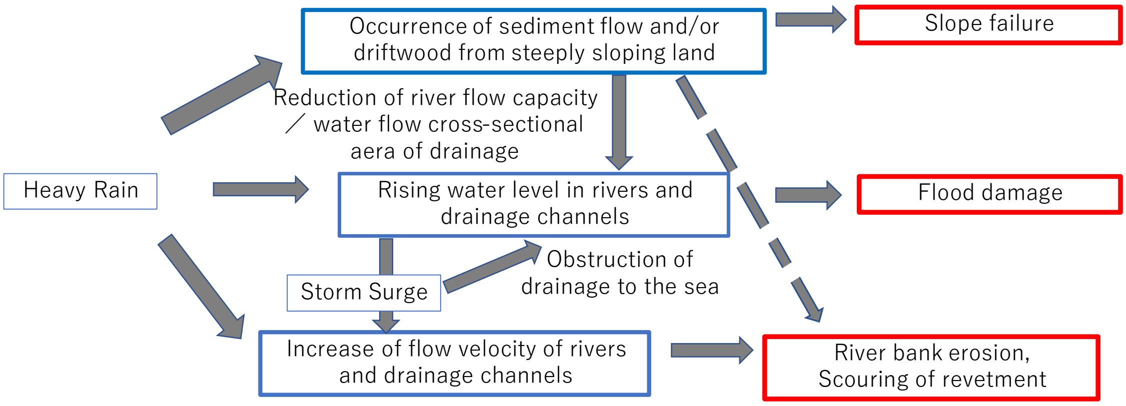


Source: JICA Survey Team based on the UNOSAT material

Figure 3.1-47 Damage situation in Tibar

2) Mechanisms of disaster occurrence

The disaster occurrence mechanism of ***This Flood*** is roughly classified as shown in Figure 3.1-48.



Source: JICA Survey Team

Figure 3.1-48 Disaster occurrence mechanism of *This Flood*

Relatively high elevation areas of Dili have steep slopes, but its forest and land are not properly managed, and sediment runoff is likely to occur during rainfall. Check dams, which have the function of suppressing of sediment out flow, were not functioning, and sediment that flowed out from the upstream accumulated in the downstream of river channel, which caused rising of riverbed and blockage of the river channel. From the damage situation, it is presumed that sediment and water flood is occurred in the small river area of Dili during ***This Flood***.

With respect to the Comoro River, there was no overflow but it is assumed that mudflow flowed through the river channel, which cause riverbank erosion, scouring of revetment foundation, outflow of revetment blocks and collapse of revetment.

In Bemos River, there was evidence that flood flow carried rocks and driftwoods, which is thought to have caused enormous damage at the intake facility.

Based on these circumstances, future flood countermeasures should take into account not only rainfall and water levels/flow rates in rivers and drainage channels, but also sediment dynamics in the watershed.

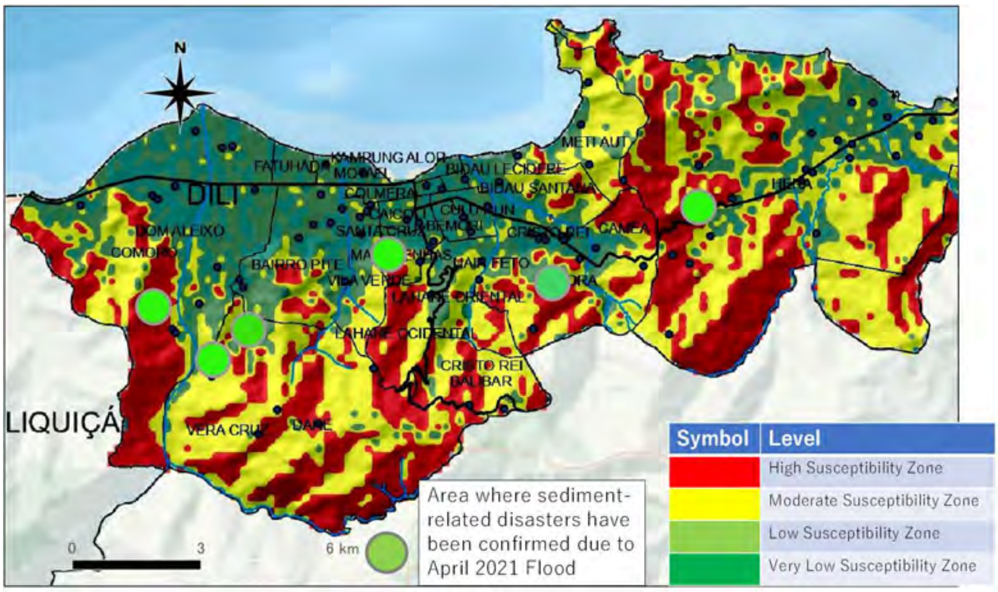
3.1.4 Analysis of disaster risk at survey area

Based on the disaster occurrence mechanism discussed in 3.1.3, disaster risk assessment was carried out by overlaying the damage situation of ***This Flood*** on the existing landslide risk map and Flood risk map.

(1) Risk assessment for landslide

In the event of sediment-related disasters, the Institute of Petroleum and Geology (hereinafter referred to as “IPG”) made risk map of Timor-Leste. Figure 3.1-49 shows the location of sediment-related disaster in Dili of ***This Flood*** with the map.

The affected area of ***This Flood*** is located in a High Susceptibility Zone in most areas. From this map, it is likely that there are areas where sediment-related disasters occurred other than the areas shown in Figure 3.1-49.

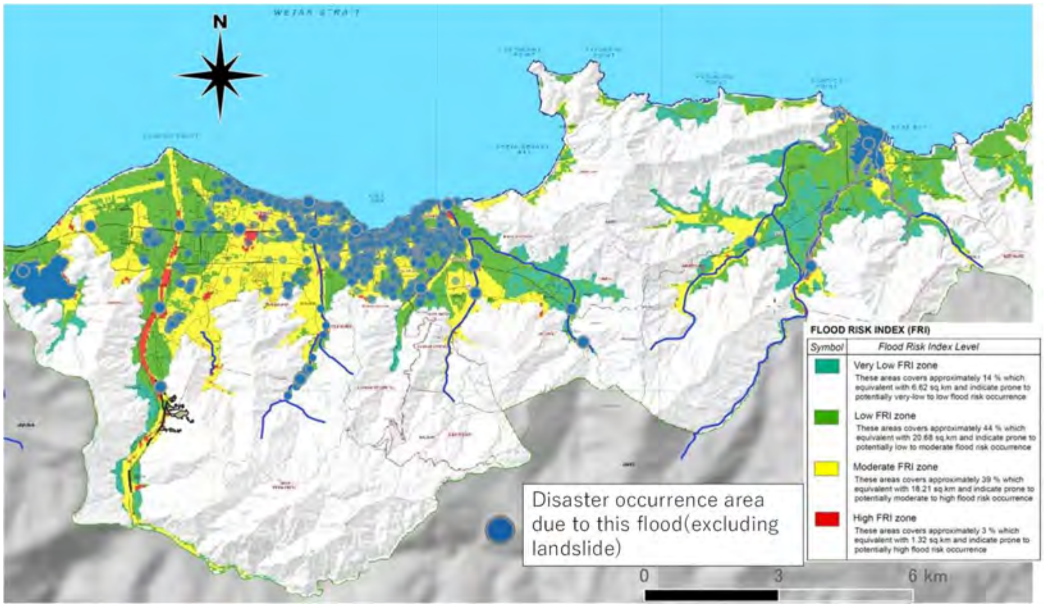


Source: JICA Survey Team based on the material provided by IPG

Figure 3.1-49 Landslide risk assessment map

(2) Flood risk assessment

Flood Risk Map was created by researchers at UNTL and IPG and Yamaguchi-University. Figure 3.1-50 shows location where flood damage and riverbank erosion occurred due to ***This Flood*** with the map.



Source: JICA Survey Team based on the material provided by UNTL

Figure 3.1-50 Flood risk assessment map

From this figure, it can be confirmed that the damage caused by ***This Flood*** did not necessary occur in High Risk zone. It is presumed that the damage of ***This Flood*** was not just flood damage but a complex disaster of sediment and water flood.

On the other hand, there are some places the damage could have been avoided if rivers, channels, or other facilities were properly maintained. In addition, there are some areas that were not damaged by ***This Flood*** but located in High Risk Zone.

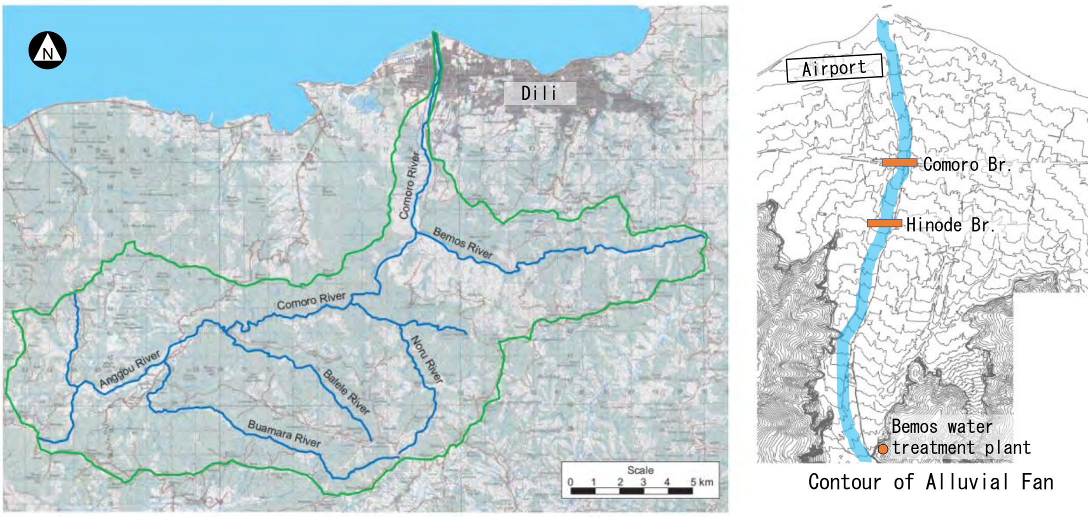
Based on these situations, the measures for survey area and each facility for Build Back Better were examined in the following sections.

3.2 Study on rehabilitation plan of the Comoro River

3.2.1 Outline of the Comoro River

(1) General Overview

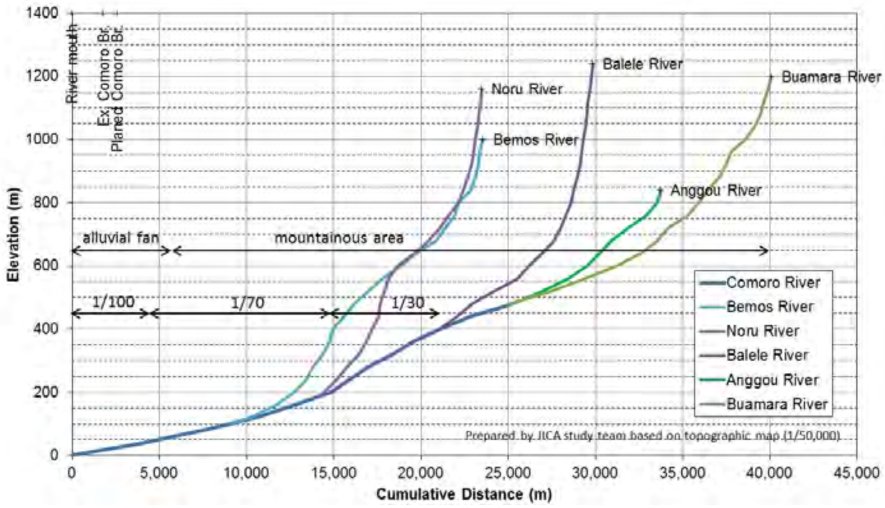
Comoro River basin has a catchment area of 207 km^2, which covers about 30 km east-west and about 4 to 8 km north-south as shown in Figure 3.2-1. Most of the river basin area is mountainous. From the west, the Anggou River, the Buamara River and the Balete River join and become the Comoro River. The Comoro River joins the Noru River and the Bemos River, which are tributaries on the right bank in the mountainous area. It then reaches the head of the alluvial fan located about 5.5 km from the river mouth and flows straight to the see. The alluvial fan has been formed by repeating flood inundation (Figure 3.2-1).



Source: The study team revised output of "Preparatory Survey Report on the Project for the Construction of Upriver Comoro Bridge in the Democratic Republic of Timor-Leste (2014), JICA"

Figure 3.2-1 Comoro River Basin

"Preparatory Survey Report on the Project for the Construction of Upriver Comoro Bridge in the Democratic Republic of Timor-Leste (2014), JICA" illustrates the longitudinal profile of Comoro River system prepared based on topographic map of 1:50,000-scale as shown in Figure 3.2-2. Longitudinal gradients of 5 tributaries flowing in mountainous area are 1/10 - 1/24. Regarding the Comoro River, longitudinal gradient is 1/30 in mountainous area and 1/70 for the downstream reaches from the confluence with the Noru River (14 km from the river mouth). Longitudinal slope gets gentler as the river flows downstream.



Source: Preparatory Survey Report on the Project for the Construction of Upriver Comoro Bridge in the Democratic Republic of Timor-Leste (2014), JICA

Figure 3.2-2 Longitudinal Profile of Comoro River System

(2) River Management

1) River Administrator and River Law

Rivers are used by the public, and river management must be carried out properly for the purpose of preventing the occurrence of disasters such as floods and storm surges and maintaining public safety. The person/organization who has the authority and obligation to manage this river is the river administrator, but in East Timor, the river administrator is not clearly defined. In addition, the River Law, which stipulates river administration including the river administrator, has not been enacted.

Originally, the river administrator is responsible for installing and managing facilities that have functions such as stabilizing the flow discharge and water level of the river and preventing damage caused by floods, such as embankments, revetments, ground sill, weirs, etc. In addition, the river administrator formulates plans of flood control, water utility and environmental improvement, and carries out construction and maintenance of river management facilities. In East Timor, the construction of river management facilities is carried out by DRBFC, and maintenance after construction is the role of the municipalities, but it may differ depending on the location and facility.

In general, the River Law is a law that stipulates comprehensive river administration such as construction of facilities to prevent damage caused by floods, regulation of river water use, management of river terrace use, and river water quality management.

2) River Structures in Comoro River

a) Revetment

There are three types of revetments on the Comoro River, i.e., wet masonry, gabion mattress, and concrete block masonry. The placing status of the revetments for each of the left and right banks is as follows.

(Left Bank)

- River mouth – 1.2km: wet masonry is installed. The height is about 2m but the foundation of 1 – 2m is exposed. Houses are built on embankment filled in front of revetment at the upper reach.
- 1.2km – 1.69km (ground sill No. 1): Revetment for this section is not clearly visible because of densely packed houses.
- 1.7km - 2.3km: No revetment.
- 2.3km – 2.67km (Hinode Bridge built by Japan’s Grant Aid in 2018): Low water channel revetment (wet masonry, H=1.6 – 2.5m) is placed 50m away from the high water channel bank.

・ 2.67km: Concrete block masonries (1:0.5) are placed on highwater channel bank and low water channel bank in the upper/lower reaches. On the end of the concrete masonries, gabion mattress is placed as transition structure.
・ 2.8km - 3.0km: Low water channel revetment of wet masonry with about 4m height is installed.
・ 3.0km - 3.36km: Gabion mattress is laid in as low water channel revetment.
・ 3.36km - 4.13km: The ground sill No.2 exists in this stretch. Wet masonry with 1.5m height is set in.
・ 5.4km – 5.57km: Wet masonry revetment is placed. It seemed to be constructed in a little old time, because the surface of revetment is not mortar finish as other wet masonry.

Source: Taken by the study team

Figure3.2-3 Revetment of Hinode Bridge

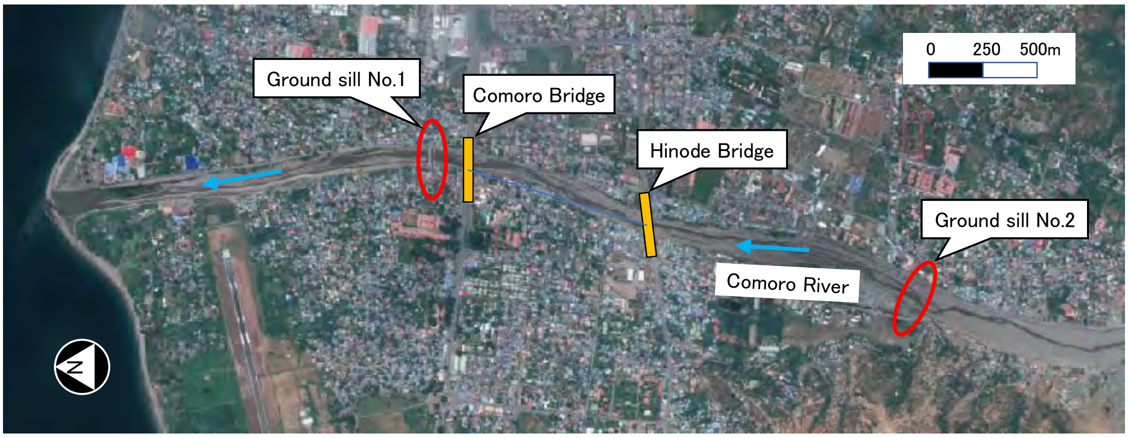
・ 6.1km - 6.5km: Wet masonry revetment is installed. In lower stream from 6.1km, it is not clear the stretch placing revetment because it is completely washed away.

(Right Bank)

・ From river moth to 9km (confluence with Bemos River), revetment is installed on the right bank. Wet masonry is mainly adopted except the following sections.
・ At Hinode bridge site (2.67km), Concrete block masonries (1:0.5) are placed on highwater channel bank and low water channel bank in the upper/lower reaches. On the end of the concrete masonries, gabion mattress is placed as transition structure.
・ For 750m from the upper end of revetment of Hinode bridge, status of revetment is not visible because many houses are densely built.
・ For 450m upstream from 3.4km, revetment by gabion mattress is set in. 10 layers of gabion mattress are piled up with 1:0.5 slope on riverbank with about 10m height.
・ From 5.6km to 6.2km, a gravel mining company extensively fills up in the river. The earth filled has no slope protection.

b) Ground sill

2 ground sills are installed from river mouth to 10km in the lower Comoro River (Figure 3.2-4). Current status of them is described respectively. They are expressed as ground sill No.1 in downstream and ground sill No.2 in upstream.



Source: The Study Team

Figure 3.2-4 Location Map of Groundsills

Ground sill No.1 (1.69km, Figure 3.2-5): Ground sill No.1 is located 150m downstream of Comoro Bridge in order to prevent riverbed degradation at the bridge. It was renovated in 2019 because the damage became large from around 2017, the center of head part was missing, the sediment on the upstream side was washed away, and the range of the riverbed scouring could extend to the upstream

Comoro Bridge. The gap the upstream level and the downstream one is relatively large due to riverbed material mining on a large scale. DRBFC has a plan that installation of more groundsills near future.

Source: The Study Team

Figure 3.2-5 Ground sill No.1

Ground sill No.2 (3.88km, Figure 3.2-6): Ground sill No.2 was constructed in 2017 aiming to prevent riverbed degradation caused by excessive riverbed material mining. Figure 3.2-7 shows the changing of riverbed elevation before and after 2021 April flood. Comparing the riverbed heights, the riverbed rise is remarkable upstream of the groundsill No.1, while the riverbed decline tendency is shown downstream, and the ground sill No.1 restrains the movement of the riverbed material.

Source: The Study Team

Figure 3.2-6 Ground sill No.2

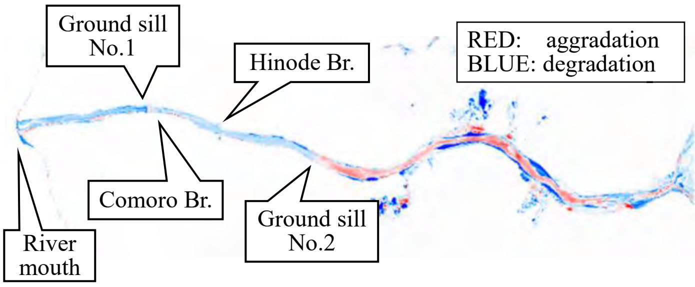


Figure 3.2-7 Changing of riverbed level around ground sill No.2

c) Groin

There are 6 new and old groins in place over a distance of 10km from the river mouth. All the groins are located on the right bank. The status of each groin is described below.

Groin No.1 (0.78km on the right bank, Figure 3.2-8): A groin made of gabion mattress is installed, but it is filled with embankment according to the height of the top and used as agricultural land. It can be said that it is in a safer state from the viewpoint of riverbank protection, but it is not preferable for river management to change the shape of the river channel and use it privately.

Groin No.2 (1.32km on the right bank, Figure 3.2-9): A groin made of gabion mattress is set in. It is 20m long, 2m high (2 layers of gabion mattress), and faces 68 degrees downstream from the direction perpendicular to the revetment alignment.

Source: Taken by the study team

Figure 3.2-8 Groin No.1

Source: Taken by the study team

Figure 3.2-9 Groin No.2

Groin No.3 (6.2km on the right bank): It is made of reinforced concrete and has a length of 45 m, facing 55 degrees downstream from the direction perpendicular to the revetment alignment. Figure 3.2-10 shows the photographs of June 2013 and October 2021. From the figure, it can be seen that the riverbed has declined in eight years. The 3rd to 4th and 5th groins are installed at intervals of 200m. It is probable that these three groins were installed as a group.

This groin has three cracks on the way. In "a) Revetment", the landfill by a gravel company on the right bank of 5.6km to 6.2km was described, but the groin No.3 located at the upstream end of the section eventually protects the landfill embankment.

2013 June: View form tip of groin to revetment

2021 October: View from upstream to groin

Source: Taken by the study team

Figure 3.2-10 Groin No.3

Groin No.4 (6.4km on the right bank): It is made of reinforced concrete and has a length of 40 m, facing 55 degrees downstream from the direction perpendicular to the revetment alignment. The main body of the groin is tilted upstream as a whole, and there are large cracks in two places. Figure 3.2-11 shows the situation in 2013 and 2021.

2013 June: View from upstream to groin

2021 October: View from tip of groin to revetment

Source: Taken by the study team

Figure 3.2-11 Groin No.4

Groin No.5 (6.6km in the right bank, Figure3.2-12): Since it is not damaged in appearance, it is not known whether or not there is a reinforcing bar, but it is considered to be made of reinforced concrete like the 3rd and 4th groins. It is 30m long and faces 48 degrees downstream from the direction perpendicular to the revetment alignment. An embankment is built between the groine and the riverbank, and a work hut is built on it.

Groin No.6 (7.68km on the right bank, Figure 3.2-13): The main body of the groin has already been destroyed, and now only the revetment attachment part can be confirmed.

Source: Taken by the study team

Figure 3.2-12 Groin No.5

Source: Taken by the study team

Figure 3.2-13 Groin No.6

(3) Gravel Mining in the River

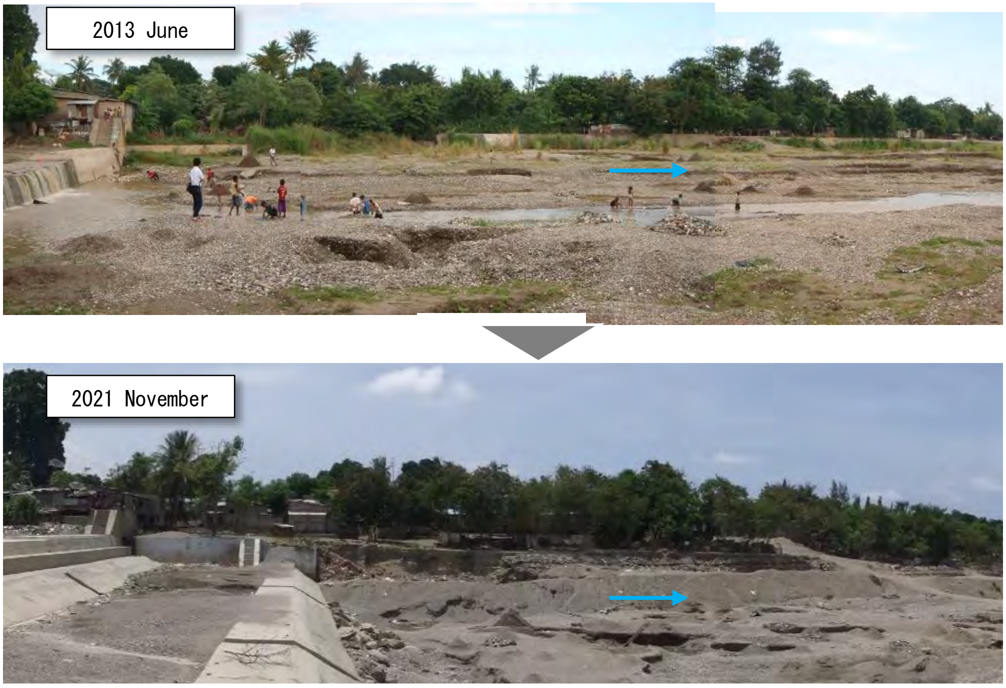
Gravel mining is actively conducted on the riverbed of the Comoro River, but the scale of mining is increasing year by year. In addition, the range is expanding further upstream. Figure 3.2-13 illustrates the change of riverbed from 2013 to 2021.

The Environment Bureau has jurisdiction over the provisions of the following laws and manages gravel mining by issuing environmental licenses.

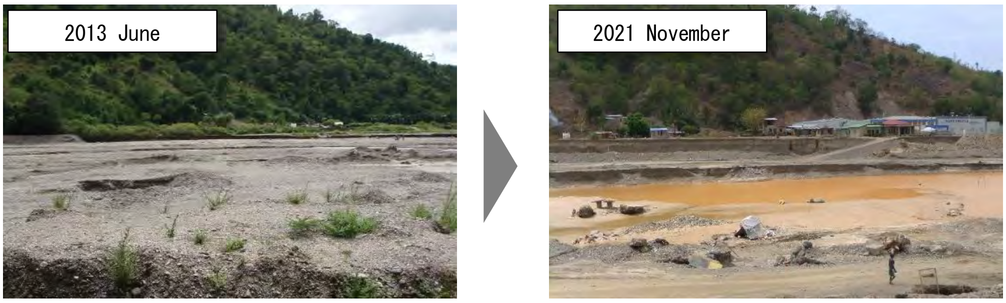
・ Government Decree Law No. 26/2012 4th July, Basic Law on Environment
・ Government Decree Law No.5/2011 9th February, Environmental Licensing

As a law related to gravel mining in rivers, there is a mining bill drafted at the time of the 7th constitution government, but the bill has not been passed until now. In addition, there is no river law in East Timor, and no draft has been considered for this. For this reason, gravel mining restrictions for river management are only indirectly screened for negative impacts when environmental license mentioned above is obtained.

Ground sill No.1 (1.69km)



6.7km



Source: Taken by Survey Team

Figure 3.2-14 Changing of Riverbed (2013-2021)

Figure 3.2-14 is a signboard indicating the minable range by the Ministry of Petroleum and Natural Resources, the Ministry of Public Works, and the Environment Bureau. However, in reality, gravel mining is being actively conducted even in the vicinity of the revetment, where mining is not permitted, and it is thought that this is one of the causes of the revetment damage caused by the 2021 April flood.

In the lower reaches of the Comoro River, the current alluvial fan is formed by repeated flooding of sediment-rich flood currents and sedimentation (Figure 3.2-1). Since there is no facility to control the sediment in the upper reaches of the Comoro River, it is expected that the supply of sediment from the upstream will continue in the future.

The flood flow with sediment from the upstream decrease flow velocity in the section where the riverbed gradient becomes gentler than that in the upstream section, and sediment is deposited. When the riverbed rises due to sedimentation, the flow cross-sectional area at the time of flood decreases, so it is necessary to manage the river by excavating the riverbed to secure the flow cross-sectional area.

Source: Taken by the study team

Figure 3.2-15 Signboard indicating minable range

In the Comoro River, the downstream points of 14km and 5.5km correspond to this (Fig. 3.2-2). However, in reality, it can be said that the riverbed rise due to natural power is suppressed by the active gravel mining in the river channel. Excessive gravel mining in the river channel causes the riverbed to drop and local scouring during floods, which is one of the factors that cause the revetment foundation to rise and collapse, but it also has a positive aspect of securing a flow cross sectional area. It is necessary to consider measures for gravel mining on the Comoro River from multiple perspectives as follows.

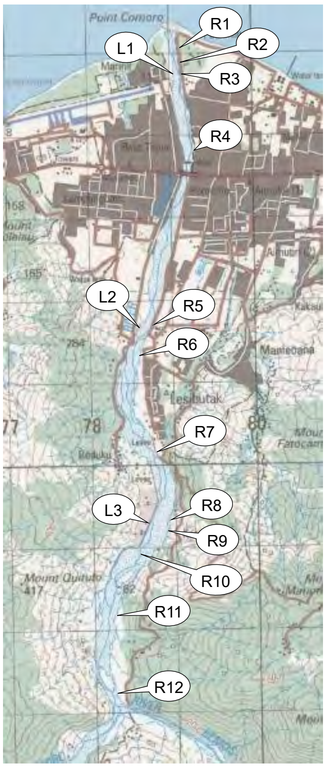
・ Not to ban gravel mining
・ To control gravel mining in line with a plan stipulating allowable mining range, volume, period, etc.
・ To incorporate gravel mining into river management

3.2.2 Damage assessment of the Comoro River

The damage to the Comoro River caused by the April 2021 floods can be divided into (a) damage to the revetment due to the flood flow and associated riverbank erosion, (b) washout of the foot protection blocks around the pier of the Hinode Bridge, and (c) inundation or flushing of houses in the river channel. The flood did not cause overflow from the Comoro River.

(1) Damage of bank protection works and riverbank erosion

Figure 3.2-16 shows the location of the damaged revetment and the length of the damage in the Comoro River from the river mouth to the confluence with the Bemos River. The damage to the revetment is concentrated on the right bank, and the number of damaged locations is four times that of the left bank and the damaged length is twice that of the left bank. In particular, the revetments constructed after 2013 have been continuously damaged on the right bank (R7 to R12) upstream of 5.5km. On the other hand, on the left bank side of the same section, the road on the riverbank is cut off in the middle, so the land development is not progressing, and the revetment is limited. Details of each damaged area are described below.



Length of damaged revetment		
Left/Right bank	Symbol	Length (m)
Left bank	L1	460
	L2	23
	L3	374
	Sub-total	857
Right bank	R1	168
	R2	39
	R3	38
	R4	141
	R5	100
	R6	110
	R7	142
	R8	100
	R9	112
	R10	232
	R11	560
	R12	53
	Sub-total	1,741
Total		2,598

Source: Made by Survey Team

Figure 3.2-16 Location and Length of Damaged Revetment

a) L1 (0.7km)

Wet masonry revetment with a height of 3.5 to 4 m has collapsed in a section of about 460 m. It is probable that the flooding promoted scouring and collapsed in the place where the revetment was shallow due to the deterioration of the riverbed over the years. In addition, since there is no lateral strip in the revetment, it is probable that the collapse at a certain point propagated to the adjacent revetment. When the revetment is restored, it is necessary to lay lateral strips at regular intervals.

The riverbank of this section is located about 180m from the runway end of the airport. From the viewpoint of reducing the disaster risk of the airport, which is a critical infrastructure, the priority of restoration of this section is high.

Source: (L) Made by the study team using satellite image (NTT DATA) and (R) taken by the study team

Figure 3.2-17 Damaged Revetment (L1)

b) L2 (3.8km)

The low water revetment on the left bank 100m downstream of the check dam has been washed away by 23m. The structure is wet masonry, and the surface is finished with mortar. The height of the revetment is about 2m from riverbed. It seems that gravel is artificially piled up on foot of slope, and the situation before the disaster is unknown. There is no lateral strip in the remaining revetment. With the construction of the check dam 100m upstream in 2019, there is concern that sediment movement from the upstream will be suppressed during floods and the riverbed will decline. The back of the revetment is the site of a construction company (soil storage area).

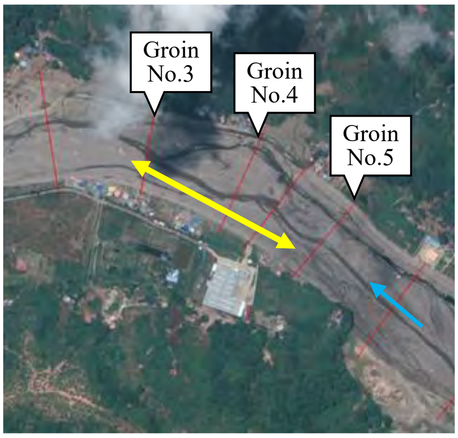
Source: (L) Made by the study team using satellite image (NTT DATA) and (R) taken by the study team

Figure 3.2-18 Damaged Revetment (L2)

c) L3 (6.3km)

The revetment has been damaged over 374m. As shown in Figure 3.2-19, there is a mixture of sections where the revetment is completely washed away and sections where the lower part is washed away, leaving only the upper part of the revetment. The structure is a masonry retaining wall. No lateral strip is installed on the retaining wall. The opposite bank (right bank) of the damaged section is the outer bank of the curved part, and groins are installed. It is somewhat likely that due to these groins, the mainstream during the flood hit the left bank directly and washed the revetment buttock, leading to the collapse of the revetment. If so, the groin is the main cause of the revetment collapse, but in other words, it can be said that it exerted the expected function of the groin to keep the flow direction away from the riverbank. It can be expected as an effective riverbank defense measure if the arrangement, length, installation interval, etc. of the groin are reviewed and installed.

However, the revetment has collapsed even in the same section where the groins are installed (R8, R9), and the groin did not protect the riverbank in this flood.

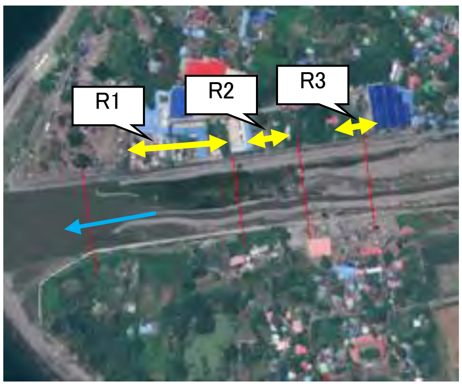


Source: (L) Made by the study team using satellite image (NTT DATA) and (R) taken by the study team

Figure3.2-19 Damaged Revetment (L3)

d) R1 (0.3km), R2 (0.5km), R3 (0.6km)

It is an intermittent revetment collapse section of 0.3km to 0.6km from the river mouth. The length of the damaged section is R1 168m, R2 39m, R3 38m. Since the satellite images before the 2021 April flood show the flow course near the riverbank, it is inferred that the revetment foundation was washed away by the flood flow and collapsed. But no trace of the causes because no revetment left in these sections, and small embankment with a width of 5 m to 10 m is filled in the foot of slope.



Source: (L) Made by the study team using satellite image (NTT DATA) and (R) taken by the study team

Figure 3.2-20 Damaged Revetment (R1-R3)

e) R4 (1.6km)

The retaining wall with wet masonry has collapsed over 141m on the right bank downstream of the ground sill No.1 located 1.69km from the river mouth. The alignment of the river channel turns to the left near the ground sill, and the damaged section is located on the outer side of the bend. Although the slope is stabilized by embankment with a width of 4 to 5 m on the foot of slope, which is now a bare slope because the revetment has disappeared, the flood flow falls from the ground sill with a head of about 5 m and the flow is disturbed in the same section. Therefore, it is desirable to restore the revetment as soon as possible or to lay a protection block on the embankment.

Source: (L) Made by the study team using satellite image (NTT DATA) and (R) taken by the study team

Figure 3.2-21 Damaged Revetment (R4)

f) R5 (3.8km)

Of the 570m long revetment with gabion mattress section, the revetment has collapsed and fell in the 100m section near the middle. This damaged reach has narrow width, and so flow velocity in flooding was high and caused suction of revetment backfill and local scouring. Ten gabion mattresses are piled up on the riverbank with a height of about 10m to form a revetment. The shape of the bottom layer is also deformed in the remaining section. When the riverbank height is high, it is required to adopt gentle slope or to provide a small step in the middle of the height. The slope collapse has spread to the road on the riverbank, and it is currently forced to pass one way. Restoration of the section is urgent from the viewpoint of ensuring safe traffic.

Source: (L) Made by the study team using satellite image (NTT DATA) and (R) taken by the study team

Figure 3.2-22 Damaged Revetment (R5)

g) R6 (4.1km)

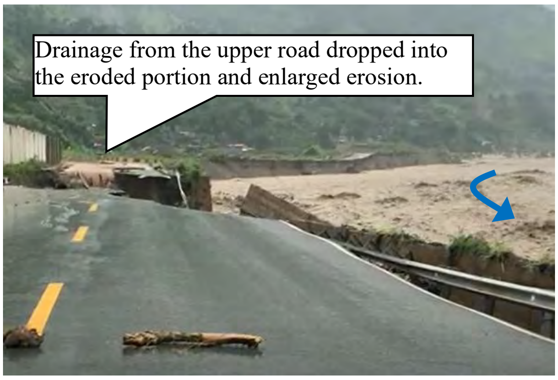
A retaining wall with a height of about 7m has collapsed over 110m. As a first-aid measure, gravel is piled up in front of the riverbank to protect the slope. The width of the river narrowed from 140m to 115m from the upstream point of 230m, so it is possible that the faster flow velocity caused the revetment collapse. Similar to R5, the road on the riverbank has cracks and depressions, making it one-sided. Restoration of the section is urgent from the viewpoint of ensuring safe traffic.

Source: (L) Made by the study team using satellite image (NTT DATA) and (R) taken by the study team

Figure 3.2-23 Damaged Revetment (R6)

h) R7 (5.5km)

At the point where the Comoro River passed through the mountains and entered the alluvial fan, the revetment collapsed, and riverbank erosion occurred over 142 m. Since the river on the right bank upstream of this section is being reclaimed by a gravel company, the flood flow hits the section directly, which causes the revetment foundation to be washed and the back sediment to be sucked out. It is thought that this progressed and led to the collapse of the revetment. This damaged riverbank section was reclaimed for construction of the bypass road in the past, and this narrow river width caused bank erosion by rapid flood flow. Furthermore, as shown in Figure 3.2-24 drainage from the upper road dropped into the eroded portion and enlarged erosion.



Source: The Study Team

Figure 3.2-24 R7 site during 2021/4 Flood

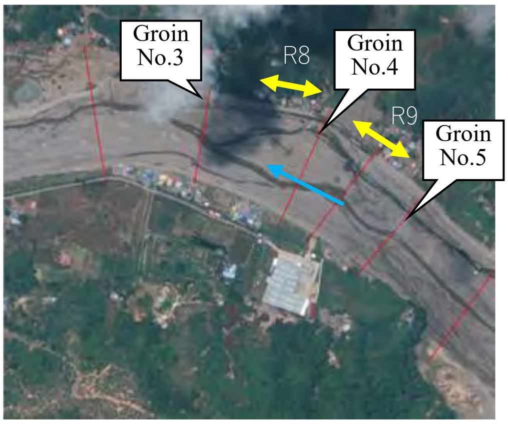
The road surface of both lanes has been washed out on the riverbank road, and vehicles are passing at a position about 2 m lower than the original road surface. Although the urgency of reconstruction is high, countermeasures need to be considered together with countermeasures for upstream landfill activities.

Source: (L) Made by the study team using satellite image (NTT DATA) and (R) taken by the study team

Figure 3.2-25 Damaged Revetment (R7)

i) R8 (6.3km), R9 (6.5km)

Three groins are installed in the section located on the outer bank side of the curved part. The installation interval is about 200m, but the retaining wall revetment is damaged over 100m (downstream side, R8) and 121m (upstream side, R9) in each section. Since the revetment on the left bank, which is the inner bank of the curved part, is also damaged, it can be said that the groin functions to shift the flow direction toward the river center. It is possible that the flow over the groin during the flood directly hit the revetment and caused the scouring of the revetment foundation because the direction of the groin is not perpendicular to the revetment alignment but toward the downstream side. Of the three groins, two on the downstream side are severely damaged, so it is desirable to consider renovating the groin when restoring the revetment.



R8

Groin No.4

Source: (L) Made by the study team using satellite image (NTT DATA) and (R) taken by the study team

Figure 3.2-26 Damaged Revetment (R8, R9)

j) R10 (6.8km)

The retaining wall revetment with wet masonry was damaged by 232m in the straight section. Looking at the existing revetment connected to the downstream end of the damaged section, the foundation (about 1.5 m) is exposed and raised. Before the flood, sediment had accumulated in front of the riverbank in this section, but it is probable that it was eroded during the flood and reached the revetment, causing the foundation to rise and collapse. It is desirable to install a high-water basin from the viewpoint of riverbank protection, but it should be noted that installing a high-water basin will attract the construction of houses on it.

Source: (L) Made by the study team using satellite image (NTT DATA) and (R) taken by the study team

Figure 3.2-27 Damaged Revetment (R10)

k) R11 (7.8km), R12 (8.6km)

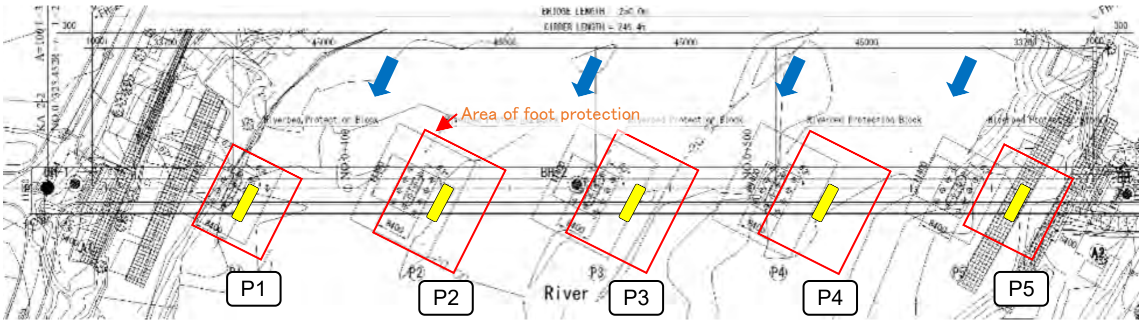
560m and 53m revetment with wet masonry were damaged in the straight section after the confluence with the Bemos River. Gravel is piled up on the riverbank as an emergency restoration, but since the gravel is collected from the riverbed closed to the foot of damaged slope. As a result, flow course is formed near the riverbank. The damage length of R11 is 560m, which is the longest in the section covered by this survey. In the restoration, it is recommended to put lateral spits in the revetment at regular intervals and to lay a floor protection works (concrete block) on the foot of riverbank.

Source: (L) Made by the study team using satellite image (NTT DATA) and (R) taken by the study team

Figure 3.2-28 Damaged Revetment (R11, R12)

(2) Washing out of foot protection blocks

Hinode Bridge has five piers in the river. These piers are P1 pier to P5 pier from the right bank side. The riverbed of each pier is covered with foot protection blocks about 20m square to prevent scouring. Figure 3.2-29 shows the plan view of the bridge.



Source: The study team revised output of "Preparatory Survey Report on the Project for the Construction of Upriver Comoro Bridge in the Democratic Republic of Timor-Leste (2014), JICA"

Figure 3.2-29 Plan of Hinode Bridge

On the P3 pier, a large hole has been dug for gravel mining right next to the pier, and the original foot protection block cannot be confirmed. In addition, three foot protection blocks can be confirmed outside of laying range at the construction time. (Figure 3.2-30).

Source: Taken by the study team

Figure 3.2-30 Riverbed around P3 pier

The causes of the washout and movement of these foot protection blocks are considered to be as follows. In restoration, it is necessary to pay attention to these points and try to prevent disasters again.

- Because the metal buckle that connect the blocks were removed, the resistance of the block group was lost, and it was washed away.

- Because the block and the riverbed ground were in contact with each other at the end of the laying area of the blocks, the flow was disturbed due to the sudden change in roughness, and the part in contact with the end was locally washed and the block was washed away.
- The circular hole dug for gravel mining near the foot protection block expanded due to the flood flow and reached the blocks, causing the block to slide and run off.

(3) Inundation and washing out of houses inside the riverbanks

In recent years, many houses have been built on high water channel of higher land in the Comoro River. During 2021 April flood, some houses have been inundated and washed away. As of October 2021, it was confirmed that houses were being rebuilt on the sites that had been washed away. Figure 3.2-19 shows changes of the houses built in the river before and after the 2021 April flood.

1.15km on the left bank: Approximately 15 houses have been newly constructed after the flood.

Source: Made by the study team using satellite image (NTT DATA)

2.65km on the left bank: A house on a high-water basin downstream of Hinode Bridge. The high-water basin was eroded, and part of the house was washed away.

Source: (L) Provide by a local partner, (R) Taken by the survey team

3.8km on the right bank: The location of the damaged revetment R5 shown in 3.2.2 (1) (f). The 5 or 6 houses on the river side have disappeared after the flood.

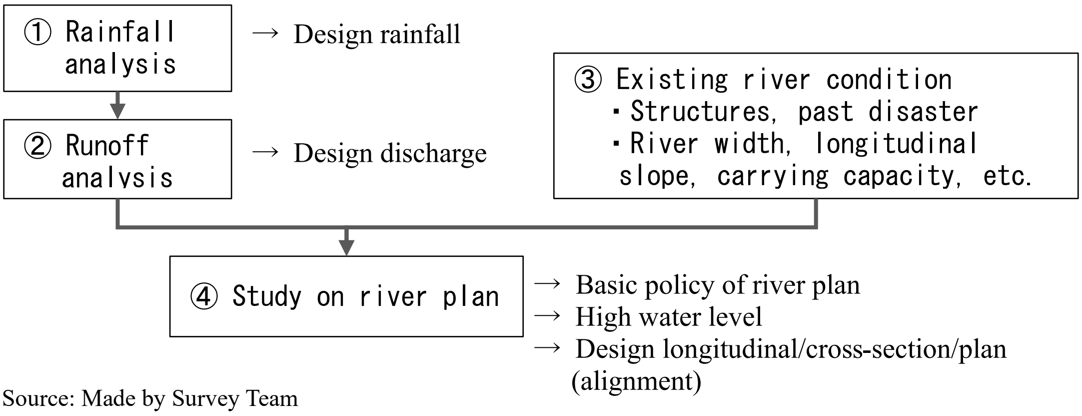
Source: Made by the study team using satellite image (NTT DATA)

Figure 3.2-31 Changing of Houses before/after Flood

3.2.3 Review of the present river plan of the Comoro River

A river plan for Comoro River from river mouth to 3.6km was prepared for basic design of Hinode bridge (2.6km from river mouth) in the Preparatory Survey on the Project for the Construction of Upriver Comoro Bridge (2014).　In the Post Situation and Data Collection Survey for the Flood Countermeasures, this river plan is revised adding new hydrological data, and its range extended from river mouth to the confluence with the Bemos River.

Figure 3.2-32 illustrates the flow of planning.



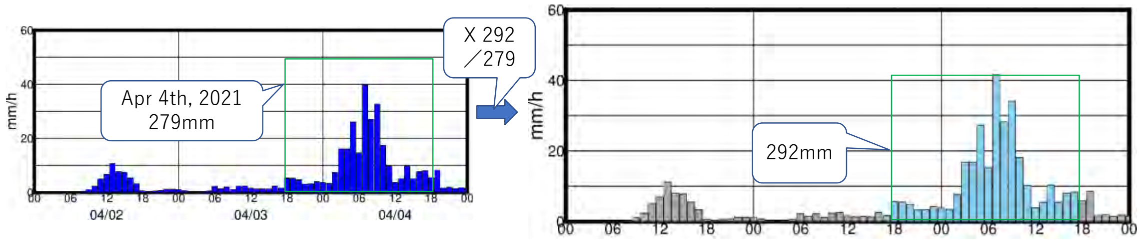
Source: Made by Survey Team

Figure 3.2-32 Flow of Planning

(1) Rainfall analysis

From the study described in 3.1.3(2), the 24-hour basin averaged rainfall on April 4th, 2021 was 279 mm, which is equivalent to 172-year probability rainfall for GEV. Based on this, JICA Survey Team set the design rainfall at 292 mm (24-hour rainfall), equivalent to 200-year probability, from the viewpoint of Build Back Better.

Regarding the temporal variation of rainfall, JICA survey team used the hyetograph of the case which showed the maximum peak discharge for the This Flood analysis described in 3.1.3(2).

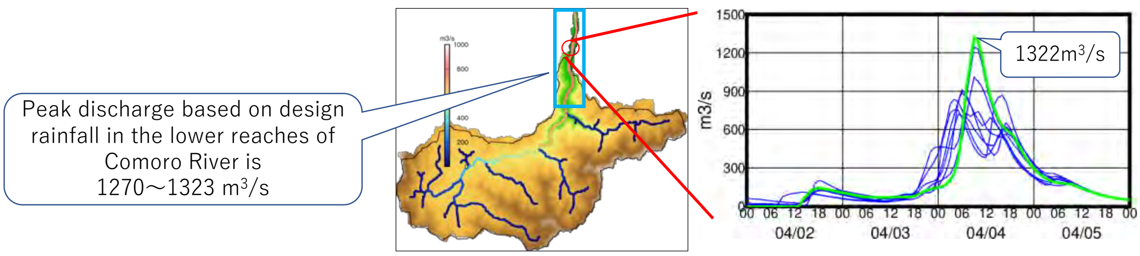


Source: JICA Survey Team

Figure 3.2-33 Hyetograph of design rainfall (basin-averaged rainfall)

(2) Runoff analysis

Runoff analysis was conducted by using the design rainfall set in the previous section to determine the design discharge. The peak discharge of the analysis in the downstream of the Comoro River was 1,270-1,323 m^3/s. Based on this result, design discharge was determined to be 1,320m^3/s.



Source: JICA Survey Team

Figure 3.2-34 Runoff analysis result using the design rainfall

(3) Existing river condition

① Existing river structure

River structures in Comoro River are listed in Table 3.2-1. The detail of each structure is described in Section 3.2.1 (2).

Table 3.2-1 River Structures in the Comoro River

Structure	Quantity	Remarks
Revetement	Left bank：4km (river mouth 6.5km, intermittent Right bank: 9km (river mouth - the confluence with Bemos River	Wet masonry, Gabion mattress, Concrete block masonry
Ground sill	2 (No.1: 1.7km, No.2: 3.9km)	No.1: Renovation in 2019 No.2: Construction in 2017
Groin	6 (No.1 - No.6)	No.1 and 2: Gabion mattress No.3~6: Reinforced concrete No.6: almost destroyed

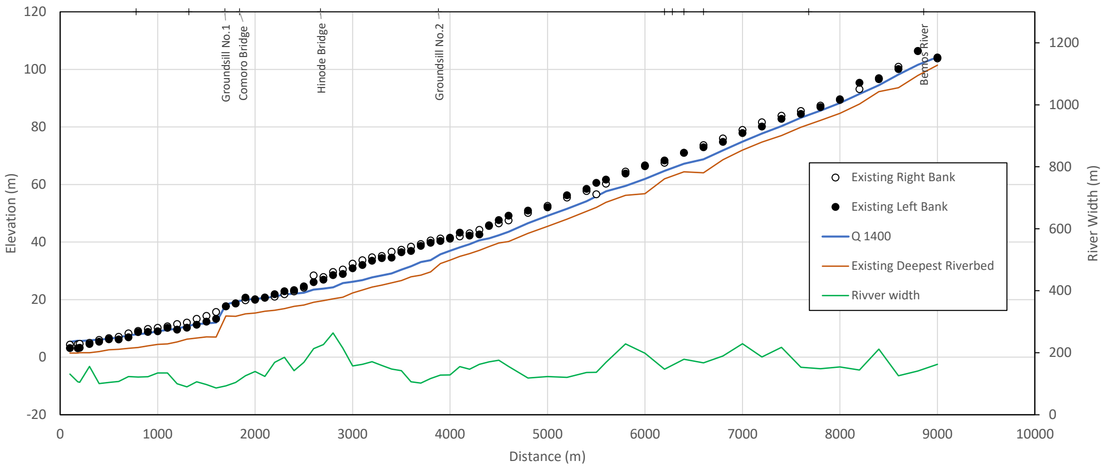
Source: Survey Team

② Building Houses and Filling Land inside the River

River area has not been set for the Comoro River. Therefore, many houses are built inside the riverbank, which are flooded in the event of a large-scale flood such as the April 2021 flood. The number of houses is increasing in proportion to the recent active gravel mining in the river channel. There are also large-scale landfills in the river by gravel collectors. It is probable that the reclamation in these river channels caused the occurrence of high-speed currents due to the deflection of flood flow and the reduction of river width, which led to the damage of revetment.

③ Existing River Condition of Comoro River

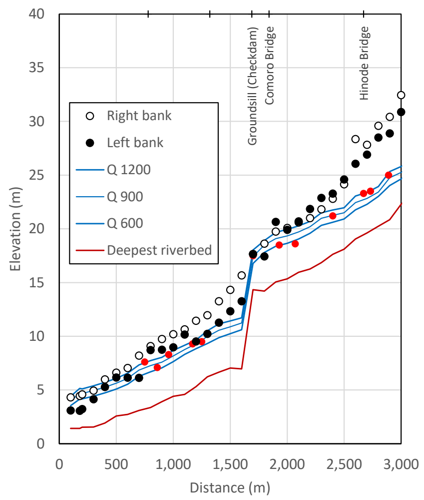
Figure 3.2-35 shows the existing longitudinal profile of the Comoro River prepared from cross-sections obtained by topographic survey implemented in this survey.



Source: Survey Team

Figure 3.2-35 Existing Longitudinal Profile

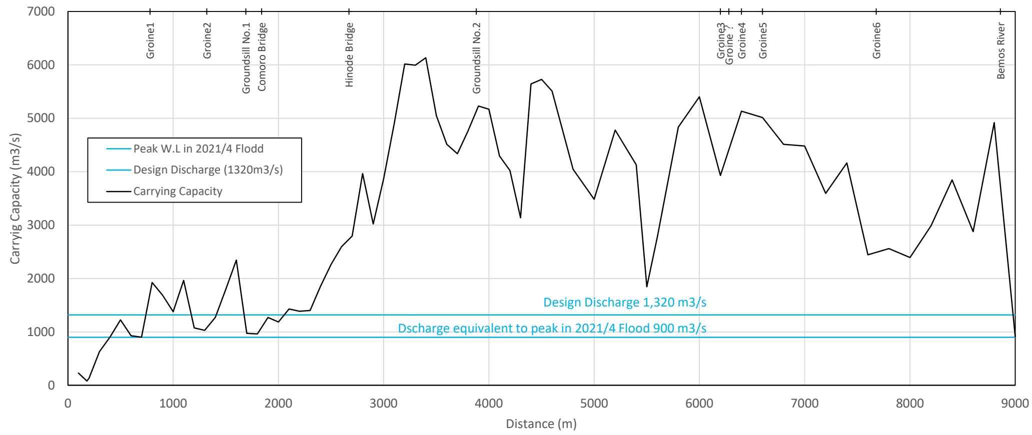
The figure also illustrates the river width in green line and calculated water level of 900 m3/s and 1,400 m3/s. 0.04 is adopted for roughness coefficient because the riverbed material is mainly gravel. Water level of 900m3/s, which is equivalent to the peak discharge of 2021 April flood (described in 3.1.3 (2) 2), is under the riverbank elevations. It is consistent with the fact that no overflow occurred in these reaches. Figure 3.2-36 shows the flood marks obtained by hearing survey.



Source: Survey Team

Figure 3.2-36 Flood Marks of 2021 April Flood

Carrying capacity of the existing river is estimated by non-uniform flow as shown in Figure 3.2-37. Carrying capacity is estimated using the lower elevation of left and right riverbank elevations.



Source: Survey Team

Figure 3.2-37 Carrying Capacity of Existing Comoro River

Comoro River has been changed by human activities in the past decade and influence by the change is seen in the longitudinal profile (Figure 3.2-35) and carrying capacity (Figure 3.2-37). Change of Comoro River and the influence by the change on river management are as follows.

(*) The date in the following text is the date, when the image was taken, not when the river was changed.

1) From river mouth to groundsill No.1 (0km~1.69km)

Image 2005/09/07: The groundsill No.1 exists, but there is no vertical difference between upstream and downstream. (Left bank) There is a revetment with a length of about 150m downstream of the groundsill No.1. (Right bank) There is natural riverbank without revetment. A riverbank road runs from the river mouth to 0.85 km.

Image taken on 2005/9/7

Source: JICA Survey Team based on Google Earth

Figure 3.2-38 Change of River: river mouth–groundsill No.1 (2005/9/7)

Image 2006/09/10: (Left bank) A revetment is installed upstream from 1.2km.

Image taken on 2006/9/10

Source: JICA Survey Team based on Google Earth

Figure 3.2-39 Change of River: river mouth–groundsill No.1 (2006/9/10)

Image 2009/07/07: (Left bank) Revetment is extended from 0.65km to 1.2km. (Right bank) Revetment is installed from the river mouth to the groundsill No.1. Up to about 1.2 km from the river mouth, the alignment of revetment is almost same as current one, but upstream from that, the alignment of revetment is located on inland side.

Image taken on 2009/7/7

Source: JICA Survey Team based on Google Earth

Figure 3.2-40 Change of River: river mouth–groundsill No.1 (2009/7/7)

Image 2013/07/16: (Left bank) Revetment is extended from 0.45km to 0.65km.

Image taken on 2013/7/16

Source: JICA Survey Team based on Google Earth

Figure 3.2-41 Change of River: river mouth–groundsill No.1 (2013/7/16)

Image 2016/10/30: (Left bank) Revetment is extended from the river mouth to 0.45km. (Right bank) The revetment from 1.2km to the groundsill No.1 is shifted to the current position. The riverbank road is extended from 0.85 km to the groundsill No.1.

Image taken on 2016/10/30

Source: JICA Survey Team based on Google Earth

Figure 3.2-42 Change of River: river mouth–groundsill No.1 (2016/10/30)

2) From groundsill No.1 to groundsill No.2 (1.69km~3.88km)

Image 2005/09/07: (Left bank) A low water revetment can be seen from the groundsill No.1 to 2.3km. Houses exists in the riverside along the riverbank road from Comoro Bridge to Hinode Bridge, which is not constructed at this time. This width (range) is generally considered to be the ground level. From Hinode Bridge to the groundsill No.2 (not yet constructed at this time), there is a builder/gravel contractor's land about 100m wide on the river side of the road. Other than that, there is no house. (Right bank) Revetment is installed from the groundsill No.1 to 2.3km. The riverside road ends near the groundsill No.2.

Image taken on 2005/9/7

Source: JICA Survey Team based on Google Earth

Figure 3.2-43 Change of River: groundsill No.1-No.2 (2005/9/7)

Image 2009/07/07: (Left bank) A slight highland along the riverbank spreads out near the center of the river channel at about 2.3 km. Houses begin to build on the downstream side of the builder/ gravel contractor's land. Around 2.9km, the contractor's land will be extended to the river side, and revetment is installed. (Right bank) Houses begin to be built in the river channel around 2.6km.

Image taken on 2009/7/7

Source: JICA Survey Team based on Google Earth

Figure 3.2-44 Change of River: groundsill No.1-No.2 (2009/7/7)

Image 2011/05/02: (Left bank) Low water revetment extends from 2.3km to 2.55km. (Right bank) Houses begin to be built on the river side from 2.7km to 3.0km. More houses on the underside of the builder/gravel contractor's land.

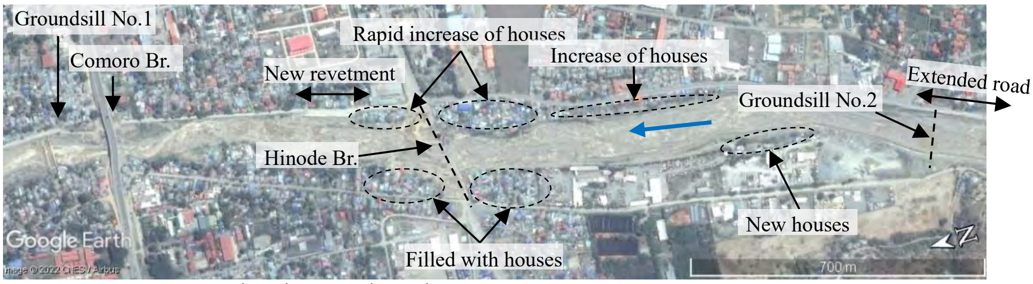
Image taken on 2011/5/2

Source: JICA Survey Team based on Google Earth

Figure 3.2-45 Change of River: groundsill No.1-No.2 (2011/5/2)

Image 2016/10/30: (Left bank) The upstream and downstream sides of Hinode Bridge are filled with houses. Houses are built on the riverside land of the contractor from 3.4km to 3.6km. Low water revetment is laid from 3.6km to 4.1km. (Right bank) At 2.3km, a ramp down to the riverbed is installed, and revetment was extended from 2.3km to 2.5km. The number of houses in the river channel increased rapidly from 2.5km to 2.6km. The number of houses increases rapidly from 2.7km to 3.0km, and the houses increases up to 3.4km upstream. The riverbank road extends upstream from the groundsill No.2 (not yet constructed at this time).

Image taken on 2016/10/30 (Hinode Bridge and groundsill No.2 do not exist.)



Source: JICA Survey Team based on Google Earth

Figure 3.2-46 Change of River: groundsill No.1-No.2 (2016/10/30)

Image 2018/04/23: The groundsill No.2 is installed.

Image taken on 2018/4/23 (Hinode Bridge is under construction.)

Source: JICA Survey Team based on Google Earth

Figure 3.2-47 Change of River: groundsill No.1-No.2 (2018/4/23)

Image 2019/12/21: (Right bank) Several houses are constructed between 2.2km and 2.3km. Revetment is installed upstream from 3.4km. Houses increased from 3.6km to 3.7km.

Image taken on 2019/12/21 (Hinode Bridge is under construction.)

Source: JICA Survey Team based on Google Earth

Figure 3.2-48 Change of River: groundsill No.1-No.2 (2019/12/21)

3) From groundsill No.2 to the confluence of Bemos River (3.88km~8.86km)

Image 2005/09/07: (Left bank) It is a natural bank without revetment. (Right bank) There is no revetment, and it is a natural riverbank. Alignment of riverbank from 5.5km to 6.6km is straight.

Image taken on 2005/9/7

Source: JICA Survey Team based on Google Earth

Figure 3.2-49 Change of River: groundsill No.2-Bemos River (2005/9/7)

Image 2006/09/10: (Right bank) A riverside road can be seen from 6.4km to 7.0km.

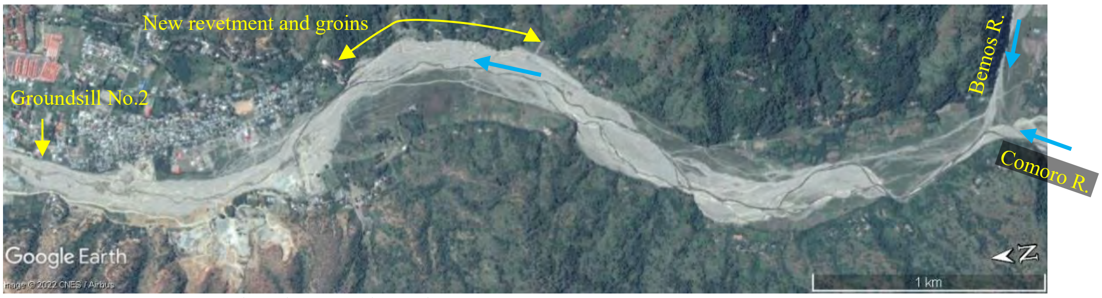
Image taken on 2006/9/10

Source: JICA Survey Team based on Google Earth

Figure 3.2-50 Change of River: groundsill No.2-Bemos River (2006/9/10)

Image 2013/07/16: (Right bank) Revetment and groins are installed from 5.6km to 6.4km.

Image taken on 2013/7/16



Source: JICA Survey Team based on Google Earth

Figure 3.2-51 Change of River: groundsill No.2-Bemos River (2013/7/16)

Image 2016/10/30: Riverbank road extends from the groundsill No.2 to the confluence of Bemos River. Between 5.2km and 5.6km, the riverbank is reclaimed with a width of 40m to 50m to install a riverbank road. At 5.6km to 6.0km, large-scale reclamation in the river channel by gravel contractors can be confirmed.

Image taken on 2016/10/30

Source: JICA Survey Team based on Google Earth

Figure 3.2-52 Change of River: groundsill No.2-Bemos River (2016/10/30)

Image 2017/08/03: (Left bank) Revetment is installed from 5.5km to 6.1km.

Image taken on 2017/8/3

Source: JICA Survey Team based on Google Earth

Figure 3.2-53 Change of River: groundsill No.2-Bemos River (2017/8/3)

(4) River plan

1) Basic Concept for the River Plan

Basic concept for design of a river plan prepared in "Preparatory Survey Report on the Project for the Construction of Upriver Comoro Bridge in the Democratic Republic of Timor-Lest" (2014) and in this survey are shown in Table 3.2-2.

Table 3.2-2 Basic Concept of River Planning

Item	Preparatory survey (2014)	Post situation and data collection survey
Design Scale	Design scale of the river is determined to be 50-year return period (2,500m^3/s) for the reason of that Comoro River flows in Dili, the capital of Timor-Leste, and also flows between the international airport and the inner city.	Design scale will be set to prevent damage against 2021 April flood. Because river basin daily rainfall is 172-year return period, design scale is decided to be 200-year return period (1,320m3/s). [*] Supplementary explanation is shown in the box below this table.
Design Longitudinal Slope	Design longitudinal slope is determined considering existing riverbed slope.	Design longitudinal slope is determined factoring in riverbank height, surrounding ground height, etc. not riverbed. This is because riverbed elevation is affected by gravel mining.
Design High Water Level (H.W.L)	Design high water level is determined in consideration of existing dike elevation for the stretch downstream of the groundsill (1.6 km) and existing riverbank elevation for the stretch upstream of that. For the upper reach of planed new bridge (2.6 km), design high water level is determined as it does not require dike construction because flow section area is quite large due to massive gravel extraction.	Even in the April 2021 flood, no inundation from the Comoro River occurred near the river mouth where the flow capacity was small. Based on this, the planned high water should be set to a height that does not exceed the riverbank height as much as possible.
Dike Alignment	Comoro River on the alluvial fan shows linear channel alignment. Design alignment of dike is set parallel to the existing channel alignment. For the stretch downstream of 2.3 km with less carrying capacity, design dike alignment is determined considering channel widening. For the stretch not requiring channel widening, design dike alignment is set based on existing riverbank alignment.	(Left bank) River mouth – the ground sill No.1: Design dike alignment is current retaining wall constructed after 2006. Upstream of the groundsill No.1: Design dike alignment is position expected to be riverbank. (Right bank) Design dike alignment is current riverbank because the bypass road of National Road No.2 is on the riverbank. From 5.6k to 6.2k that a gravel

Item	Preparatory survey (2014)	Post situation and data collection survey
		company fills inside the river, original bypass rout is set as design dike alignment.

Source: Survey Team

[*] The difference of design discharge of preparatory survey (2014) and post situation and data collection survey (this survey)

Design discharge in preparatory survey (2014) is 2,500m3/s (50-year return period) but that in this survey is 1,320m3/s. The causes of this difference are differences of rainfall amount and runoff model used in study.

At the time of preparatory survey, only Dili station had recorded rainfall for enough period for rainfall analysis. Dili station sits in low lying area near the sea. But almost of the Comoro River basin is occupied by mountainous area, which has much more rainfall amount than low lying area. Therefore, annual maximum daily rainfall in river basin was calculated by multiplying annual maximum daily rainfall of Dili station by a weighting factor. The weighting factor was 1.7 because annual average rainfall in Comoro River basin is 1.7 times as much as that of Dili station according to the isohyetal map.

However, in this survey, annual maximum daily rainfall in Comoro River basin is decided based on daily rainfall calculated by Thiessen polygon method using daily rainfall data recorded in 10 stations that some of them were installed after preparatory survey.

These differences cause the gap of annual maximum daily rainfall and probable rainfall as show below.

Table The Comparison of Probable Daily Rainfall

Return period	Probable daily rainfall (2014)	Probable daily rainfall (2022)
5-year	193.8mm	
10-year	226.6mm	
50-year	298.9mm	191.8mm
100-year	329.5mm	236.9mm
200-year		291.8mm

Source: Survey Team

In addition, design discharge was decided by the Rational method in preparatory survey. But in this survey, it is decided by RRI model using rainfall distribution pattern based on satellite observed rainfall on April 4, 2021.

These differences of design rainfall and runoff model causes the gap of design discharge.

2) River Plan

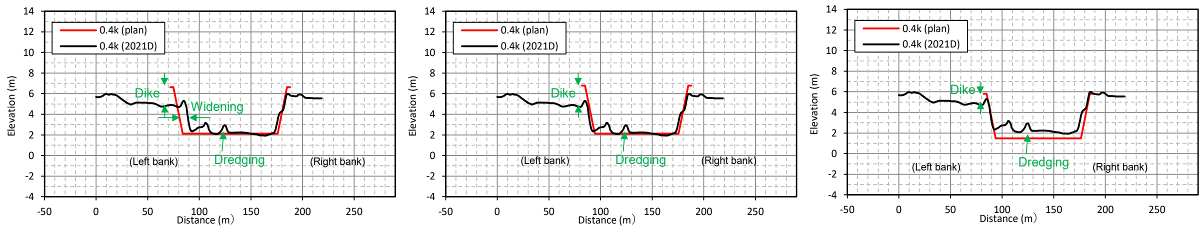
Three cases of river improvement shown in Table 3.2-3 were examined for the section from 0.1km to the groundsill No.1 (1.69km) including 0.1km to 0.7km where the carrying capacity is particularly small. Figure 3.2-54 shows an image of river improvement of each case. For each case, the design river channel is determined based on the calculated water level for design discharge. Determined longitudinal profiles are shown in Figure 3.2-55.

From the viewpoint of flood risk reduction, Option 3 is the most advantageous because it can keep the water level during floods and design dike height low, but it is necessary to excavate the riverbed by about 1.8m near the river mouth. After excavation, the cross-section area will expand, but sand will accumulate in a short period due to the effects of waves. Therefore, regular excavation is required, and it means that it is difficult to sustainably maintain the design river channel. In conclusion, Option 1, which can lower the flood water level and dike height next to Option 3, will be design river channel for this section. Option 1 requires widening, but the range is 400m in length from 0.2km to 0.6km, which is narrower than upstream and downstream, and widening width is limited to 12m at maximum. In addition, there are no houses on the widening site, so no relocation will occur (see Figure 3.2-56).

Table 3.2-3 Study Case for Downstream

Case	Dike / Elevating of riverbank road	Riverbed dredging	Widening
Option 1	Middle scale	Small scale	Max. widen width: 12m
Option 2	Large scale	Small scale	-
Option 3	Small scale	Large scale	-

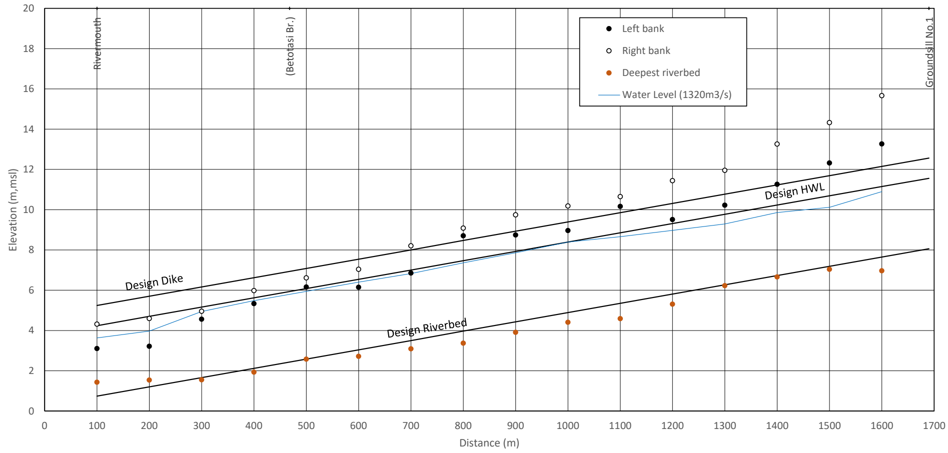
Source: Survey Team



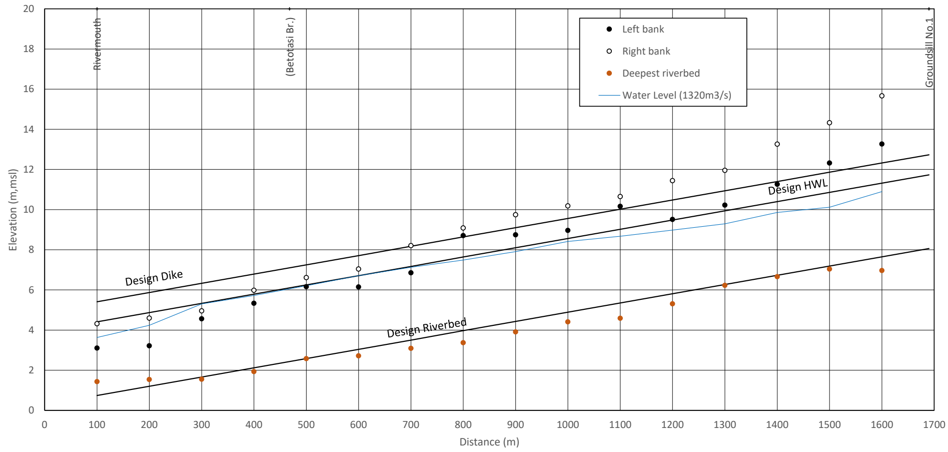
Source: Survey Team

Figure 3.2-54 Image of River Improvement for Each Option

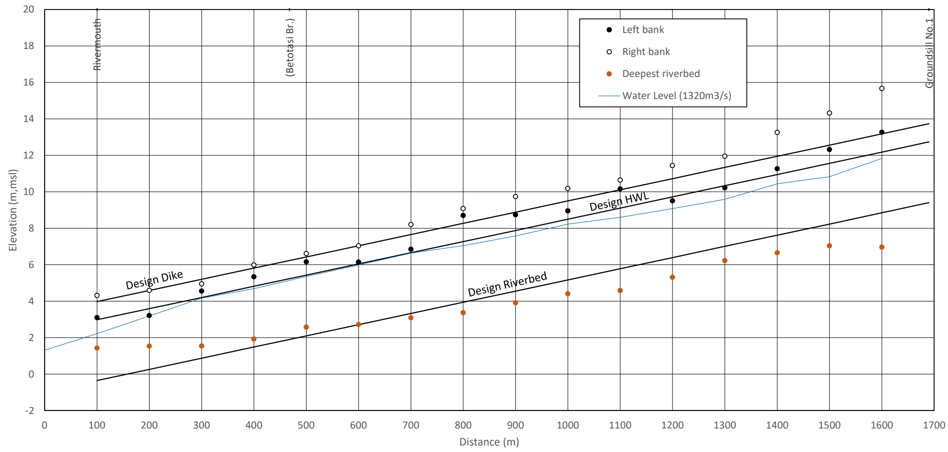
Option 1



Option 2



Option 3



Source: Survey Team

Figure 3.2-55 Design Longitudinal Profile (0.1km – the groundsill No.1) for each Option

Source: JICA Survey Team based on Google Earth

Figure 3.2-56 The stretch to be widen

For the upstream of the above stretch from 0.1km to the groundsill No.1, based on the concept shown in Table 3.2-2, river plan, which can convey design discharge 1,320m3/s without overflow, is decided. Decided design longitudinal profile, design cross sections and design alignment of dike are respectively shown in Figure 3.2-57, 58 and 59. Table 3.2-3 shows the design elevation of each section. Figure 3.2-57 also illustrates calculated water level for design flood discharge 1,320m3/s.

Design riverbed elevations are higher than the existing riverbed elevations due to excessive gravel mining on riverbed at some cross sections such as from 3.0k to 3.9k in Figure 3.2-58. When river structures like revetment is planned or designed in such sections, the existing riverbed lower than design riverbed should be considered.

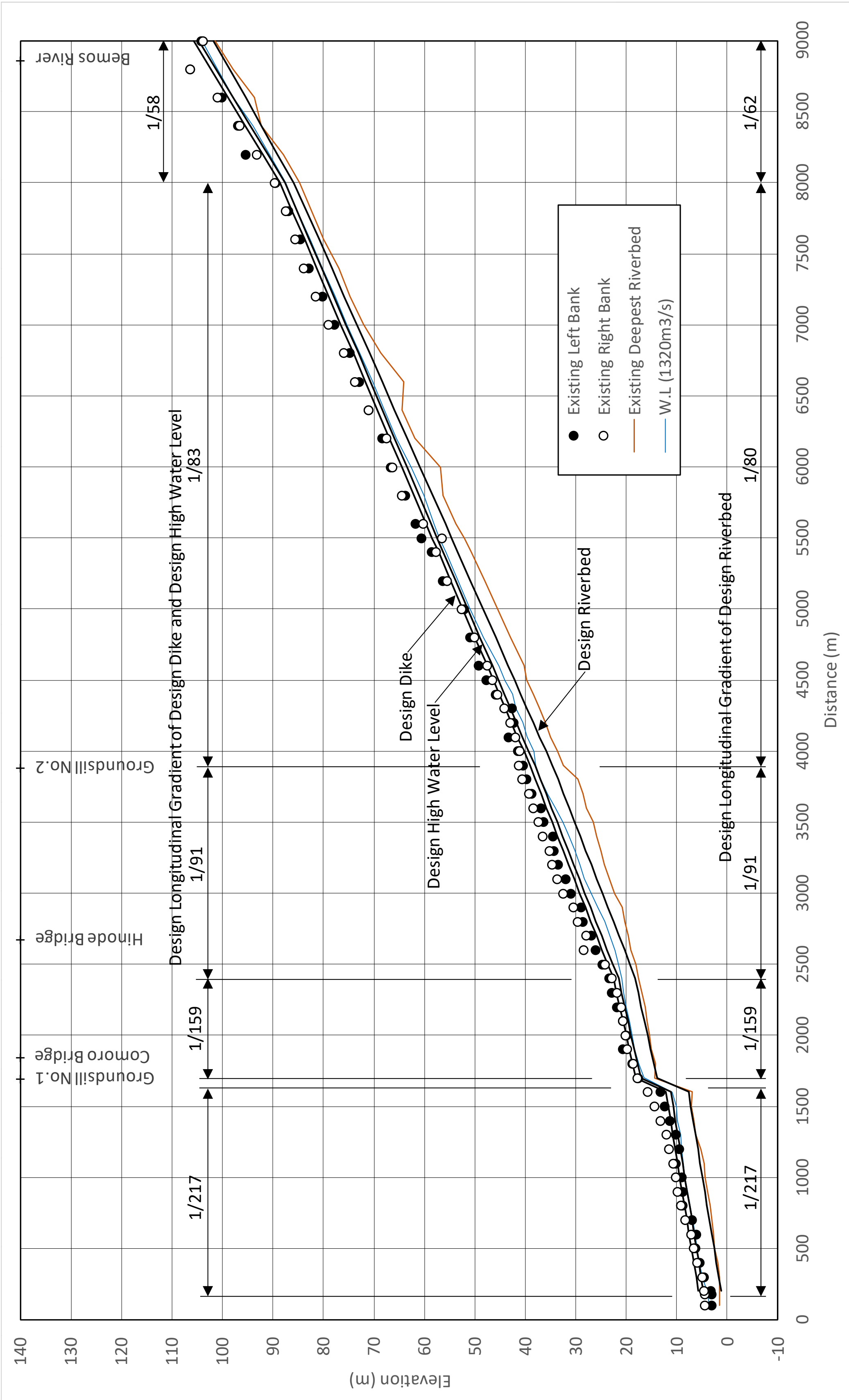


Figure 3.2-57 Design Longitudinal Profile of Comoro River

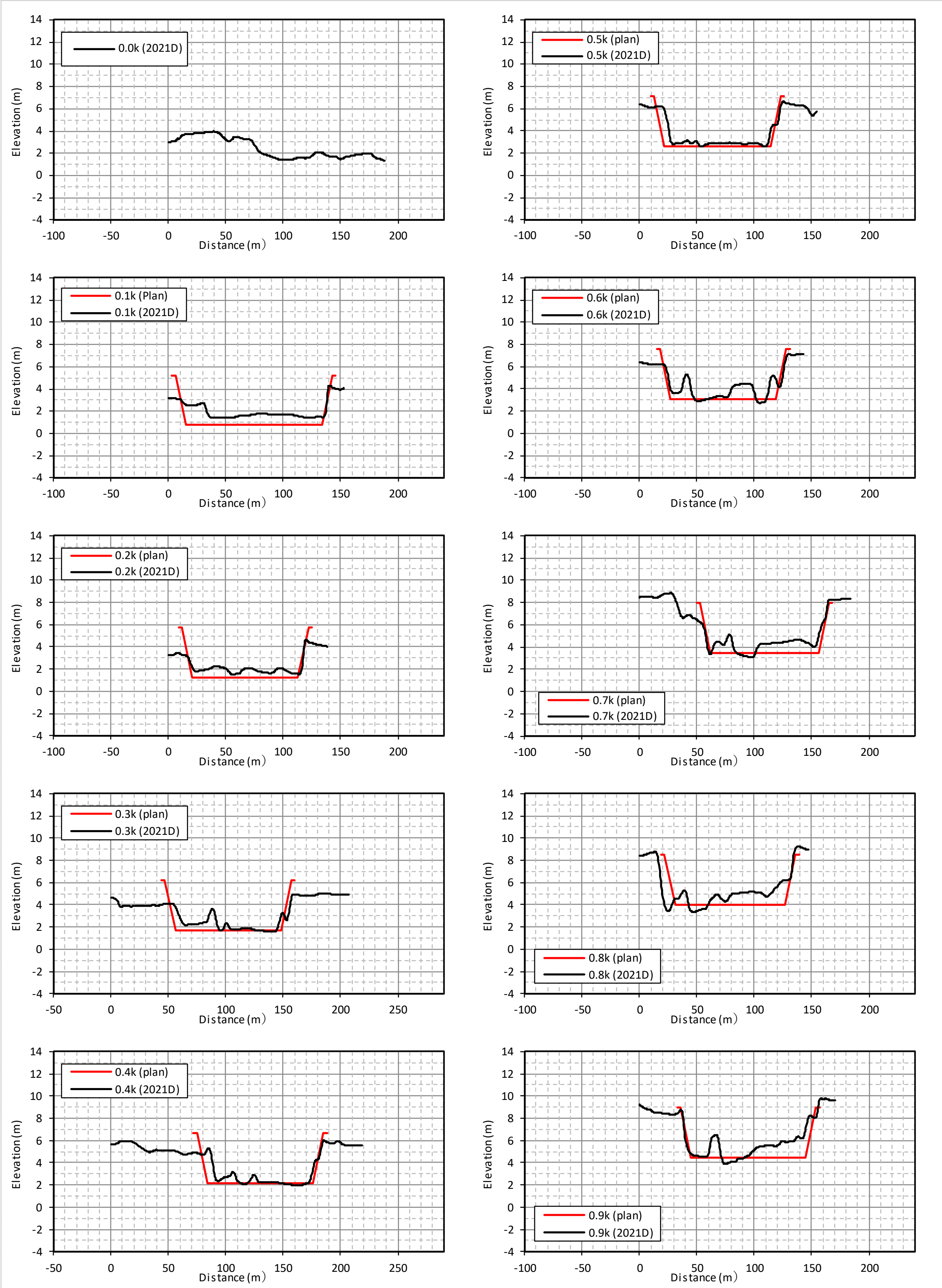


Figure 3.2-58 Design Cross Section (1/7)

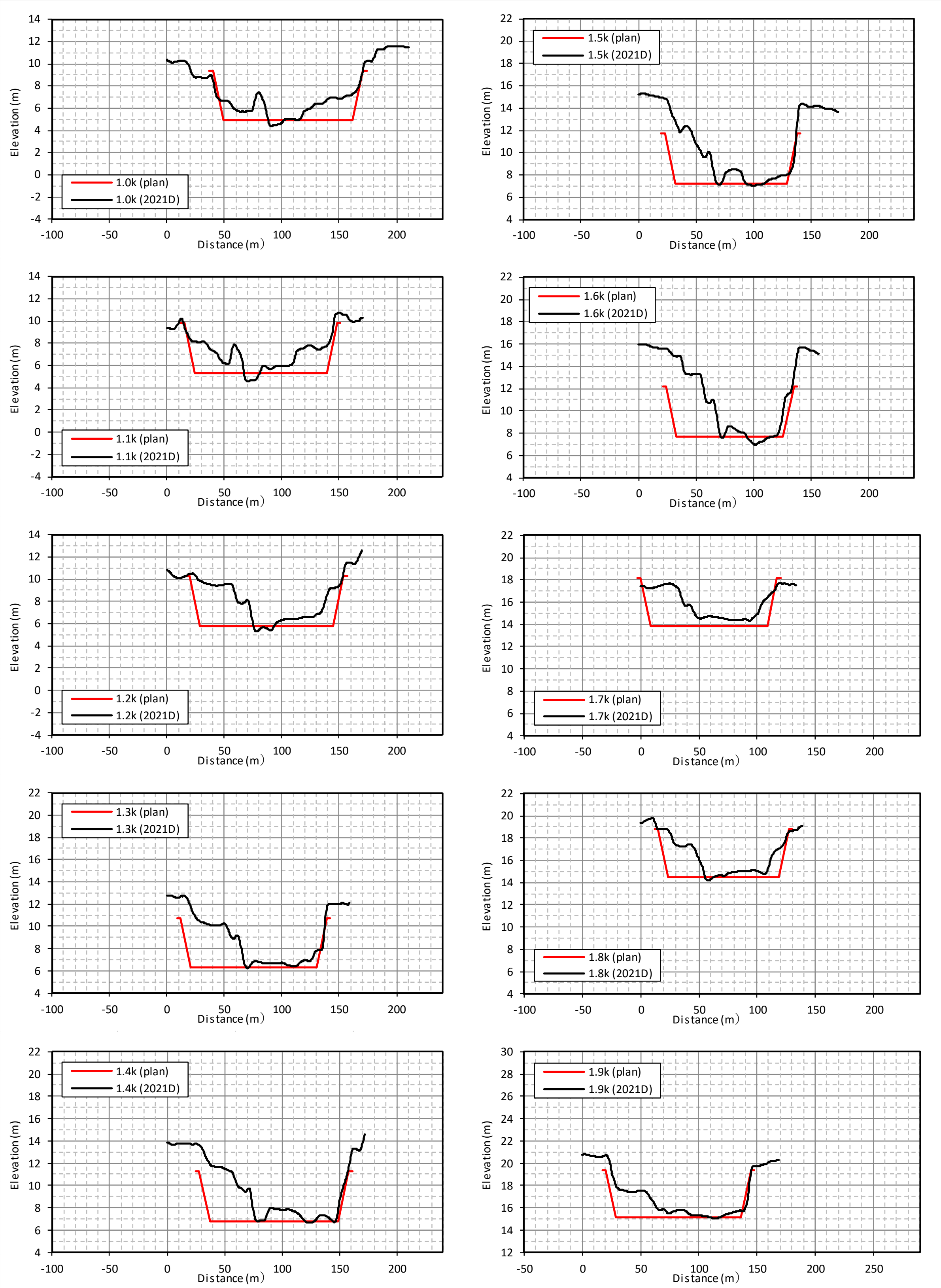


Figure 3.2-58 Design Cross Section (2/7)

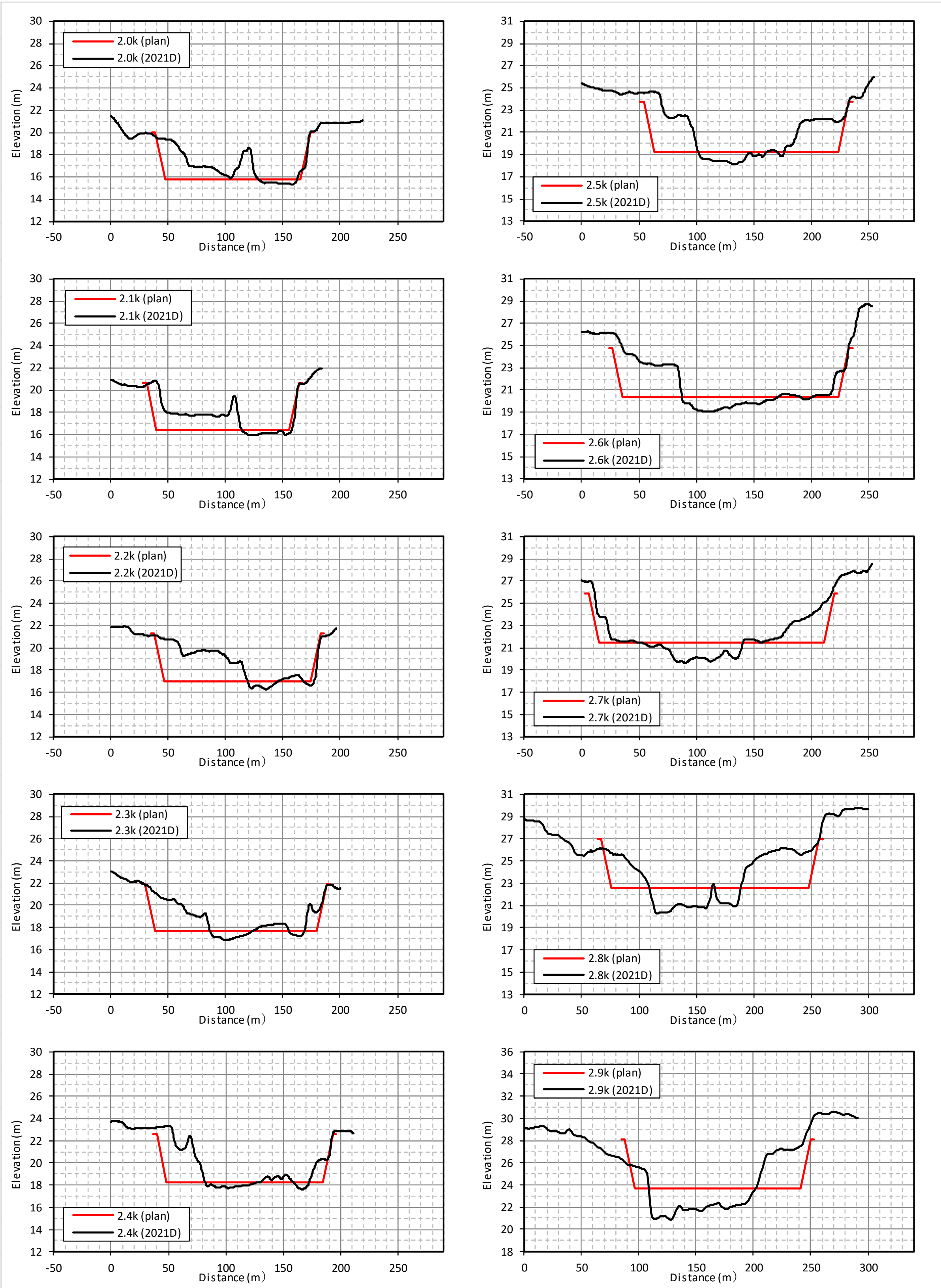


Figure 3.2-58 Design Cross Section (3/7)

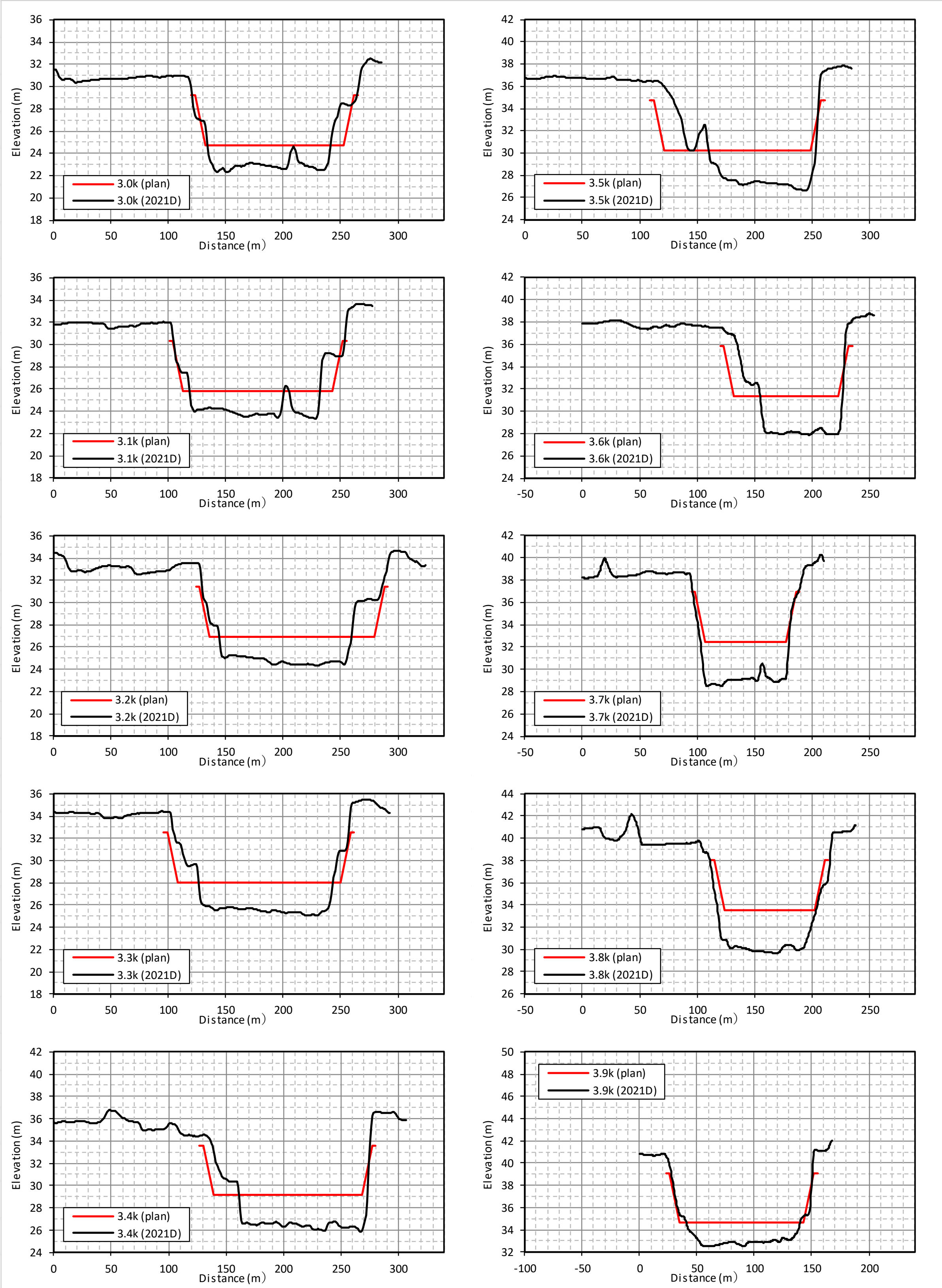


Figure 3.2-58 Design Cross Section (4/7)

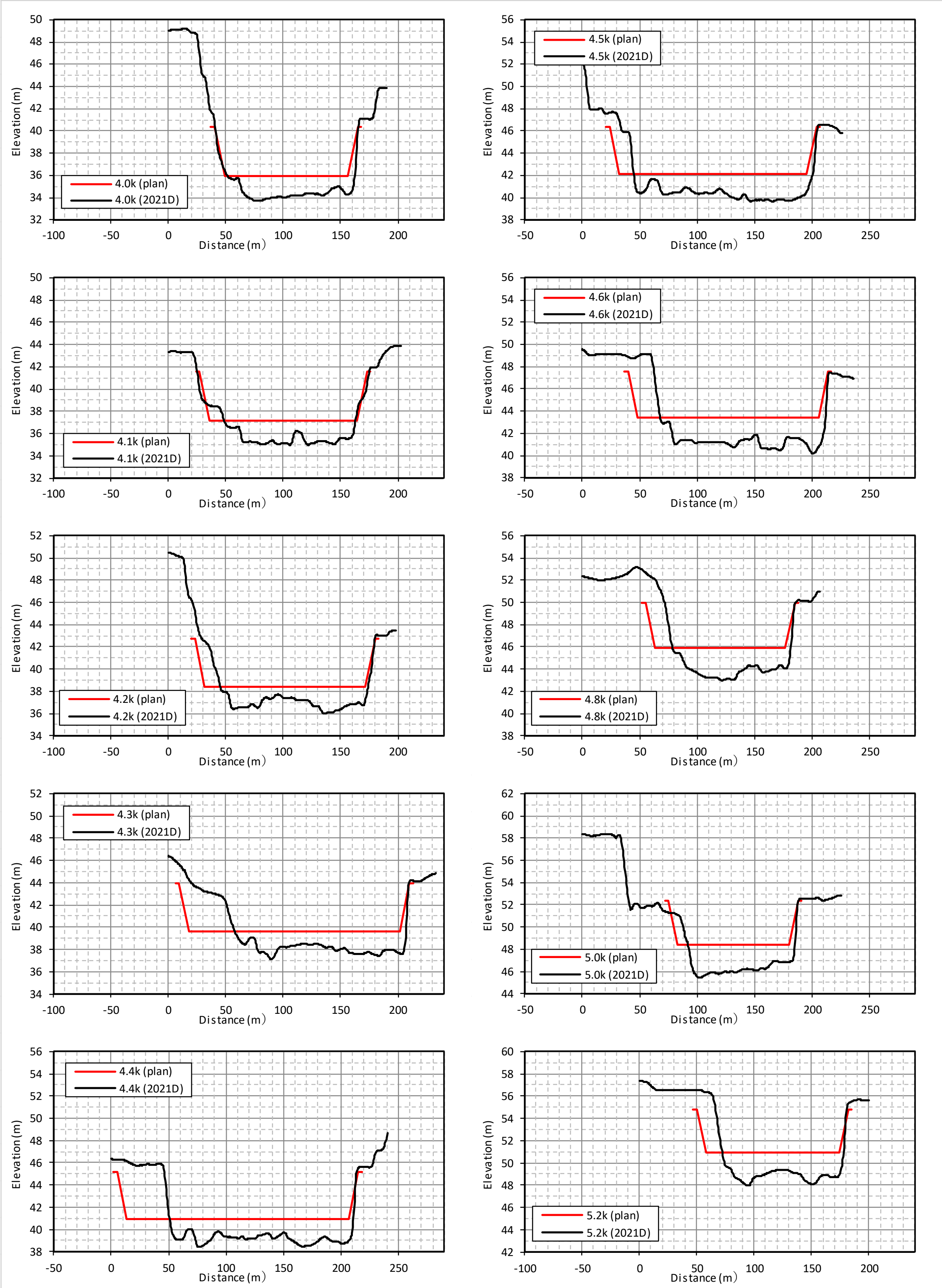


Figure 3.2-58 Design Cross Section (5/7)

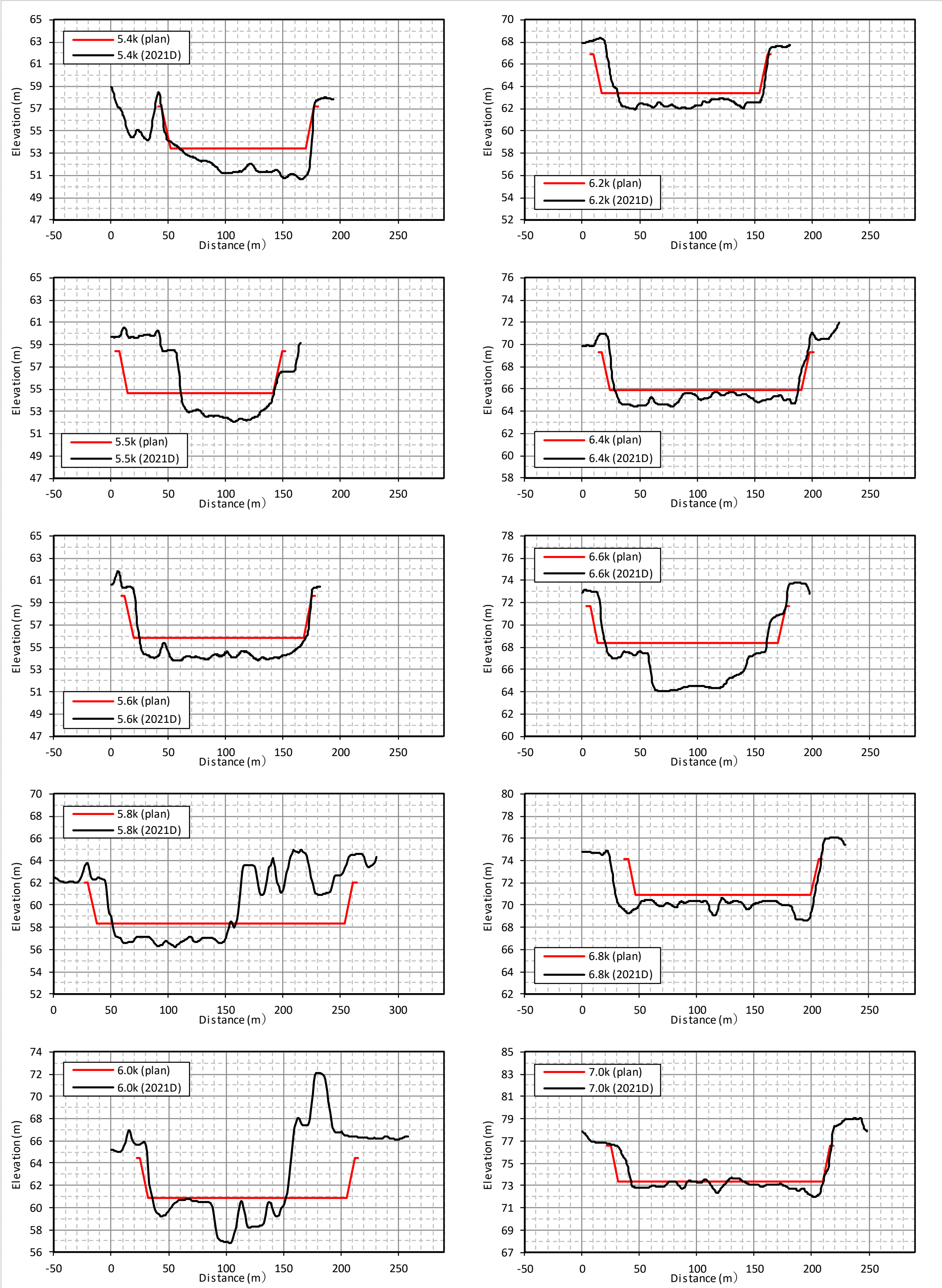


Figure 3.2-58 Design Cross Section (6/7)

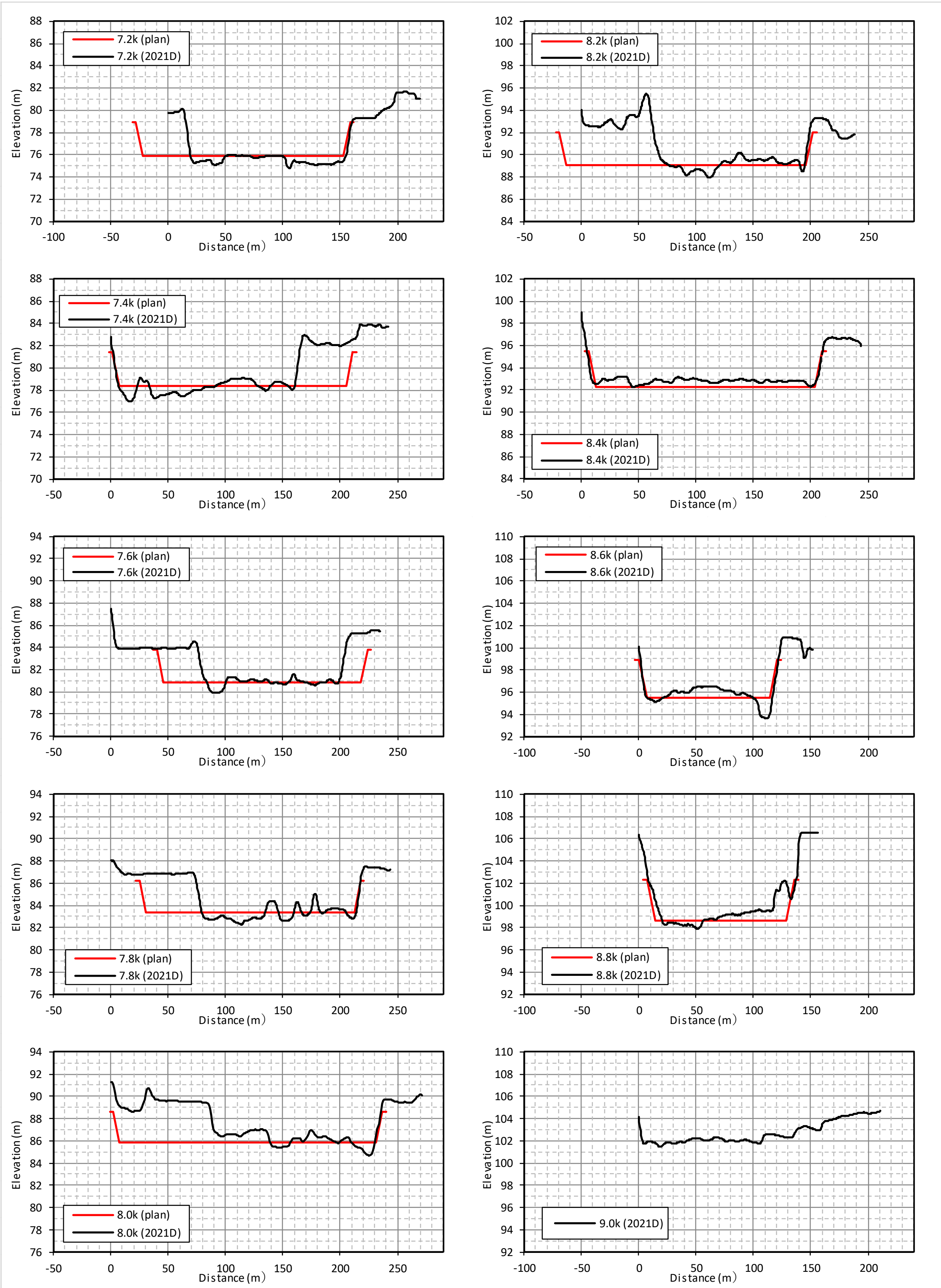


Figure 3.2-58 Design Cross Section (7/7)

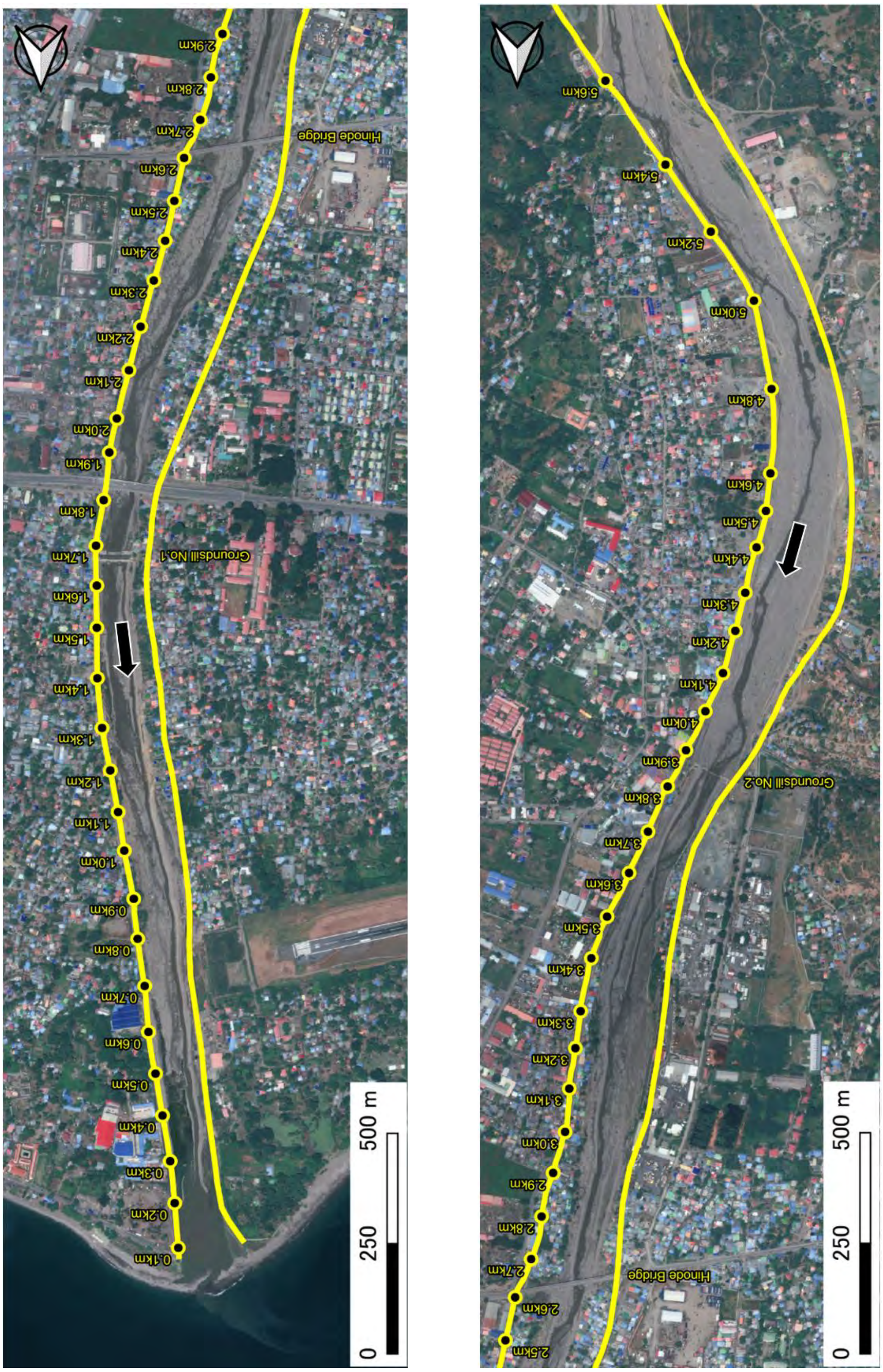


Figure 3.2-59 Design Dike Alignment of Comoro River (1/2)

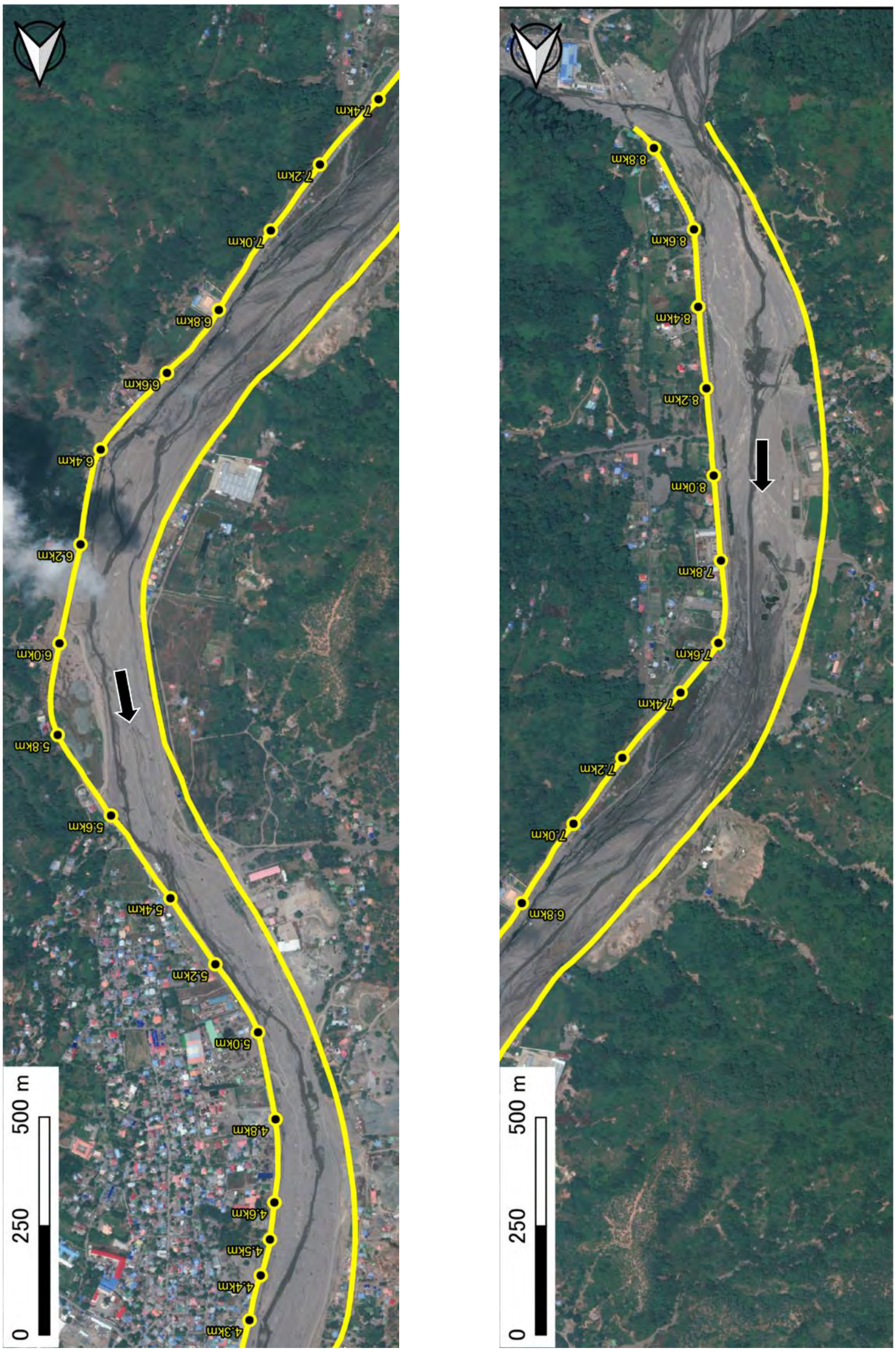


Figure 3.2-59 Design Dike Alignment of Comoro River (2/2)

Table 3.2-4 Design Elevation of Comoro River

No.	Distance	Existing			Plan			No.	Distance	Existing			Plan		
		Left bank	Right bank	Deepest riverbed	Design Dike	Design H.W.L	Design riverbed			Left bank	Right bank	Deepest riverbed	Design Dike	Design H.W.L	Design riverbed
	(m)	(El.m)	(El.m)	(El.m)	(El.m)	(El.m)	(El.m)		(m)	(El.m)	(El.m)	(El.m)	(El.m)	(El.m)	(El.m)
0.1 km	100	3.102	4.314	1.43	5.24	4.24	0.74	3.6km	3600	36.891	38.37	27.91	35.81	34.81	31.35
0.2km	200	3.218	4.594	1.54	5.70	4.70	1.20	3.7km	3700	38.644	39.285	28.50	36.91	35.91	32.45
0.3km	300	4.561	4.954	1.55	6.16	5.16	1.66	3.8km	3800	39.73	40.52	29.62	38.01	37.01	33.55
0.4km	400	5.339	5.985	1.93	6.62	5.62	2.12	3.9km	3900	40.347	41.207	32.50	39.11	38.11	34.65
0.5km	500	6.164	6.614	2.58	7.08	6.08	2.58	4.0km	4000	41.466	41.116	33.69	40.32	39.32	35.90
0.6km	600	6.147	7.043	2.72	7.54	6.54	3.04	4.1km	4100	43.237	41.943	35.00	41.53	40.53	37.15
0.7km	700	6.853	8.209	3.09	8.00	7.00	3.50	4.2km	4200	42.245	43.02	36.00	42.73	41.73	38.40
0.8km	800	8.708	9.086	3.37	8.47	7.47	3.97	4.3km	4300	42.591	44.206	37.13	43.94	42.94	39.65
0.9km	900	8.745	9.747	3.91	8.93	7.93	4.43	4.4km	4400	45.788	45.542	38.41	45.15	44.15	40.90
1.0km	1000	8.965	10.185	4.41	9.39	8.39	4.89	4.5km	4500	47.599	46.473	39.66	46.36	45.36	42.14
1.1km	1100	10.165	10.649	4.59	9.85	8.85	5.35	4.6km	4600	49.123	47.475	40.17	47.56	46.56	43.39
1.2km	1200	9.513	11.444	5.31	10.31	9.31	5.81	4.8km	4800	50.887	50.13	42.99	49.98	48.98	45.89
1.3km	1300	10.222	11.959	6.23	10.77	9.77	6.27	5.0km	5000	52.027	52.547	45.46	52.39	51.39	48.39
1.4km	1400	11.266	13.259	6.66	11.23	10.23	6.73	5.2km	5200	56.251	55.415	47.94	54.81	53.81	50.89
1.5km	1500	12.322	14.325	7.04	11.69	10.69	7.19	5.4km	5400	58.437	57.699	50.65	57.23	56.23	53.39
1.6km	1600	13.266	15.669	6.97	12.15	11.15	7.65	5.5km	5500	60.532	56.549	52.06	58.43	57.43	54.63
1.7km	1700	17.65	17.666	14.33	18.13	17.13	13.88	5.6km	5600	61.69	60.276	53.79	59.64	58.64	55.88
1.8km	1800	18.687	18.619	14.20	18.76	17.76	14.51	5.8km	5800	63.803	64.436	56.24	62.06	61.06	58.38
1.9km	1900	20.638	19.752	15.06	19.39	18.39	15.14	6.0km	6000	66.628	66.334	56.83	64.47	63.47	60.88
2.0km	2000	19.908	20.085	15.35	20.02	19.02	15.77	6.2km	6200	68.303	67.503	61.94	66.89	65.89	63.38
2.1km	2100	20.698	20.591	15.95	20.64	19.64	16.39	6.4km	6400	70.963	70.99	64.40	69.30	68.30	65.88
2.2km	2200	21.852	20.999	16.27	21.27	20.27	17.02	6.6km	6600	72.905	73.678	64.07	71.72	70.72	68.37
2.3km	2300	22.873	21.824	16.86	21.90	20.90	17.65	6.8km	6800	74.797	75.963	68.63	74.13	73.13	70.87
2.4km	2400	23.286	22.799	17.63	22.53	21.53	18.28	7.0km	7000	77.827	78.937	71.97	76.55	75.55	73.37
2.5km	2500	24.598	24.146	18.11	23.71	22.71	19.25	7.2km	7200	80.134	81.574	74.76	78.96	77.96	75.87
2.6km	2600	26.063	28.349	19.06	24.81	23.81	20.35	7.4km	7400	82.779	83.875	76.99	81.38	80.38	78.37
2.7km	2700	26.901	27.829	19.62	25.91	24.91	21.45	7.6km	7600	84.494	85.499	79.92	83.79	82.79	80.86
2.8km	2800	28.493	29.584	20.25	27.01	26.01	22.55	7.8km	7800	86.858	87.404	82.29	86.21	85.21	83.36
2.9km	2900	28.885	30.431	20.85	28.11	27.11	23.65	8.0km	8000	89.394	89.626	84.70	88.63	87.63	85.86
3.0km	3000	30.871	32.446	22.29	29.21	28.21	24.75	8.2km	8200	95.337	93.109	87.94	92.05	91.05	89.06
3.1km	3100	31.996	33.645	23.34	30.31	29.31	25.85	8.4km	8400	96.895	96.6	92.27	95.47	94.47	92.26
3.2km	3200	33.48	34.654	24.34	31.41	30.41	26.95	8.6km	8600	100.067	100.888	93.62	98.89	97.89	95.46
3.3km	3300	34.374	35.102	25.05	32.51	31.51	28.05	8.8km	8800	106.392	106.338	97.86	102.31	101.31	98.66
3.4km	3400	34.534	36.585	25.84	33.61	32.61	29.15	9.0km	9000	104.151	103.758	101.48	105.73	104.73	101.86
3.5km	3500	36.413	37.307	26.59	34.71	33.71	30.25								

Source: Survey Team

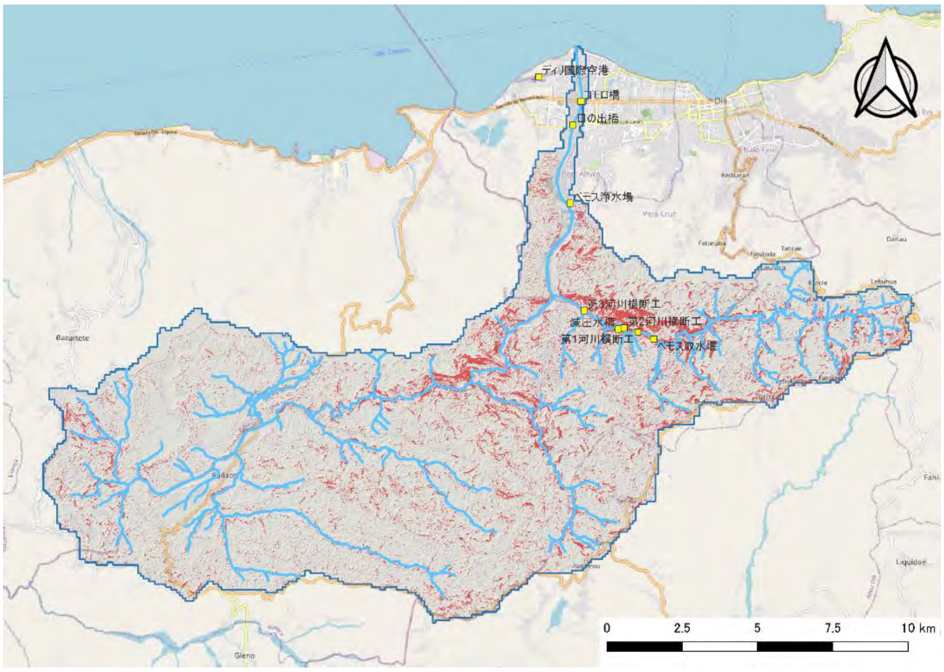
(5) Sediment Disaster Countermeasures

1) Countermeasures against Riverbed Degradation

In the reach from 3.0km to 7.0km, the existing deepest riverbed is lower about 3m than design riverbed as shown in Figure 3.2-28. Degradation of riverbed has merit that carrying capacity will be increased by cross sectional area expanded by riverbed degradation. On the other hand, it has demerit that it will cause shorten foundation depth of structures such as revetment, bridge pier, etc. Such shortened foundation depth of revetment is one of the cause of damage in 2021 April flood. In order to prevent further degradation, installation of groundsills (about 1.5m height), which is similar to the groundsill No.2, is recommended. It is recommended that a groundsill is installed from downstream and after confirmation of sediment accumulation upstream of the groundsill, the position of a second groundsill is studied.

2) Countermeasures against Steep Slopes in the Comoro River Basin

Figure 3.2-60 shows the results of extracting points with an inclination of 30 degrees or more from the Digital Elevation Model (NTT DATA) of the Comoro River basin. According to the figure, steep slopes are concentrated on the right bank of the Bemos River. In the 2021 April flood, a large number of stones and gravel flowed into the Bemos River and accumulated from the both the left and right banks. In the Bemos River, it is thought that gravel and sediment accumulated on the riverbed will be supplied to the Comoro River every time floods occur in the next few years. Fortunately, the section from the confluence of Bemos (around 9km) on the Comoro River to about 2.5km downstream has sufficient flow capacity, so it is not necessary to actively prevent sediment outflow from the Bemos River, but regular monitoring is necessary.



Source: Survey Team

Figure 3.2-60 Steep Slopes in the Comoro River Basin

3.2.4 Recommendation on river management of Comoro River

The table below summarizes the efforts necessary to properly implement river management in East Timor.

Table 3.2-5 Necessary Efforts for River Management

Major Component of River Management	Necessary Efforts
1. Development of laws and standards	1) Formulation of river law, legislation of mining law 2) Formulation of operation and maintenance manuals for rivers and river structures
2. Planning	1) Formulation of river plan 2) Formulation of operation and maintenance plan 3) Formulation of gravel mining regulation plan
3. Enhancement of hydrological observation	1) Installation of rainfall/water level gauging stations 2) Improvement of hydrological observation system
4. Installing flood control facilities	1) Installation of revetments against riverbank erosion 2) Installation of groundsills against riverbed degradation
5. Practice of river management in collaboration with gravel companies and citizens	Practice of proper gravel mining based on gravel mining regulation plan
6. Improvement of operation and maintenance capacity	1) Development of organizational structure 2) Implementation of operation and maintenance (longer infrastructure life, preventive maintenance, utilization of ITC)

Source: Survey Team

3.2.5 Concept of rehabilitation of Comoro River retaining wall

(1) Concept of rehabilitation of retaining wall and the priority

Concept of rehabilitation of 15 retaining walls in Figure 3.2-16 is described in Table 3.2-4. The priority of rehabilitation is shown in the table according to the influence by damage to the critical infrastructures such as an airport, a national road bypass, etc. The damaged retaining walls should be rehabilitated promptly and surely by securing enough budget according as the priority.

Table 3.2-6 Concept of Rehabilitation of Damaged Retaining Wall and Priority

Left/ Right bank	No	Distance from river mouth	Length	Description for rehabilitation	Priority H:high M:middle L:low
Left Bank	L1	0.7km	460m	For about 200m near the runway of the airport, which is critical infrastructure, more stable type such as L-shaped retaining wall is adopted and rehabilitated on a priority basis.	H
	L2	3.8km	23m	Because it is a limited damaged, wet masonry type is adopted same as the up/downstream of it. For exposure of foundation of revetment, filling it with gravel to prevent scouring. Backland of the site is filled ground by gravel company.	L
	L3	6.3km	374m	This site was originally the land filled in the riverside and so may not be so durable against erosion. It is possible to proceed bank erosion but less property to be protected is here.	L
Right bank	R1	0.3km	168m	For this reach, new dike or elevating the riverbank are needed for the river plan. If more time is required for land acquisition in construction of design cross section, temporary rehabilitation is implemented by gabion mattress, etc. to protect a bypass road on the riverbank.	M
	R2	0.5km	39m		M
	R3	0.6km	38m		M
	R4	1.6km	141m	Revetment of 2-steps is adopted because the riverbank height is more than 7m. The site is just downstream of the groundsill No.1. Because the damage of the revetment is in danger of influencing the groundsill, the site is rehabilitated on a priority basis.	H
	R5	3.8km	100m	The middle part with 100m is damaged of gabion mattress with 570m in total. Riverbank height is about 10m, so 2-steps revetment type consisting of retaining wall (lower) and concrete block (upper) is adopted. Because the collapsed gabion pulls the neighboring proper gabions, the priority of rehabilitation is high.	H
	R6	4.1km	110m	Riverbank height is about 8m, so 2-steps revetment type consisting of retaining wall (lower) and concrete block (upper) is adopted. Collapse of riverbank expanded to the bypass road that houses exist along the road as of May 2022. Therefore, the priority of rehabilitation is high.	H
	R7	5.5km	142m	Collapse of revetment and riverbank erosion compel one lane traffic of bypass road on the riverbank and lower its elevation. The site is rehabilitated with improvement of road drainage. Flood water directly flows to the site due to landfill inside the river just upstream of it. The priority of rehabilitation is high for maintaining the function and securing the safe traffic, but the rehabilitation needs to be implemented with dealing with the landfill (removal).	H
	R8	6.3km	100m	Since R8 and R9 are in a continuous section, they are rehabilitated at the same time. Because the riverbank height is as high as 7 to 8m, 2-setps revetment structure is used. It is located on the outer side of the curved section, and 3 spurs have been installed. It is recommended that the damaged spurs are repaired and densely add new ones to mitigate the direct impact of flood flow.	M
	R9	6.5km	112m		M
	R10	6.8km	232m	Because the riverbank height is as high as 7 to 8m, 2-setps revetment structure is used. Collapse of the revetment partially	H

Left/ Right bank	No	Distance from river mouth	Length	Description for rehabilitation	Priority H:high M:middle L:low
				extend into the bypass road on the riverbank. Therefore, the priority of rehabilitation is high.	
	R11	7.8km	560m	Since it is a straight section of about 930m downstream from the confluence with the Bemos River, the slope of riverbank is 1:2. Gradual slope make it easier for trucks to enter the river, so it is necessary to take measures along with river management and river use restrictions.	M
	R12	6.8km	53m		M
Total			2,442m		

Source: Survey Team

(2) Study on Rehabilitation by Japan's Grant Aid

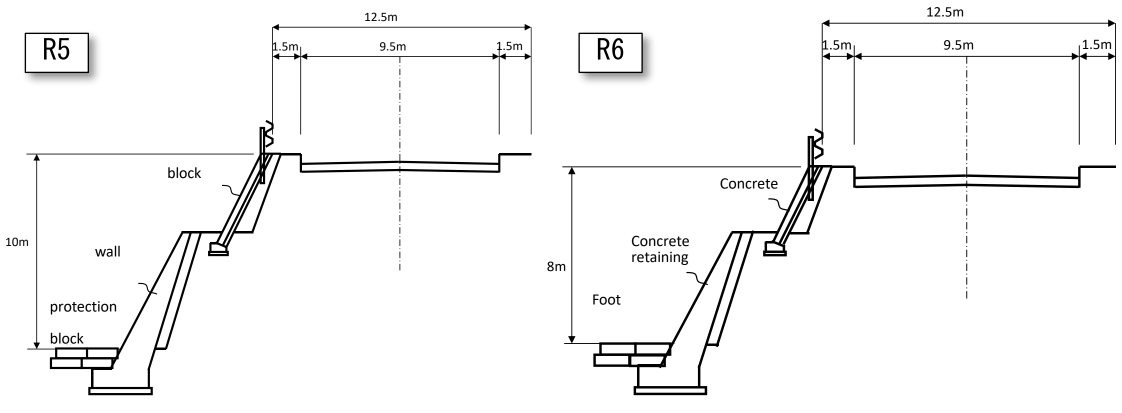
R5 (3.8km point, damage length 100m) and R6 (4.1km point, damage length 110m) will be candidate subject to rehabilitation by Japan's Grant Aid. Reasons of selection of these 2 sites are as follows.

- The damage to the bank protection works expands to the road on the riverbank and traffic on the road is affected.
- If the damage to the road is not repaired, there is an increased risk of collapse of the houses along the road.
- R5 and R6 sites are located 1.2km and 1.5km upstream of Hinode Bridge built by Japan's Grant Aid in 2018. And 2 sites are visible locations because they are near the center of Dili. Therefore, they can appeal the progress of rehabilitation with Hinode Bridge.

The basic idea in the revetment restoration plan is as follows.

- Ensure a sufficiently safe foundation depth against scouring and lay a foot protection blocks to prevent local scouring at the foot of slope.
- A lateral strip will be installed on the revetment at regular intervals in the extension direction to insulate the revetment so that transfer or damage at one point will not spread to others.
- If the riverbank is high, a small step will be provided in the middle of the slope to stabilize the slope. However, the width of the small steps should be such as to discourage housing construction.
- The above ideas of plan and design for rehabilitation are adopt to other sites and projects.

Figure 3.2-42 shows the standard cross sections of the rehabilitation.



Source: Survey Team

Figure 3.2-61 Standard Cross Section of the Rehabilitation

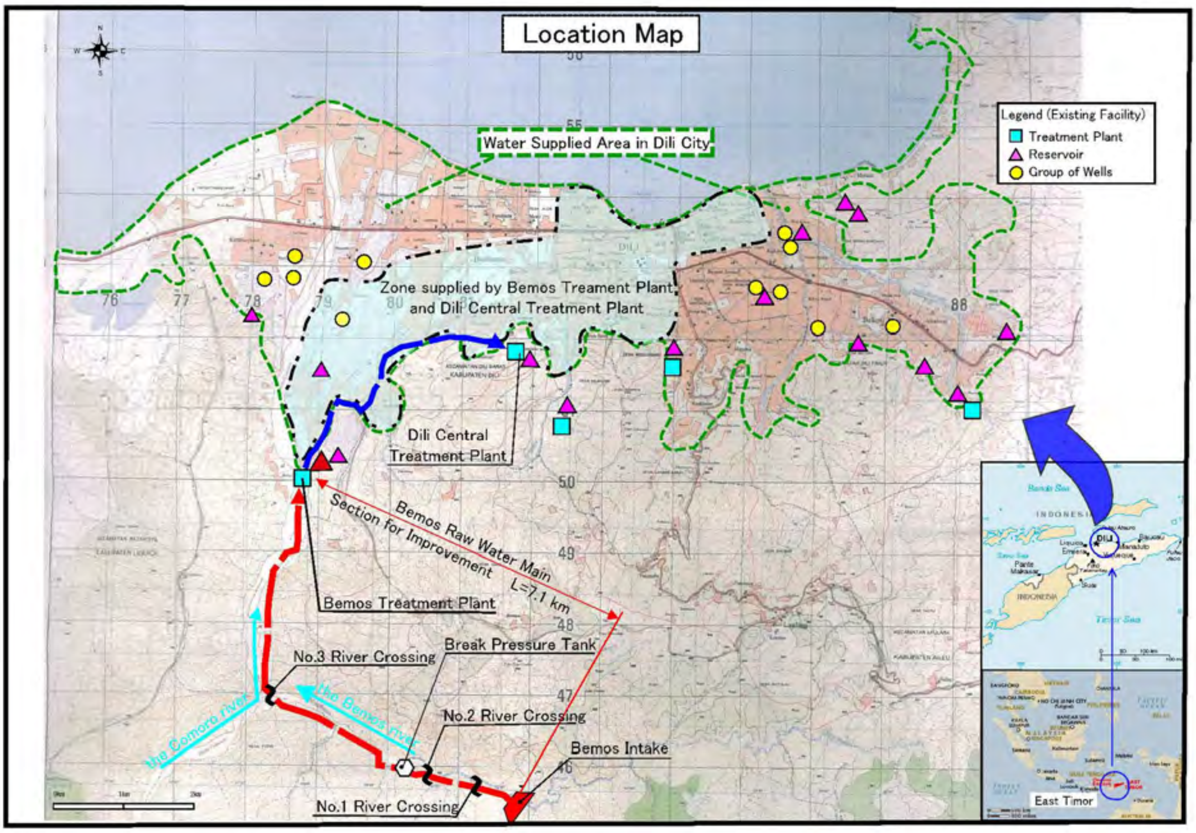
3.3 Study on Rehabilitation Plan of Bemos Water Supply System

3.3.1 Outline of Bemos Water Supply System

(1) History of Construction and Renewal of Bemos Water Supply System

The Bemos Water Supply System, which uses the Bemos River as its water source, was constructed in 1984 during the Indonesian colonial period. Water is supplied from the Bemos River intake weir to the Dili Central Water Treatment Plant and the Bemos Water Treatment Plant by water pipes, and then distributed to the city of Dili.

Later, the Bemos Water Treatment Plant was upgraded with the Rahane and Benamauk Water Treatment Plants under the Japanese Grant Aid Project "Dili Water Supply Improvement Project" from 2004 to 2006 due to deterioration of concrete and leakage. The Dili Central Water Treatment Plant was also constructed in 2000-2003 under the UNDP Emergency Grant Program "Dili Water Supply Facility Improvement Project" funded by the Japanese government. The location of each facility from the Bemos intake weir to the water treatment plant is shown in Figure 3.3-1.



Source: "Bemos-Dili Water Supply System Emergency Rehabilitation Plan Basic Design Study Report (2009)".

Figure 3.3-1 Location of the Bemos-Dili water supply facility.

After the Bemos water pipeline was restored with Japan's assistance (UNDP Emergency Grant "Dili Water Supply Facility Improvement Project" in 2000), it was severely damaged due to river flooding caused by heavy rains in 2004 and 2005, and was repaired on an emergency basis by the Water Supply and Sanitation Department. However, since the system was not fully prepared for future flooding, it was assumed that it would take a long time to restore the system and the safe supply of water would be suspended for a long period of time in the event that a water pipe broke or an aging distribution reservoir collapsed due to flooding.

Under these circumstances, a request for grant aid was made to Japan in 2006 in order to enable the sustainable supply of safe drinking water to Dili City. In response to this request, Japan conducted a feasibility study in 2007 to confirm the importance, urgency, and appropriateness of the project, and after conducting a basic design study in 2008, the facilities were rehabilitated in 2009 under the "Bemos-Dili Water Supply Facility Emergency Rehabilitation Project" grant aid.

(2) Outline of the grant aid project(2009-2011)

The latest update of the Bemos water supply system is the from2009 to2011 grant assistance "Bemos-Dili Water Supply System Emergency Rehabilitation Project", which provides an overview of the project. In addition, the project was damaged by floods in the 2010 when the project was under implementation, and the project contents were added or modified after the feasibility study.

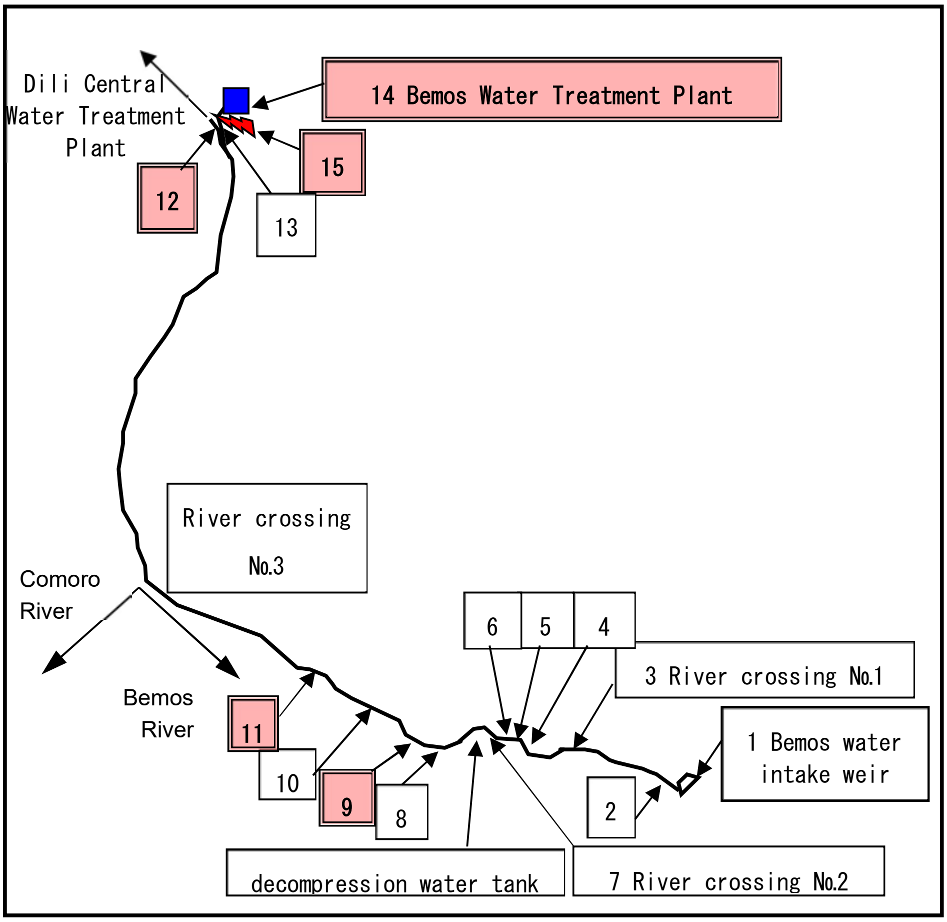
1) Purpose and target of renovation

The purpose of the renovation was to promptly upgrade the Dili water pipeline, which is the core facility of the Dili City Waterworks, from the perspective of disaster prevention, and to ensure that it can continue to stably supply raw water to the Bemos Water Treatment Plant and the Dili Central Water Treatment Plant in Dili City in the event of a flood in the future.

Table 3.3-1 Bemos-Dili water supply facilities to be upgraded

Retrofit Components	target
1) Rehabilitation of Bemos intake weir	○
2) New sand settling pond	○
3) River Crossing №.1	○
4) Route change due to the Bemos River right bank tributary lateral water pipe bridge	○
5) Pipe route change and raising of existing concrete retaining wall upstream	○
6) Bemos River right bank terrace revetment	○
7) River Crossing №.2	○
8) Raising of existing concrete retaining walls downstream, rooting and protection of pipelines	○
9) Protection of pipelines in the upper reaches of the left bank terrace of the Bemos River	●
10) Change of pipe route and protection of the lower reaches of the river terrace on the left bank of the Bemos River	○
11) Pipe route change and pipe protection on the left bank slope of the Bemos River	●
12) Pavement of steep road section on right bank of Comoro River	●
13) Water control valve, sand drainage valve, and air valve in the upper reaches of the Bemos River	○
14) Bemos Water Treatment Plant: Lower distribution area and valve repair	●
15) Bemos Water Treatment Plant Access Road Landslide Prevention Work	●

Source: "Bemos-Dili Water Supply System Emergency Rehabilitation Plan Basic Design Study Report (2009)".
Note: ●: Second-tier projects added or revised after the feasibility study after the 2010 flood



No. 9, 11, 12, 14, 15 are the target of the second project.
Note: The number indicates the part to be renovated, and 1~14 indicates the part to be renovated in the original plan for the 2009 project.
Source: "Bemos-Dili Water Supply System Emergency Rehabilitation Plan Basic Design Study Report (2009)".

Figure 3.3-2 Location of the renovated area.

Table 3.3-2 Shows a summary of the urgent repair areas of the Bemos-Dili water supply facilities.

Table 3.3-2 Summary of urgent repairs to Bemos-Dili water supply facilities

Repair area	Name of repair area
No.1	Bemos Water Intake Weir
	Dam
	Flushing gate
	Downstream bed protection works
	Left bank revetment
	Right bank revetment
	Intake
	Access channel
No.2	Settling basin
	Settling basin
	Spillway
	Sand drainage channel

Repair area	Name of repair area
No.8	Downstream existing concrete retaining wall
	Raising of existing retaining wall
	Protection work for upper part of pipe line
	Retaining wall foot protection
No.9	Upper reaches of the river terrace on the left bank of the Bemos River
	Masonry work
	Protection work for upper part of pipe line
No.10	Lower reaches of the river terrace on the left bank of the Bemos River
	Change of pipeline route
	Masonry work
	Bed protection works
No.11	Left bank slope of the Bemos River at the foot of the mountain

No.3	River crossing №.1
	Ground still works
	Left bank revetment
	Right bank revetment
No.4	Route Change and Bemos River Right Bank Tributary Crossing Water Pipe Bridge
	Change of water pipe route
	Tributary channel construction
	Tributary confluence (right bank side of main stream)
No.5	Upstream existing concrete retaining wall
	Change of water pipe route
	Raising of existing retaining wall
No.6	Bemos River right bank river terrace area
	Low channel revetment
	High water bank revetment
No.7	River Crossing №.2
	Ground still works
	Left bank revetment
	Right bank revetment
	Change of water pipe route
	Revetment
	Protection work for upper part of pipe line
No.12	Steep road section on the right bank of the Comoro River
	Concrete pavement
	Bracing works
	Roadside construction
No.13	Water control valves, sand drains and air valves
	Air valve
	Water control valve
	Drainage valve
No.14	Lower distribution pond at Bemos Water Treatment Plant and valve chamber
	Lower water distribution pond
	Valve chamber
	Appurtenant works
No.15	Bemos Water Treatment Plant Access Road Landslide Prevention Work

Source: "Bemos-Dili Water Supply System Emergency Rehabilitation Plan Basic Design Study Report (2009)".

(3) Design specifications for grant aid projects

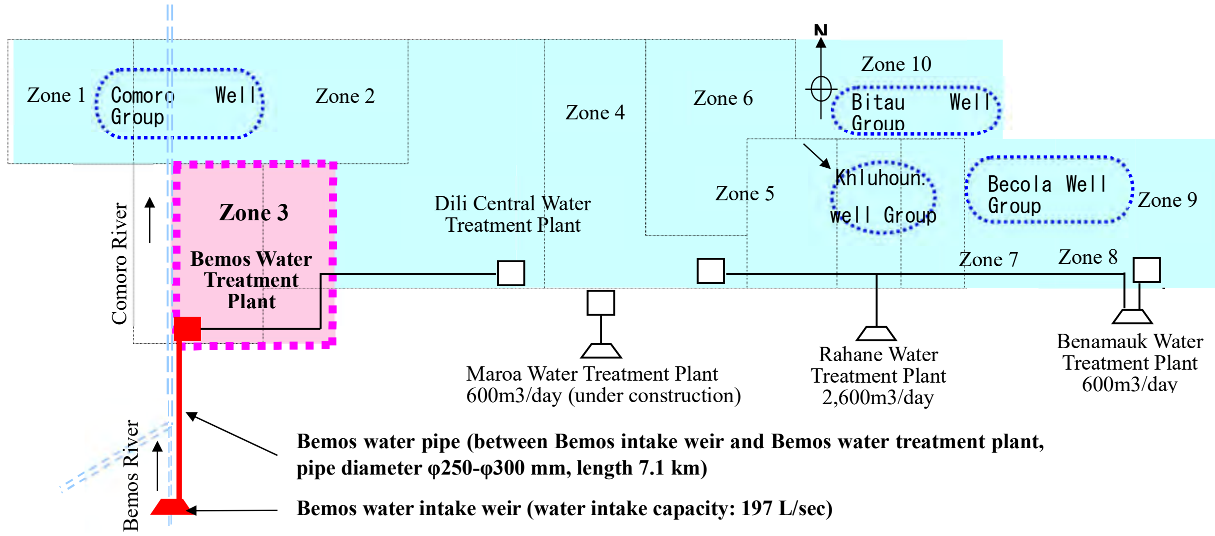
1) Water distribution plan from Bemos Water Treatment Plant

(a) Water distribution district

As shown in the figure3.3-3, the water supply area of Dili Waterworks is divided into Zone 1 to Zone 10, and the distribution area of Bemos Water Treatment Plant is Zone 3. The water distribution area of the Bemos Water Treatment Plant is Zone 3, and the end of the Bemos water pipeline is the inflow to the Dili Central Water Treatment Plant, from which water is distributed to Zone 4.

(b) Water supply

At the time of the 2009 project, based on the goals of Timor-Leste, the planned maximum daily water supply for the Bemos Water Treatment Plant was set at 2,000 m^3/day as a result of calculating the water demand based on the population growth rate, water supply penetration rate, water use intensity, water use for other purposes, effective rate, load factor, and time factor. The water distribution system from the lower distribution basin of the Bemos Water Treatment Plant is the natural flow system in consideration of the difference in elevation and topography of Zone 3 in Dili City, which is the water distribution area.



Source: "Bemos-Dili Water Supply System Emergency Rehabilitation Plan Basic Design Study Report (2009)".

Figure 3.3-3 Conceptual diagram of the distribution zone (Zone 3) at the Bemos Water Treatment Plant

2) Volume of water intake

(a) Design flow rate

The design maximum water intake of the Bemos intake weir and the design maximum water flow rate of the Bemos water pipeline were considered during the basic design study. The planned maximum water intake of the Bemos intake weir and the design maximum water flow of the Bemos pipeline at the time of the basic design are shown below. The design flow rate for each section of the Bemos water pipeline is as follows.

Table 3.3-3 Design flow rate of the water distribution zone (Zone 3) at the Bemos Water Treatment Plant

Interval	Design flow rate (liter/sec)
From the water intake weir to the decompression tank	102
From the decompression tank to the Bemos water treatment plant junction	102
From the Bemos water treatment plant junction to the No. 8 water control valve works (EP)	76
From Bemos Water Treatment Plant junction to Bemos Water Treatment Plant	26

Source: "Bemos-Dili Water Supply System Emergency Rehabilitation Plan Basic Design Study Report (2009)".

(b) Water pipe type, diameter, and extension

Table 3.3-4 Pipe types, diameters, and extensions of water pipe

Pipeline section	Pipe type	Pipe diameter (mm)	Pipe length (m)		
			Existing	After renovation	Increase/decrease in pipe length
From the water intake weir to the decompression tank	GSP	250	1,355	1,287	Installation of an open channel from the water intake to the sedimentation basin: -80.2m No.5 pipe relocation: + 8.6m No.6 pipe relocation: +4.0m
From the decompression tank to the Bemos water treatment plant junction	GSP	300	5,465	5,472	No.10-3 pipe relocation: +7.0m
From the Bemos water treatment plant junction to the No. 8 control valve works (EP)	GSP	300	237	237	—

Total			7,057	6,996	-60.6m

Note: GSP (SGP in JIS) shall be carbon steel pipe for piping JIS G 3452 or equivalent or better.
Source: "Bemos-Dili Water Supply System Emergency Rehabilitation Plan Basic Design Study Report (2009)".

(c) River discharge

The design flood volumes and dominant flows for the main river and tributaries at each location were developed during the basic design study of the Bemos-Dili Water Supply System Emergency Rehabilitation Project. The design flood volume and dominant flow rate for each location are as follows.

Table 3.3-5 Design flood volume and dominant flow rate at each location

№.	Facility Name	Position	Type of river	Watershed area (km2)	Design flow rate (m3/sec)	Regulated flow rate (m3/sec)
1	Bemos Water Intake Weir	Sta.0+000	main current	30.3	200	110
2	Settling basin	Sta.0+075	main current	30.6	200	110
3	River crossing №.1	Sta.0+530 ~0+580	main current	32.1	210	120
4	Bemos River right bank tributary lateral water pipe bridge	Sta.0+670 ～ 0+800	main current tributary	32.6 3.20	220 34.0	120 19
5	Upstream existing concrete retaining wall	Sta.0+840 ～ 0+920	main current	33.1	220	120
6	Bemos River right bank river terrace area	Sta.0+880 ~0+966	main current	33.4	220	120
7	River crossing №.2	Sta.1+220 ～1+300	main current	34.4	230	120
8	Downstream existing concrete retaining wall	Sta.1+430 ～1+520	main current	35.4	230	130
9	Upper reaches of the river terrace on the left bank of the Bemos River	Sta.1+980 ～2+020	main current	37.8	250	140
10	Lower reaches of the river terrace on the left bank of the Bemos River	Sta.2+080 ～2+300	main current	38.1	250	140
11	Left bank slope of the Bemos River at the foot of the mountain	Sta.+390 to 0+600	main current	38.8	260	140
12	Steep road section on the right bank of the Comoro River	Sta.7+000 ~7+100	main current	206.2	1,360	750

Source: "Bemos-Dili Water Supply System Emergency Rehabilitation Plan Basic Design Study Report (2009)".

3) Rainfall data

At the time of the basic design, the design rainfall intensity and the design flood volume were considered based on the data from the Dili rainfall station as an observation station near the facility. The rainfall data from the Dili station was recorded as monthly rainfall data for the 55years from 1953 to 2007, but daily rainfall data was only available for the 6 years from 2003 to 2008 (but only for the rainy season from January to June in 2008).

Therefore, the correlation between the monthly rainfall and the maximum daily rainfall in each month during the rainy season (November to May) from 2003 to 2008 was examined, and a correlation equation (maximum daily rainfall in each month = 0.2699 x monthly rainfall + 7.3037) was derived which is a high correlation coefficient 0.73. Using this correlation equation, the maximum daily rainfall for each year was estimated from the maximum monthly rainfall for each year from 1953 to 2002.

Next, based on the estimated maximum daily rainfall and the measured maximum daily rainfall from 2003 to 2007, a probability processing using the rock well method was conducted. As a result, the daily rainfall of 113.4 mm per 2005 corresponds to about 25 years the annual probability, and the daily rainfall of 126.7 mm per 2004 corresponds to the 76.6 years annual probability.

Table 3.3-6 Rainfall analysis results for basic design

Year of occurrence	Probable daily rainfall (mm/day)	Remarks
2	72.0	
3	81.3	
5	90.8	
10	101.5	
20	110.9	
2005year	113.4	R.P. 24.4 years
30	115.9	
50	121.9	
Maximum recorded 2004	126.7	R.P. 76.6 years
100	129.6	
200	136.9	

Source: "Bemos-Dili Water Supply System Emergency Rehabilitation Plan Basic Design Study Report (2009)".

The Bemos River is a general river flowing through a mountainous area, and the site is located in a mountainous area, therefore the scale of the project was judged to be appropriate for the 50 years probability of exceedance. (The 50 years probability of exceedance is 122 mm/day.) The maximum daily rainfall observed in February 2004 was 126.7 mm/day, and the difference between the 50 years probability of exceedance and the daily rainfall is about 5 mm. Considering that the facility to be rehabilitated was damaged by a flood caused by the maximum rainfall in the 2004, the base flood in this plan was determined by the maximum daily rainfall of 126.7 mm/day in the 2004.

Scale of the plan	Existing maximum flood (76.6 years exceedance probability year)
Target planned daily rainfall	126.7mm/day

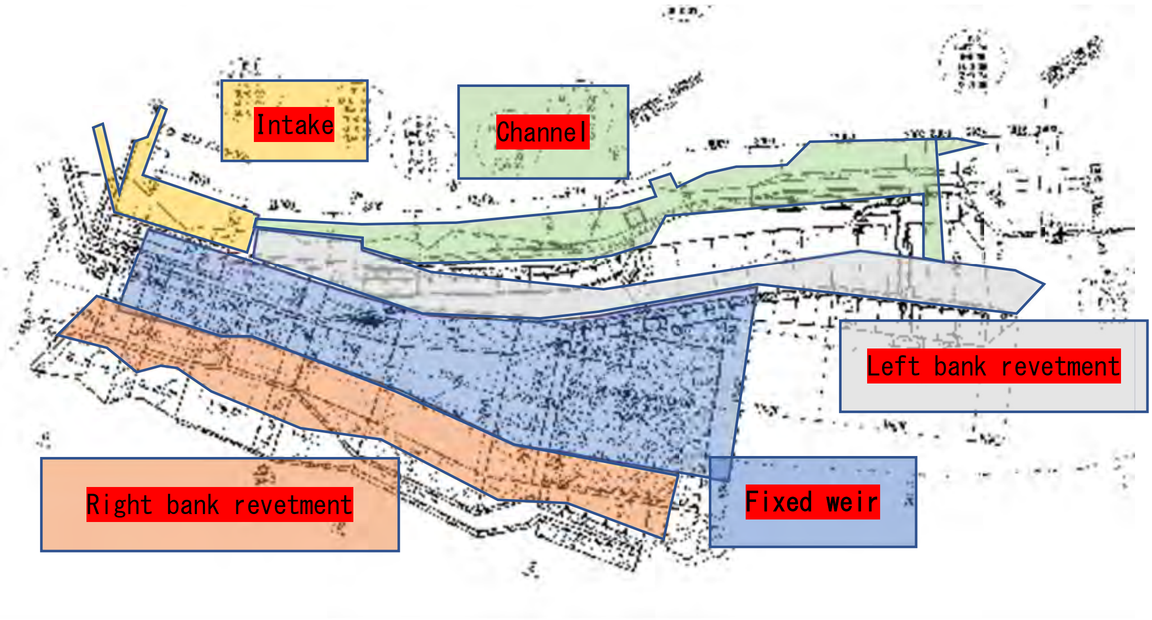
3.3.2 Damage assessment of Bemos Water Supply System

(1) Flood damage

The Bemos-Dili water supply facilities are categorized into (1) water intake facilities, (2) water conveyance facilities, and (3) water purification facilities, and the water intake facilities and water conveyance facilities were damaged by the floods in 2021. The water purification facilities were not directly damaged by the floods. The damage status is based on the data of the "Water Supply Facility Emergency Repair Plan Post Fact-Finding Survey (October 2021)".

1) Water intake facility

Water intake weirs are classified into the structures shown in Figure 3.3-4. The fixed weir is the point where river water flows downstream, and the intake is the facility that performs the prescribed water intake. The left and right bank revetments protect the river cross-section to allow river water and floodwaters to flow down safely. The access channel is a facility that conducts water from the intake to the pipeline.



Source: "Water Supply Facility Emergency Repair Plan Post Fact-Finding Survey Report (October 2021)

Figure 3.3-4 Structural classification of water intake weirs

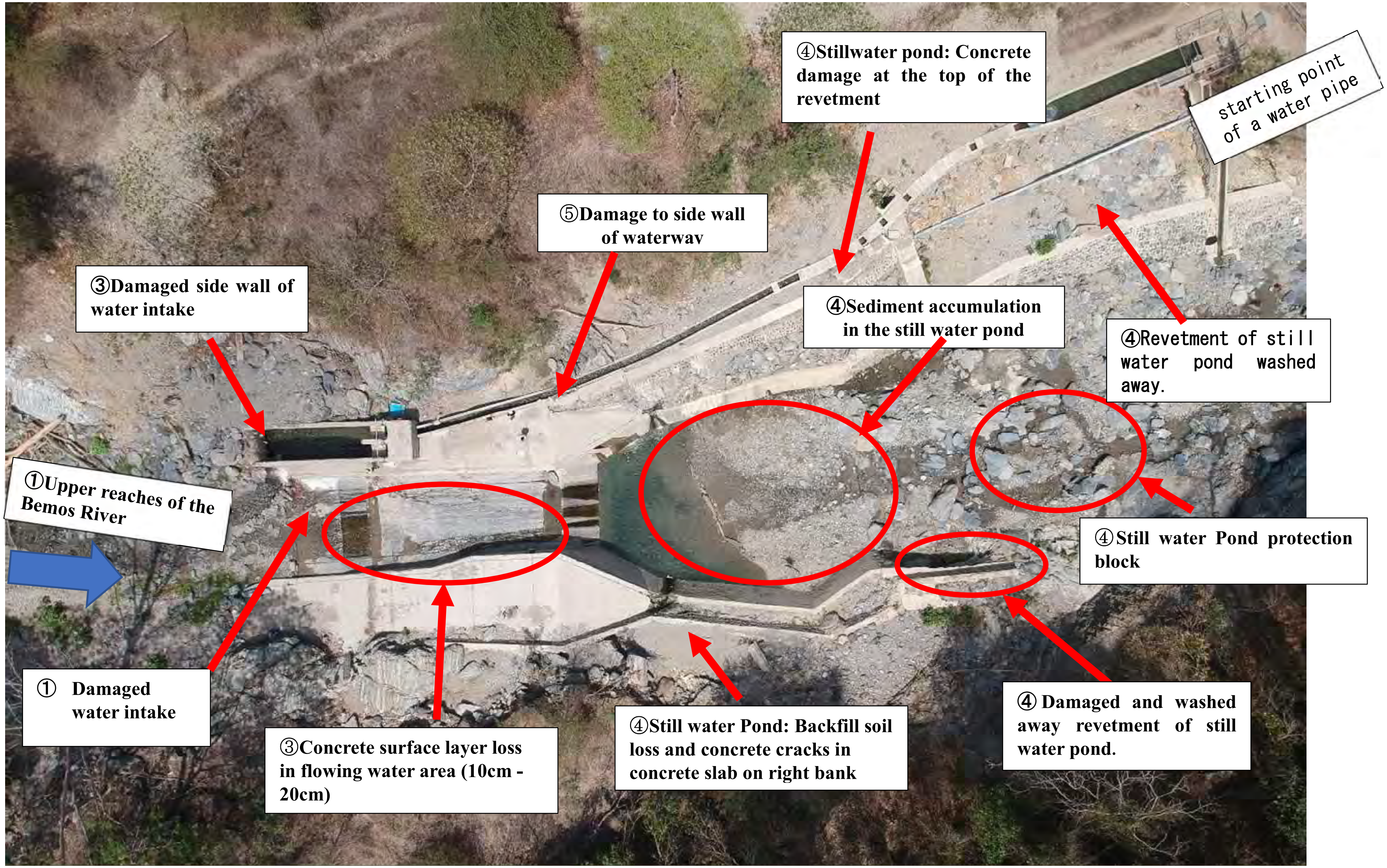
The table3.3-7 and figure3.3-5 below show the main damaged areas and the status of the water intake facilities.

Table 3.3-7 Flood damage situation

Facility Location	Situation
① Intake	The water intake is damaged. The upstream side wall is severely damaged.
② Water intake gates (2 locations)	A couple of places have been removed. In two places, the spindles were bent, making it difficult to operate them properly. There was damage to the hardware at the gate guide in both locations.
③ Fixed weir	Defects were observed on the concrete surface, and the reinforcing steel was exposed. Considering the rebar cover, about 20 cm of the concrete surface has flowed out. The surface of the concrete section of the bottom slab was scraped off, exposing the steel bars. The concrete slab on the right bank side is cracked and floating.
④ Still-water pond	Revetment on the right bank: soil on the back of the revetment has been washed away along with the blocks.

	Left bank side: Slope sediment has been washed away. The concrete at the top of the left bank revetment was found to be floating. The protective floor blocks have been washed away. The pond bottom elevation of the still-water pond is EL.217.0, but sediment and gravel are deposited up to the top elevation of the protective bed block downstream (EL.221.5). The function of the pond is not fulfilled.
⑤ Canal	The side wall of the waterway is damaged. (However, it is difficult to determine if it was caused by the flood.)

Source: "Water Supply Facility Emergency Repair Plan Post Fact-Finding Survey Report (October 2021)



Source: "Water Supply Facility Emergency Repair Plan Post Fact-Finding Survey Report (October 2021)

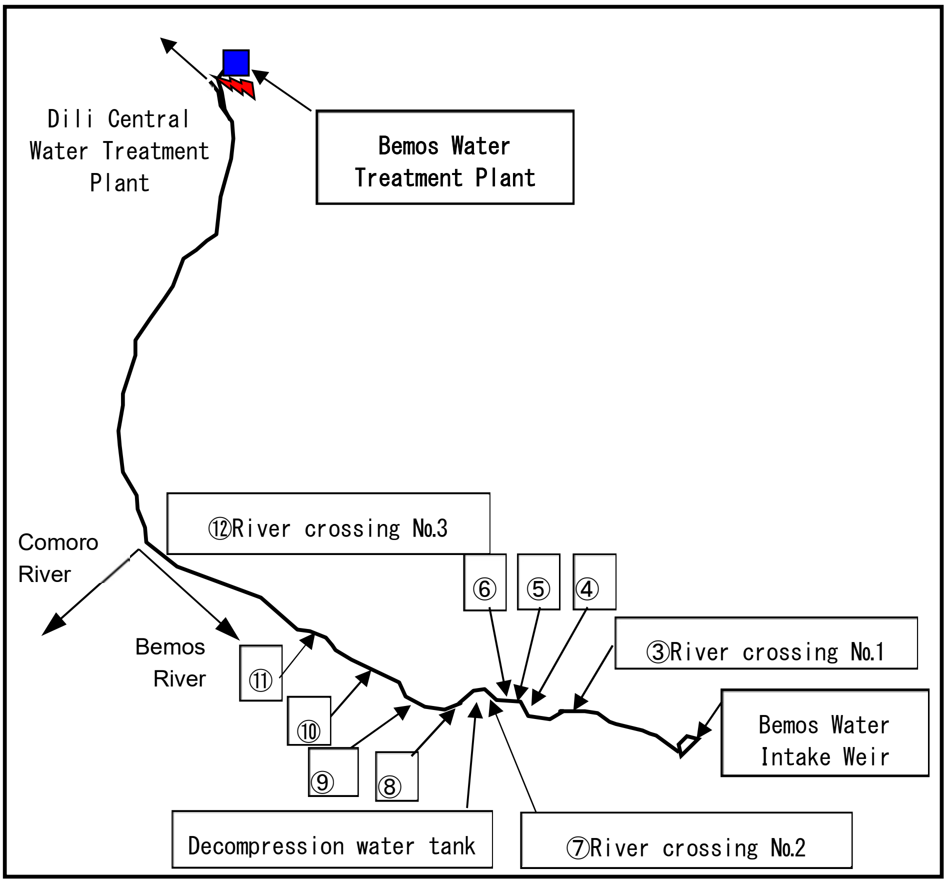
Figure 3.3-5 Damaged area of Bemos intake weir.

2) Water-conducting part

(a) Outline of the water conducting section

The section from the Bemos intake weir to the Bemos water treatment plant is served by a pipeline. The pipeline is located along the Bemos River and is connected to the water treatment plant with 3 river crossings. The length of the pipeline is L=7km (see Figure 3.3-6). The material of the pipeline is steel pipes with a diameter of 250-300mm. The pipeline is installed underground and protected by concrete revetments and piled concrete as necessary.

According to the hearing with BTL 2021, there was no damage caused by the flood in the water-conducting area downstream of the river crossing No. 3.



Source: "Water Supply Facility Emergency Repair Plan Post Fact-Finding Survey Report (October 2021)

Figure. 3.3-6 Modification of the water-conducting section (2009 - 2012)

Table 3.3-8 Damage to the water-conducting section

2009Annual Refurbishment Components	Damage caused by floods in 2021
③ River Crossing No.1	Major damage (revetment, bed protection, water pipe)
④ Route change due to the Bemos River right bank tributary lateral water pipe bridge	No damage to the water pipe bridge. Upstream and downstream pipeline are damaged.
⑤ Change of pipe route, raising of existing concrete retaining wall upstream	Damaged (due to landslide on a slope) The pipeline is conduit.
⑥ Bemos River right bank river terrace revetment	Damaged, part of revetment washed away
⑦ River Crossing No.2	Major damage (revetment, bed protection, water pipe)
⑧ Raising of existing concrete retaining walls downstream, rooting and protection of pipelines →Damaged by the flood in 2010, the countermeasure construction was replaced with concrete retaining	The retaining wall is still intact. Concrete part is not damaged. There is drift and displacement in the bed protection block.

walls.	
⑨ Protection of pipeline in the upper reaches of the left bank terrace of the Bemos River	The entire facility was swept away. The facility could not be confirmed at the site.
⑩ Bemos River left bank side river terrace downstream pipe route change, pipe protection	The upstream part of the facility has been washed away and cannot be confirmed. The retaining wall remains in the downstream section.
⑪ Pipe route change and pipe protection at the foot of the mountain on the left bank slope of the Bemos River	It is possible that the entire facility was swept away. The facility could not be confirmed at the site.
⑫ River crossing No.3	There was damage, gabions were washed away, water pipes were exposed (emergency measures were taken).

Source: "Water Supply Facility Emergency Repair Plan Post Fact-Finding Survey Report (October 2021)

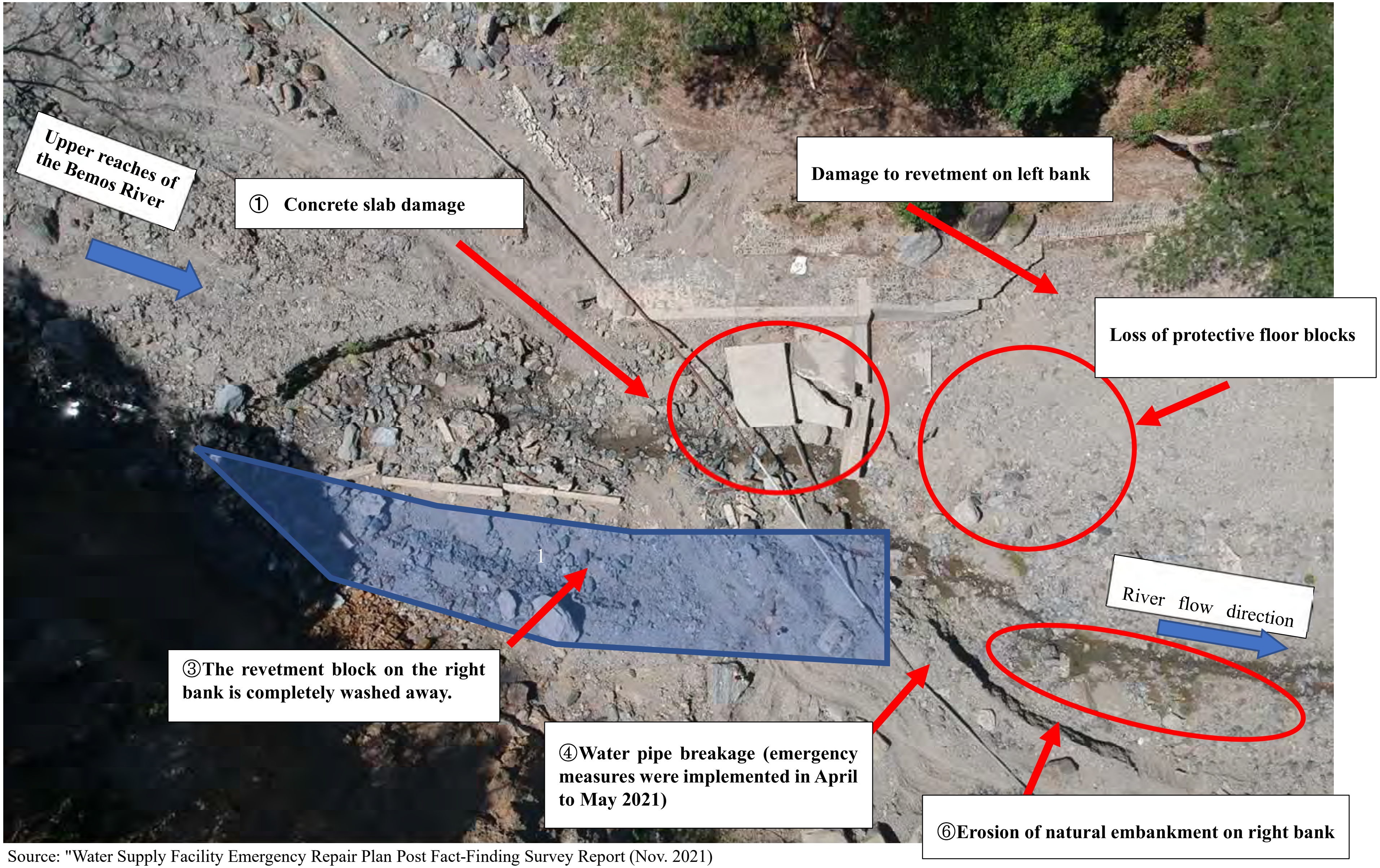
(b) River Crossing No.1

River Crossing No. 1 was severely damaged by the flood and is almost completely intact. In addition to damage to the structure, erosion of the embankment downstream can be seen. In the photo from above in figure 3.3-7, the water route are clear toward the right bank, and the erosion of the embankment downstream of the right bank is conspicuous, indicating that the river may have flowed toward the right bank instead of the expected direction during the flood. Since the flood volume far exceeded the assumed planned flood volume, the water level is considered to have been formed higher than the revetment at the crossing. Therefore, it is inferred that the erosion proceeded from the back of the revetment and the water pressure acted from the back of the retaining wall and the underside of the slab, displacing the structure.

Table 3.3-9 Damage to River Crossing No. 1

Item	Damage
① Concrete slab damage	While some of the concreate slab on the left bank remain, most of the floorboards on the right bank have been washed away.
② Damaged revetment on the left bank side	The revetment on the downstream side has been damaged and is washing away.
③ Revetment block on the right bank	Completely lost.
④ Water pipe breakage	State exposed due to destruction of protective concrete (Emergency measures were implemented in April to May 2021)
⑤ Drifting away of bed protection blocks	The existence of the block could not be confirmed. There is a possibility that the block was washed away because the right bank side is deep.
⑥ Erosion of the right bank embankment downstream of the crossing	The sediment of the natural embankment downstream of the crossing was washed away. This is thought to be because the flow direction is toward the right bank.

Source: "Water Supply Facility Emergency Repair Plan Post Fact-Finding Survey Report (October 2021)



Source: "Water Supply Facility Emergency Repair Plan Post Fact-Finding Survey Report (Nov. 2021)

Figure 3.3-7 River Crossing No. 1

(c) Raising the existing concrete retaining wall upstream

The upper part of the pipe is a structure protected by gabions. Due to the collapse of the slope, it was confirmed that the air valve box was tilted. It was confirmed that water was flowing in the pipeline and the pipe itself was usable.

(d) Bemos River right bank river terrace revetment

This facility was constructed because the pipeline could easily be scoured, exposed and suspended in the air when the river's flow path was changed. It is now in a state of being washed away by the flood.

(e) River Crossing No.2

At the river crossing No. 2, the concrete section protecting the pipe was severely damaged and the pipe was exposed. The concrete protecting the pipe was severely damaged, and the pipe was exposed. In addition, the protective bed blocks downstream could not be confirmed, so there is a possibility that the pipe may have washed away. These damages are mainly concentrated on the right bank side. The cause of the heavy damage on the right bank side is thought to be as follows.

The flow rate during the flood was higher than the design flow rate, and the river level rose.

The rising water level eroded the embankment on the back of the revetment on the right bank side, forming a new flow. When the sand are sacked out, a water path is formed and the surface layer is fragile.

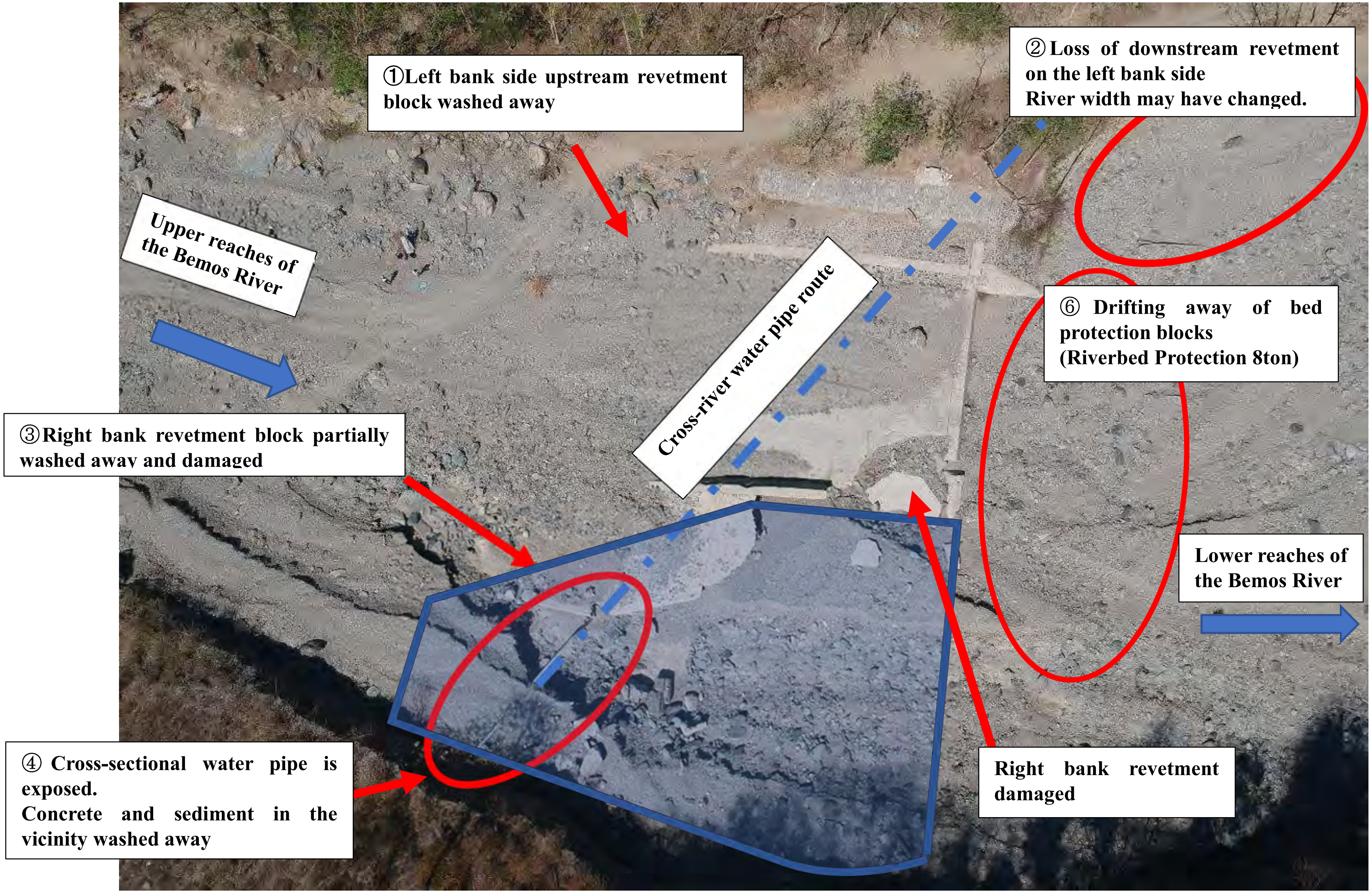
The concrete slab was destroyed by the impact of boulders and washed away.

The revetment and sand on the right bank side are washed away by erosion, and when the moat is deeply washed away, the area under the revetment block in the center is gradually washed away, leading to the loss of the block. Steel sheet piles to prevent scouring are installed downstream, but the effects of water wrapping around from the upstream side of the right bank cannot be prevented.

Table 3.3-10 Damage to River Crossing No. 2

Item	Damage
① Loss of upstream revetment block on the left bank side	The block on the upstream side has been washed away, but the damage is less severe than on the right bank.
② Washed away of the downstream revetment on the left bank side	The revetment (natural dike) on the downstream side is being eroded.
③ Right bank revetment block partially washed away and damaged	The revetment has been washed away. Damage is greater than on the left bank.
④ Loss of concrete and sediment around water pipe	The concrete and backfill soil that protected the pipes were washed away, exposing the pipes.
⑤ Washed away of the bed protection blocks	The right bank revetment and concrete slab on the right side of the flowing water section are damaged.
⑥ Washed away of the bed protection blocks	Since the block (8 tons) cannot be confirmed, it may have been washed away. Especially on the right bank side, the operation is deeply scoured, and it is thought to have been washed away.

Source: "Water Supply Facility Emergency Repair Plan Post Fact-Finding Survey Report (October 2021)



Source: "Water Supply Facility Emergency Repair Plan Post Fact-Finding Survey Report (Oct. 2021)

Figure 3.3-8 River Crossing No. 2 Damage Status

(f) Raising of existing concrete walls downstream, foot protection and protection of pipelines

The facility was completely intact and there was little damage from the flood. However, upstream and downstream of the retaining wall, sediment was washed away. The river widened downstream from its constriction just upstream of the retaining wall, and there is a clear channel trace from the right bank to the left bank direction. This suggests that the floodwaters continuously hit the retaining wall and washed away the sediment at the upstream and downstream ends, which are weak areas.

(g) Bemos River left bank side slope mountain foot pipeline change, pipeline protection

Any traces of the facility are not able to find.

(h) River Crossing No.3

A part of the pipe is exposed on the riverbed, and vehicles are passing on the left and right banks. Since there are no facilities to protect the pipe, there is a high possibility that the area around the pipe will be scoured and damaged during floods. In addition, since the soil cover is thin in the areas where vehicles pass, the load of the vehicles may be transmitted to the pipes. Therefore, there is a possibility that the pipes will be damaged for reasons other than flood damage.

3.3.3 Proposed plan of rehabilitation for Bemos Water Supply System

(1) Facility renovation policy

The details of the calculation of the probable rainfall for the study of the scale of renovation are described in 3.1.3. A summary of the planned rainfall is given below.

- ✓ The size of the facility was determined by the planned flood volume based on the maximum rainfall (126.7mm, equivalent to the probability 77 year at that time) in the grant aid project in 2009.
- ✓ The current maximum existing rainfall of 379 mm in Apr. 2021 (Bemos River basin rainfall; Thiessen method) is about 3 times the size of the previous maximum rainfall of 126.7 mm in 2009 (Dili Airport).
- ✓ The planned rainfall of 126.7 mm at the time of the project in 2009 was changed to 9 years the equivalent from 77 year at the time to the equivalent of the year by the rainfall analysis with the addition of data up to 2021.
- ✓ Engineers Without Border (EWB) of Australia has set the planned rainfall at 150mm, which is equivalent to a probability of 2 to 5 year. After consultation with the BTL, the adoption of the plan is justified because the observed data for the period from 2010 to 2021, except for the current flood, only exceeded 150mm once.

Table 3.3-11 Probable daily rainfall at Dili station and Comoro River basin

Probability year	Daily rainfall at the time of the information collection survey (mm) (GEV) (1955 to2021)	Daily rainfall at basic design (mm) (1978 to2012)
2year	70	72.0
5year	103	90.8
9year	126.7(Value adopted for basic design)	-
10year	133	101.5
30year	192	115.9
50year	228	121.9
maximum allowable	379(at the time of information collection) Probability year 233	126.7(at time of basic design) Probability year 77

Source: JICA Survey Team

Table 3.3-12 shows the flood probability years, estimated discharges, and water levels that should be adopted in the rehabilitation plan. The flood discharge is a numerical value calculated by the storage function method using eight patterns of hourly rainfall intensity data as in the case of the Comoro River. Since the water level is a guideline value calculated from the water level at the time of basic design by uniform flow method, it is necessary to improve the accuracy through local flood traces and hearing in the next stage.

Table 3.3-12 Flow rate for Bemos water supply facility

Rainfall intensity (mm/day)	Target probability year	Intake point flow rate (m3/s)	Intake point water level (m)
126.7	9 years equivalent Adopted outline design	61.96	EL.230.00
150.0	BTL adopted	76.04	EL.230.28
228	50year return period	260.27	EL.233.41
379	Largest-ever	535.43	EL.237.21

Source: JICA Survey Team

(2) Plan for rehabilitation of water supply facilities, including other donors

As shown in Fig. 3.3-9, the Bemos Dili Water Supply Facility uses the Bemos River as its water source and consists of a water intake and about 7,000m of pipeline facilities. The floods caused damage to about 2,750m of pipelines from the intake works, and little flood damage was observed in the 4,000m section downstream from the third river crossing. In this section, some houses were built on top of the pipe after it was constructed, and it will be necessary to relocate the pipe in the future after increasing its diameter to meet the increased water demand and planned water volume.

Currently, restoration projects are being planned and implemented by EWB and BTL. The contents of the current plan are shown in Table 3.3-13. The section № is in accordance with the designation of EWB.

Table 3.3-13 Rehabilitation Plan for Bemos Water Supply Facility

Section	Target area	Construction	Construction period and construction entity
Section 1.	Intake	Restoration of damaged parts of water intake works Reinforcement work for damaged areas	Emergency response measures such as repairing the water intake gate was implemented by BTL.
Section 2.	Water intake - decompression tank (About 1,360m)	Pipe installation using 315mm diameter HDPE Restoration of damaged protection wall	Mid-November 2021 -March 2022 (PLAN) Construction by EWB
Section 3.	Decompression tank - Near the river crossing №.3 (approx. 1,380m)	Pipe installation using 315mm diameter HDPE Restoration of damaged protection wall	Construction scheduled to start in 2022 Construction by BTL

Source: JICA Survey Team

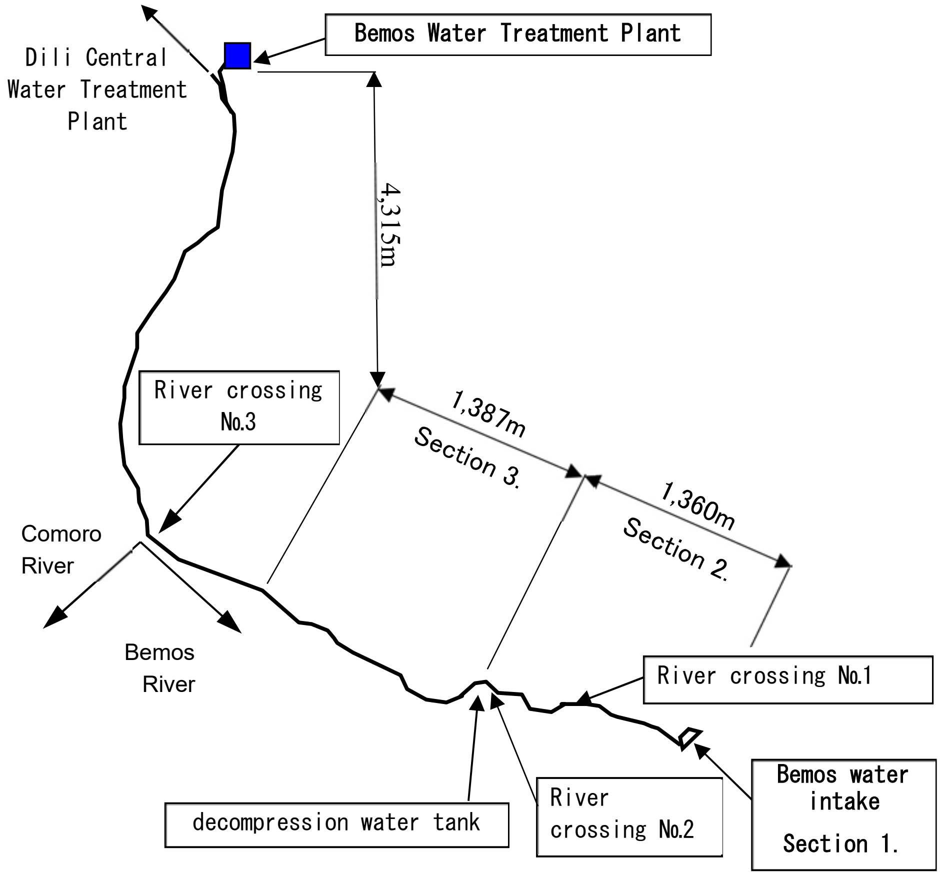


Figure 3.3-9 Schematic diagram of the Bemos water supply facility

As shown in Table 3.3-13, Section 2 was planned and implemented by EWB and was scheduled to be completed in March 2022, however, delays in material procurement have delayed construction progress, with completion currently scheduled for November 2022.For Section 3, the design documents have been submitted by BTL to ADN, and after approval of all design documents, BTL will start construction in 2022. These rehabilitation works are planned to be restored to the original structure and function as per the grant project implemented by the Japanese side in 2009. In addition, not only the pipeline facilities but also the damaged protection wall will be restored.

For this reason, the Japanese side will plan the restoration work of Section 1 (intake weir) as a grant aid project.

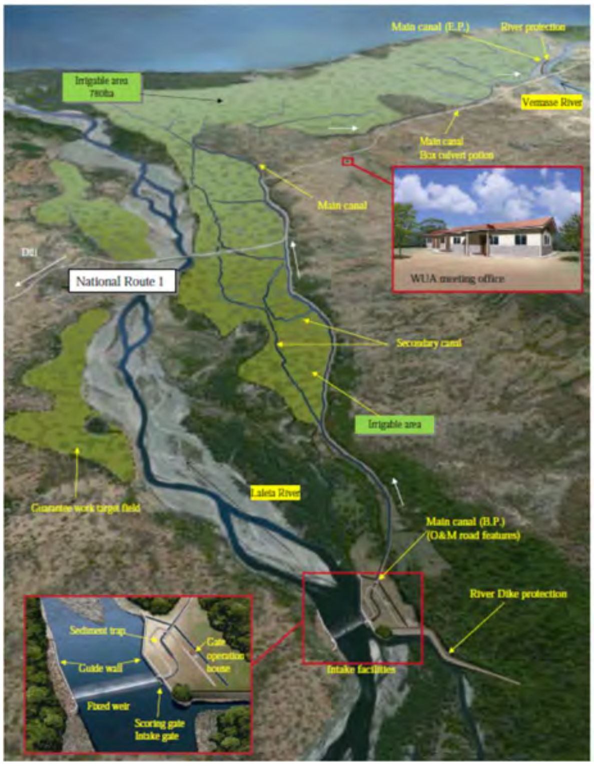
3.4 Study on Rehabilitation Plan of Buluto/Maliana Irrigation Facilities

3.4.1 Outline of Buluto/Maliana irrigation facilities

(1) Outline of Buluto irrigation facilities

1) Outline of district

The Buluto irrigation facilities are gravity irrigations with the water resource from the Laleia river, which was rehabilitated in January 2017 under the Grant aid project "Buluto Irrigation Facility Rehabilitation Project." The upstream part of the Buluto Irrigation District is located in Laleia province, and the downstream part is located in Vemasse Province. The planned irrigation area of Buluto Irrigation District is 780 ha, and the number of beneficiary farm is 533 households.



Source: Preparatory Survey Report for Rehabilitation Project of Buluto Irrigation Facility (September 2013)"

Figure3.4-1 Buluto Irrigation Scehme

2) Configuration of irrigation facilities

The configuration of the irrigation facilities is as follows,

- The headworks consist of a fixed weir, a sand sluiceway, an intake, a settling basin and its drainage.
- The main canal is equipped with a water volume control gate and an excess water discharge at the starting point to adjust the flow rate of water delivered to the main canal.
- The main canal consists of diversion works, check gates, surplus water discharges, emergency discharge outlets, and drop-off works to regulate the flow rate and diversion level to secondary canals and existing branch canals.
- The secondary canal is an earthen canal, which is connected to the existing branch canal and in-field facilities.
- Within the main canal, there are 24 water diversion facilities, 16 secondary canal routes, and 21 check gates, which make up the irrigation system.

3) Water distribution system

Water is diverted from the main canal (12.3 km long) at 24 points (16 secondary canals and 8 direct diversions to existing canals), connected to existing earthen canals, and distributed to the end fields.

4) Planting period and area

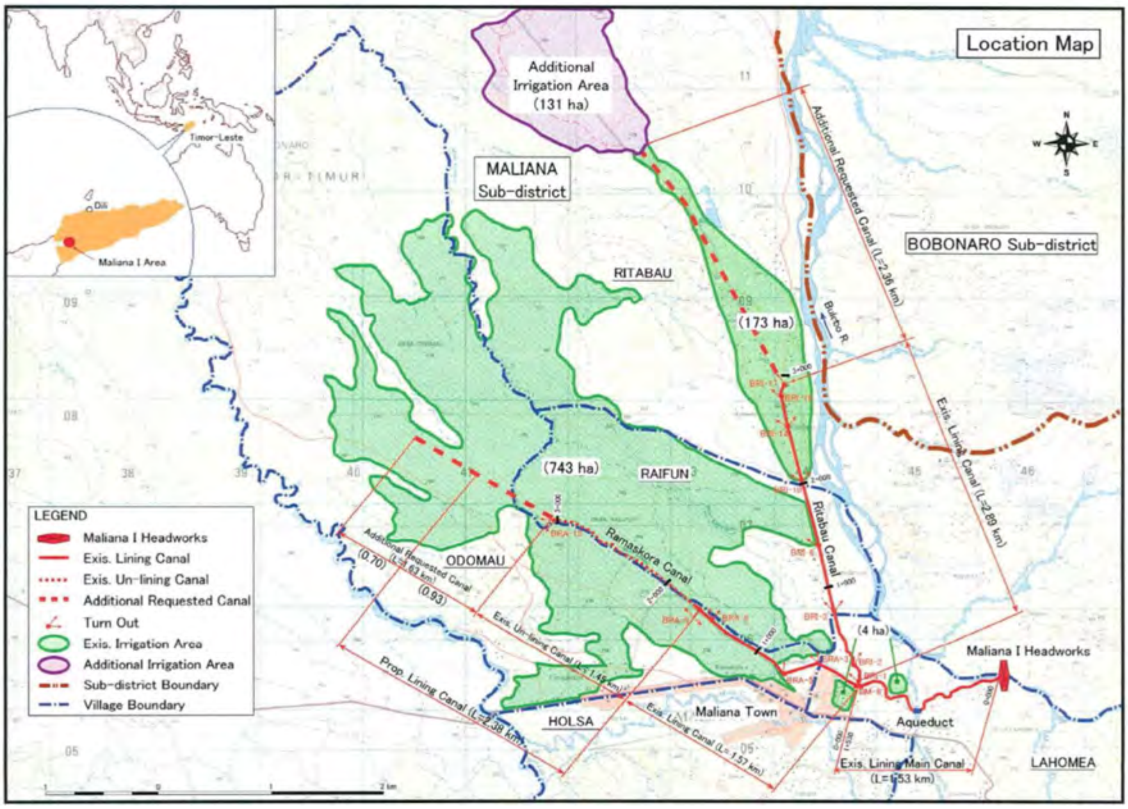
The irrigated area of Buluto Irrigation is 780 ha for rainy season crops (1month to4 month) and 390 ha for dry season crops (6month to10 month), which is a 50% of rainy season crops.

(2) Outline of Maliana irrigation facility

1) Outline of district

The Maliana Irrigation Facilities are the gravity irrigation facilities using the Bulobo River as its water source, which was rehabilitated in 2009 under the Grant aid project "Maliana I Irrigation Facility Rehabilitation and Improvement Project".

The Maliana Irrigation District is located in the villages of Odomau, Raifun, and Ritabou. The irrigation area of Maliana Irrigation is 1,050 ha, and the number of beneficiary farm is 1,454 households.



Source: Preparatory Survey Report for Rehabilitation Project of Maliana I Irrigation Facility (March,2009)"

Figure 3.4-2 Maliana Irrigation Scheme

2) Configuration of irrigation facilities

The configuration of the irrigation facilities is as follows,

- The headworks consist of a fixed weir, a sand sluiceway, an intake, a settling basin and its drainage.
- The main canal consists of the sedimentation and draining, an aqueduct over the Bipila River, and the diversion to the secondary canal.
- There are diversion works in the main channel, but no check gates.
- The gates manage the to distribute water to the two secondary canals.
- The secondary canals are diverted to the tertiary canal by a diversion works with check gate and gate, and a small diversion works with corner drop.

3) Water distribution system

The main canal (total length: 1.53 km) leads water from the intake works to the diversion works that branches off into two branch canals (Ramaskola secondary canal and Ritabou secondary canal). The Ramaskola canal (total length 4.6km) extends northwesterly and distributes water to 25 branch canals.

4) Planting period and area

The irrigated area of Maliana irrigation is 1,050 ha for rainy season cropping (January-April) and 50% of rainy season cropping (525 ha) for dry season cropping (June-October).

3.4.2 Damage assessment of Buluto/Maliana irrigation facilities

(1) Flood damage of Buluto irrigation facility

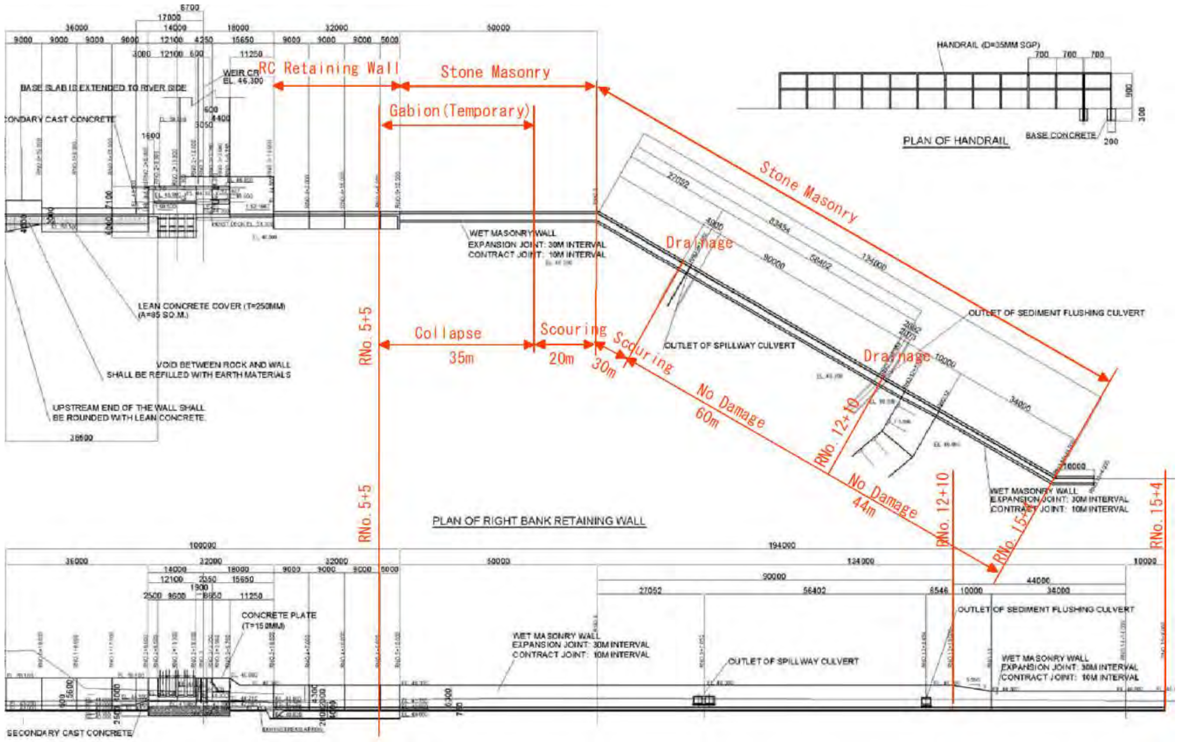
Based on the interviews with the Ministry of Agriculture and Fisheries office, the follow-up project, and the field survey, the areas where the Buluto irrigation facilities were damaged by the floods in April 2021. The locations and details of the damage are as follows,

Table 3.4-1 Locations and details of damage in Buluto irrigation facilities

Locations of the damage	Details of the damage
The retaining wall at the downstream of Buluto Headworks	The 5 m RC retaining wall and about 30 m of the stone masonry on the downstream side of the right bank of the headworks were collapsed.
Downstream apron of Buluto Headworks	The downstream apron of the Buluto headworks was scoured.
Main channel (embankment section)	The main canal (high embankment, rectangular canal cross section), was cracked on the concrete bottom slab at approximately 400m, causing water leakage.

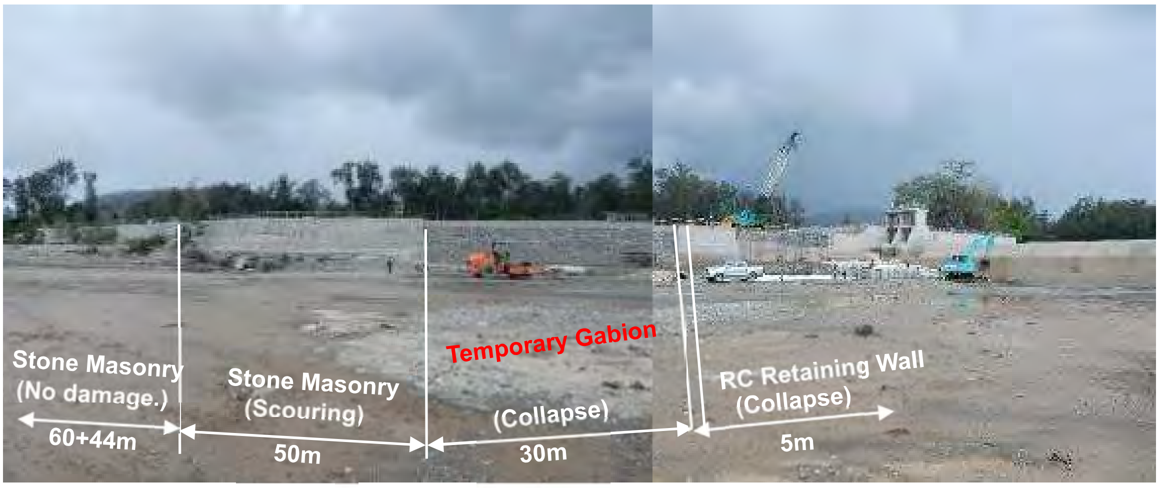
1) Stone masonry wall at the downstream of Buluto Headworks

The 5 m RC retaining wall and about 30 m of the stone masonry on the downstream of the right bank of the headworks were collapsed due to the flood in April 2021. The 50m (20m+30m) b stone masonry downstream of the collapsed wall had not been collapsed, but its foundation has been scoured and needs to be restored.



Source: JICA Survey Team

Figure 3.4-3 Damage of the stone masonry wall at the downstream of Buluto headworks



Source: JICA Survey Team

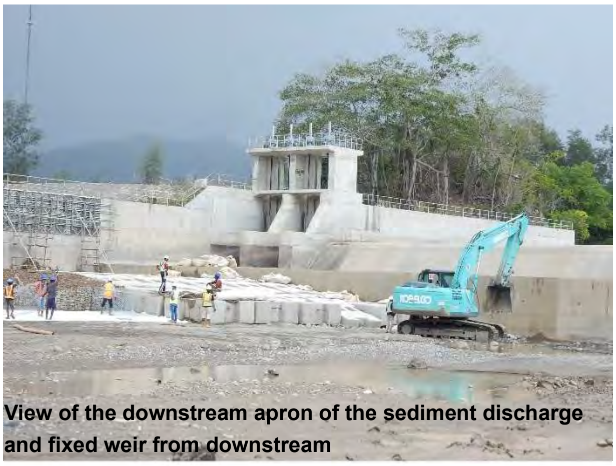
Figure3.4 -4 Photo of the Damage of the stone masonry

Source: JICA Survey Team

Figure 3.4-5 Temporary Gabon in the collapsed section **Figure 3.4-6 Scouring of stone masonry wall**

2) Downstream apron of Buluto Headworks

The downstream part of the apron in the downstream of the headworks was scoured by about 2~3m due to flooding in April 2021.



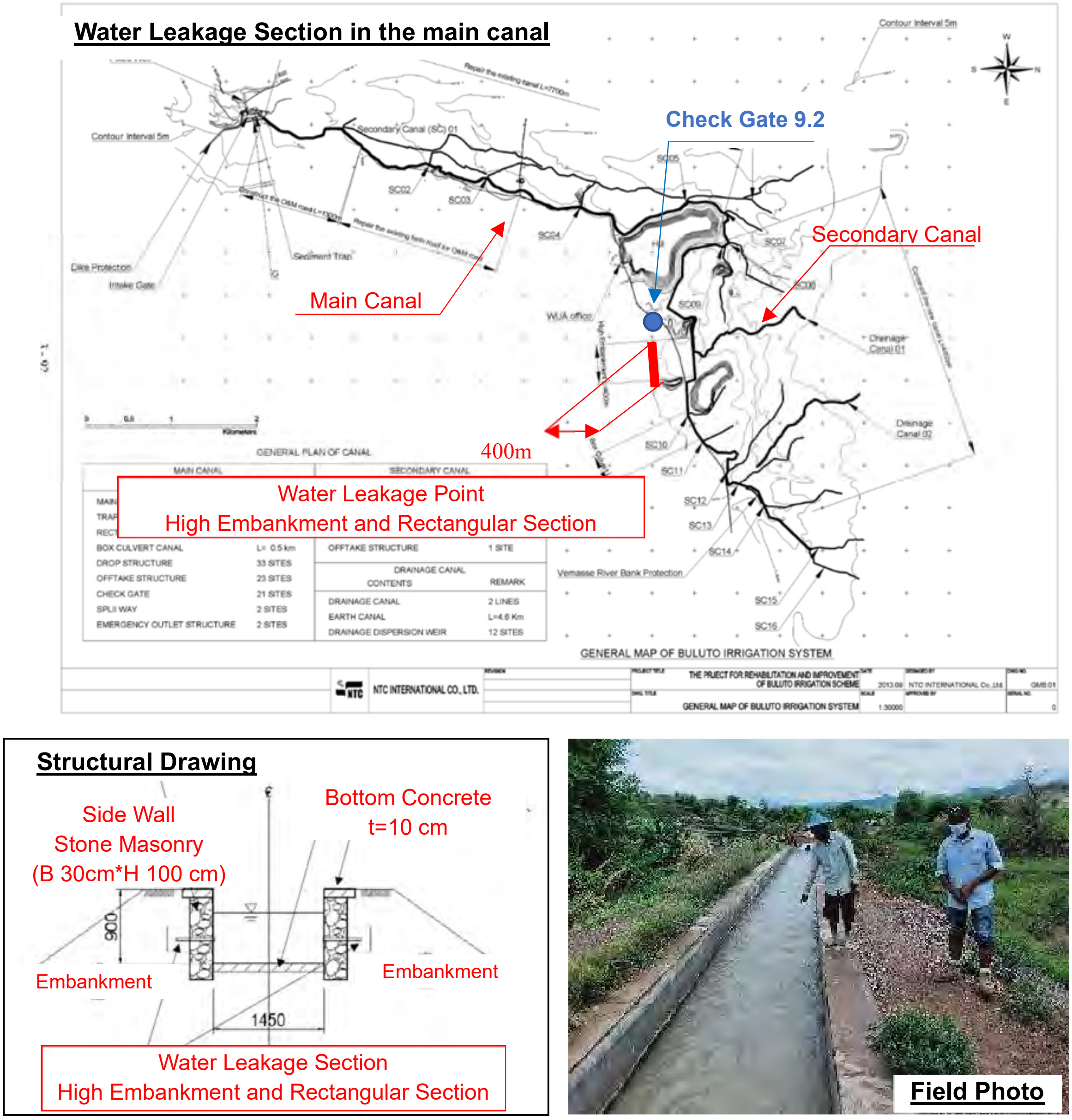
Source: JICA Survey Team

Figure 3.4-7 Scouring of the apron in the downstream of the Buluto headworks

3) Main canal (high embankment section)

① Water leakage section in the main canal

Leakage in the main canal is occurring in the high embankment and rectangular canal cross-section (approximately 400m) in the downstream of the check gate 9.2 point near Ware User Association meeting place.



Source: JICA Survey Team

Fig3.4-8 Water leakage section in the main canal, structural drawing and field photo

② Water leakage situation in the main canal

As the water was flowing during the field survey, we were not able to confirm any cracks in the main canal. However, according to interviews with the Ministry of Agriculture and Livestock and the Water Users Association (WSA), water was leaking from the wall and concrete bottom slab in the high embankment and rectangular canal section (approximately 400 m), and then water was accumulating on the site under the embankment.

As for the concrete leakage situation, cracks have been observed in the concrete bottom slab at various locations in the rectangular channel cross-section, ranging from 5m to 40m per site. At present, WSA is partially repairing the cracks, but the leakage has not stopped.

Source: "Project to Increase Farmers' Household Income by Strengthening Domestic Rice Production"

Fig. 3.4-9 Cracks in the cross section of the rectangular canal

(2) Flood damage of Maliana irrigation facilities

Based on the interviews with the Ministry of Agriculture and Fisheries office, the follow-up project, and the field survey, it is assumed that the Maliana irrigation facilities have been damaged by past floods, and have further been damaged by the current floods in April 2021. The status of the damaged areas is as follows

Table 3.4-2 Locations and details of damage in Maliana irrigation facilities

Locations of the damage	Details of the damage
Fixed weir and downstream apron of sand sluiceway apron, administrative corridor in Maliana headworks	The fixed weir and downstream apron of sand sluiceway in Maliana headworks are damaged and worn, due to repeated flood damage.
Narrowed drainage point	During floods, the cross-section of the drainage canal that runs intersected to the main canal is insufficient, therefore drainage overflows into the main canal at that point.

1) Fixed weir, downstream apron of sand sluiceway, and administrative corridor

The fixed weir and the bottom of the apron downstream of the sand sluiceway in Maliana headworks were worn out and damaged due to repeated flood damage, and the administrative corridor has also been damaged due to damage to the bottom of the apron.

Source: JICA Survey Team

Fig. 3.4-10 Damage on the fixed weir, downstream apron of the sand sluiceway, and administrative corridor in Mariana headworks

2) Narrowed drainage point

In the narrowed point of the drainage that intersects the main canal (STA.0+435), the drainage capacity is exceeded during floods and overflows into the main canal. As the result of overflows, the cross-section of the main canal is scoured.

Source: JICA Survey Team

Figure 3.4-11 Narrowing point of the main canal and drainage channel

3) Other areas that need to be repaired in the future

Table 3.4-3 Maliana Irrigation Facilities in Need of Rehabilitation and Details of Rehabilitation

	photo	Current status and details of modifications
Hoisting machine update	Sand sluiceway gate 2unit, Intake gate2 unit  Main drainage gate2, Branch line diversion gate  	Main canal gate1 unit, Sand drainage gate1 unit  To replace malfunctioning hoists due to aging and lack of maintenance.

	photo	Current status and details of modifications
Inclination of bridge pier		The pier of the aqueduct bridge on the main canal has been leaning. The situation of the inclination was confirmed in 2010. Since then, in 2014 the countermeasures have been taken as shown in the photo. Since the cause of the inclination is considered to be due to the lack of bearing capacity of the foundation, it is considered difficult to eliminate the inclination by partial repair, and renewal of the aqueduct is necessary. In the future, it will be necessary to install inclinometers and other equipment to monitor the situation as well.
Rehabilitation of Ramas Kola secondary canal		The 300m end of the Ramas Khora secondary canal is an earthen canal. It should be rehabilitated to the masonry canal by the provincial Ministry of Agriculture and Fisheries, which operates and maintains the canal.

3.4.3 Proposed plan of rehabilitation for Buluto/Maliana irrigation facilities

(1) Buluto irrigation facilites

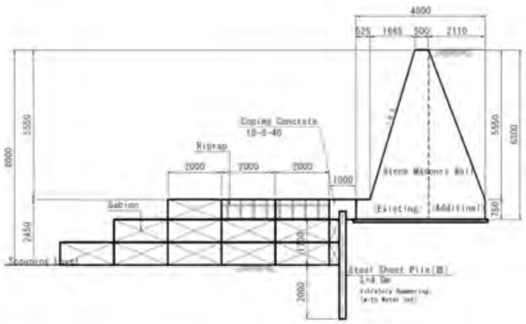
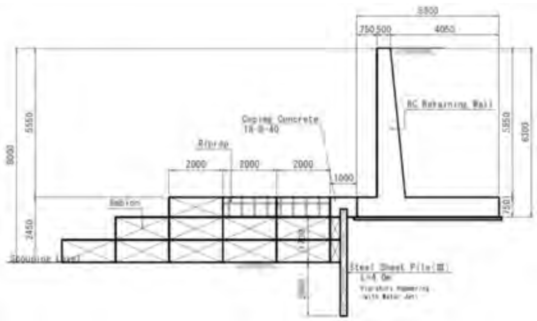
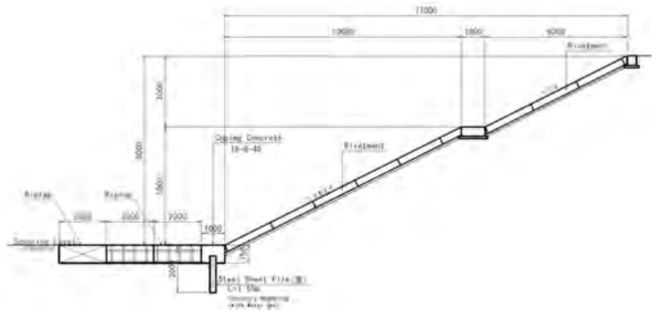
1) The retaining wall at the downstream of Buluto Headworks

The stone masonry wall in the downstream of the headworks was damaged by the flood in April 2021. At present, the gabions have been installed in the damaged masonry's sections for emergency restoration, but it is necessary to utilize the Comprehensive Grant Aid for full-scale restoration.

As a result of the comparative study on Table 3.4-4, the rehabilitation plan (3): Revetment blocks + Scour prevention measures will be considered as a candidate for the grant aid project.

In this proposal, revetment blocks (1:2.0) will be constructed on the place of temporary gabions as, and river be protections will be laid in front of the Masonry walls. The alignment will reduce the floodwater impact on the revetment.

Table3.4-4 Comparison of proposed rehabilitation plan for the retaining wall at the downstream of Buluto Headworks

	Rehabilitation Plan (1)	Rehabilitation Plan (2)	Rehabilitation Plan (3)
Plane Plan	Same as present alignment L=80.0m (80m of the total1 length 184.0m was renovated)	Revise the plane alignment and make the bending angle gentler. L=140m	Revise the plane alignment and make the bending angle gentler. L=140m
Explanation of Rehabilitation Plan	Renewal of existing stone masonry walls + Scour prevention measures The present masonry wall should be widened. Steel sheet piles be driven as a scour prevention measure to secure the scour depth (2m) from the current depth.	RC retaining wall + Scour prevention measures The present masonry wall should be removed, and the RC retaining wall be constructed. Steel sheet piles be driven as a scour prevention measure to secure the scour depth (2m) from the current depth.	Revetment blocks + Scour prevention measures The present masonry wall should be removed and new revetment blocks with a gentle slope (1:2.0) will be installed. Steel piles be driven as a scour prevention measure to secure the scour depth (2m) from the current depth.
Cross Section			
Strengths and Weaknesses	The estimated construction cost is relatively low because the present existing stone masonry wall will be used.	Its stability and durability will be excellent, because RC retaining walls are used, It is not economical to demolish the existing stone masonry wall and construct new RC retaining wall.	It is stable against flood because it is modified into alignment parallel to the flood flow. It is also economically advantageous.
Appx. Cost	155 (Million yen)	259 (Million yen)	140 (Million yen)
Judgment	○	×	◎

2) River protection block at the apron downstream for the Buluto headworks

The apron downstream of the Buluto headworks has a large scour of 2~3m. This is a section where the flow is disturbed by high velocity currents during floods, and it is judged necessary to install protection blocks to cope with unpredictable upstream and downstream riverbed fluctuations in the future. The following is the calculation of the required river protection blocks.

① Calculation of the length of the river protection block (downstream of the fixed weir)

The length of the downstream river protection block is considered using the Bligh's equation.

$L_r = L - l_a$

$L = 0.67 \cdot C \cdot f\sqrt{\Delta H \cdot q}$ = 0.67 × 12 × √(2.30 × 7.78) × 1.0 (safety factor) = 30.46m

Where, L_r: Length of the bed protection (m)

L: Total length including apron length (l_a) and river protection length (L_r) (m)

l_a: Length of the downstream apron, l_a = 13.70m

C: Bligh's coefficient (coarse sand) C =12 (field survey confirmed)

⊿ H: Maximum water level difference (m) ⊿ H =2.30m

q: Flow rate per unit width at maximum flow rate ($m/sec/m^3$)

q = 1,500 m/sec^3 ÷ 192.90 m = 7.78 $m/sec/m^3$

f: Safety factor (fixed weir 1.0)

<u>Therefore, the length of the downstream bed protection Lr = 30.46 - 13.70 = 16.76 → 18.0m.</u>

The length of the retaining wall is 18.0m. The weight of the downstream revetment is 15tf/piece.

② Calculation of the length of the river protection block (downstream of the sand sluiceway)

The length of the downstream river protection block is considered using the Bligh's equation.

$L_r = L - l_a$

$L = 0.67 \cdot C \cdot f\sqrt{\Delta H \cdot q}$ = 0.67 × 12 × √(2.40 × 6.32) × 1.5 (safety factor) = 42.06m

Where, Lr: Length of the bed protection (m)

L: Total length including apron length (la) and river protection length (Lr) (m)

L : length of apron, la = 18.00m

C: Bligh's coefficient (coarse sand) C =12 (field survey confirmed)

⊿ H: Maximum water level difference (m) = 2.40m

Q = K・L・d13/2 = 1.70 × 6.20 × 2.43/2 = 39.19 m3/sec

q: Flow rate per unit width at maximum flow rate (m3/sec/m)

q = 39.19m3/sec ÷ 6.2m = 6.32 m3/sec/m

f: Safety factor (gated weir 1.5)

<u>Therefore, the length of the downstream bed protection Lr = 42.06-18.00 = 24.06m → 27.0m.</u>

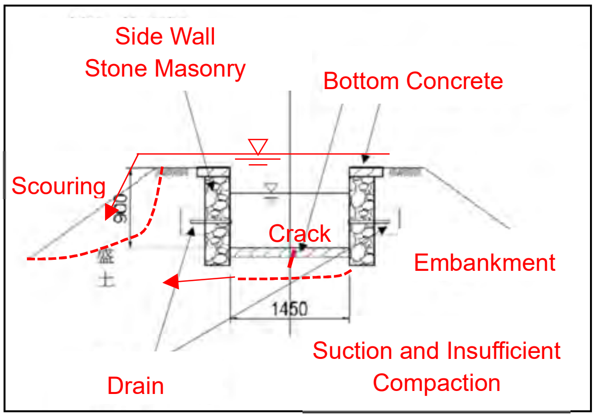
The length of the retaining wall3 is 27.0m. The weight of the downstream revetment is 15tf/piece.

3) Main channel (embankment section)

(1) Causes of cracks

The canal made by stone masonry is the standard structure for irrigation canals in Timor-Leste. In addition, since this section is a high embankment, a rectangular cross-section was adopted in order to reduce the width and amount of embankment as much as possible. Based on the interviews with the Ministry of Agriculture and Livestock and the Water Users Association and the field survey, the following causes of cracks were identified.

- ✓ During the flood, more water than the specified flow rate flowed into the main canal, causing water to overflow from the canal and scour the embankment slope and bottom. Soil was sucked out of the concrete base of the bottom concrete slab of the rectangular channel. As a result, tensile stress was generated in the unreinforced concrete of the bottom slab, and cracks occurred.
- ✓ Due to the illegal operation of the gate by a member of the association, more water than the specified flow rate flowed down into the main canal, causing water to overflow from the canal and scour the embankment slope and bottom, which sucked out the soil from the concrete base of the rectangular canal bottom concrete slab. As a result, tensile stress was generated in the unreinforced concrete of the bottom slab and cracks occurred.
- ✓ Due to insufficient compaction of the concrete base of the bottom concrete slab during construction, tensile stress was generated in the unreinforced concrete, resulting in cracks.



Source: (Figure) JICA Study Team
(Photo) "Project to Increase Farm Household Income by Strengthening Domestic Rice Production

Figure 3.4-12 Causes of cracks in embankment section

③ Study on the repair method of concrete bottom slabs in the main canal (embankment section)

The bottom slab concrete of the embankment section in the main canal (bottom: unreinforced concrete) will be upgraded to reinforced concrete. The repair method for the rectangular section with cracks will be studied. The preconditions for the repair are shown below.

1) Construction period: Although the line canal is watered all year round, the area under farming in the dry season is half that in the wet season, therefore the construction will be carried out during the dry season (May to October) whenever possible.

2) Temporary construction plan: Since the main canal is currently operated year-round, it is necessary to install a temporary canal. The required water volume for the temporary canal shall be 0.64m3/s (dry season).

3) In addition, although it is possible to carry out repair work while water is flowing, the method of carrying out construction work while water is flowing is excluded because (1) it is necessary to identify the location of cracks in advance, and (2) it is difficult for the water users' association to

maintain and manage this special method in the future. (2) It is difficult for the water users' association to maintain and manage this special construction method.

4) Construction method study

Repair plan (1)

Since tensile stress occurred in the unreinforced bottom slab concrete, the entire 400m of the bottom slab concrete shall be repaired with reinforced concrete to cope with similar cases in the future. In addition, localized repair of joints and stone masonry in the direction perpendicular to the flowing water shall also be carried out. Temporary canal shall be installed in the main canal.

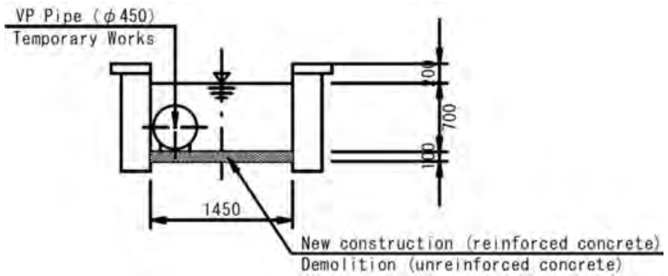
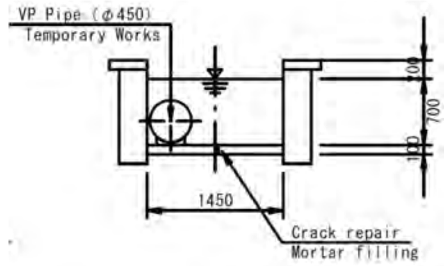
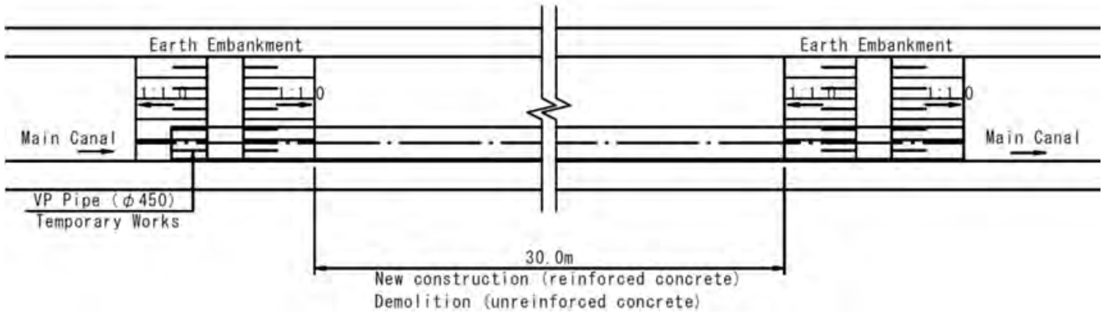
Repair plan (2)

The cracks (in the direction of water flow) in the bottom concrete slab shall be repaired partly. The repair method shall be the general mortar filling method. Temporary canal shall be installed in the main canal.

5) Renovation method

Since the bottom slab concrete is to be replaced with reinforced concrete, there is no risk of cracks in the bottom slab even if similar scouring occurs in the future, the repair plan (1) Bottom slab concrete replacement (unreinforced concrete to reinforced concrete) shall be adopted.

Table 3.4-5 Comparison of repair plan for the Main canal in Buluto irrigation

<table>
<tr><th></th><th>Repair plan (1)</th><th>Repair plan (2)</th></tr>
<tr><td>Cross Section</td><td>Concrete replacement for bottom slab (unreinforced concrete → reinforced concrete)

</td><td>Cracks in the bottom plate filled with mortar

</td></tr>
<tr><td>Temporary construction method</td><td>Temporary pipe will be installed in the main canal; concrete repairs will be made every 30 m.

</td><td>Temporary pipe will be installed in the main canal; concrete repairs will be made every 30 m. (same as left)</td></tr>
<tr><td>Strengths and Weaknesses</td><td>Since the bottom slab concrete is replaced with reinforced concrete, there is no risk of cracks occurring in the bottom slab even if similar scouring occurs in the future.</td><td>Although it is economically superior, there is a possibility that bottom plate cracks will occur when similar scouring occurs in the future.</td></tr>
<tr><td>Appx. Cost</td><td>6,600（Thousands yen)</td><td>1,000（Thousands yen)</td></tr>
<tr><td>Judgement</td><td>○</td><td>×</td></tr>
</table>

(2) Maliana irrigation facility

1) Maliana headworks fixed weir, sand sluiceway, and administrative corridor

For sustainable operation of the headworks, it is necessary to rehabilitate the headworks fixed weirs, sand sluiceway and administrative corridor that have suffered from the repeated flood damages. Basically, the rehabilitation shall be made to the original design condition.

① Rehabilitation of fixed weirs

The unreinforced concrete (high strength concrete σ=35N/mm2) of the fixed weir shall be demolished and replaced with new unreinforced concrete (same high strength). The new concrete shall be fixed with anchor bars (D22*1.0m) at intervals of 0.5m. The scope of rehabilitation of the fixed weir is shown below.

② Rehabilitation of sand sluiceway

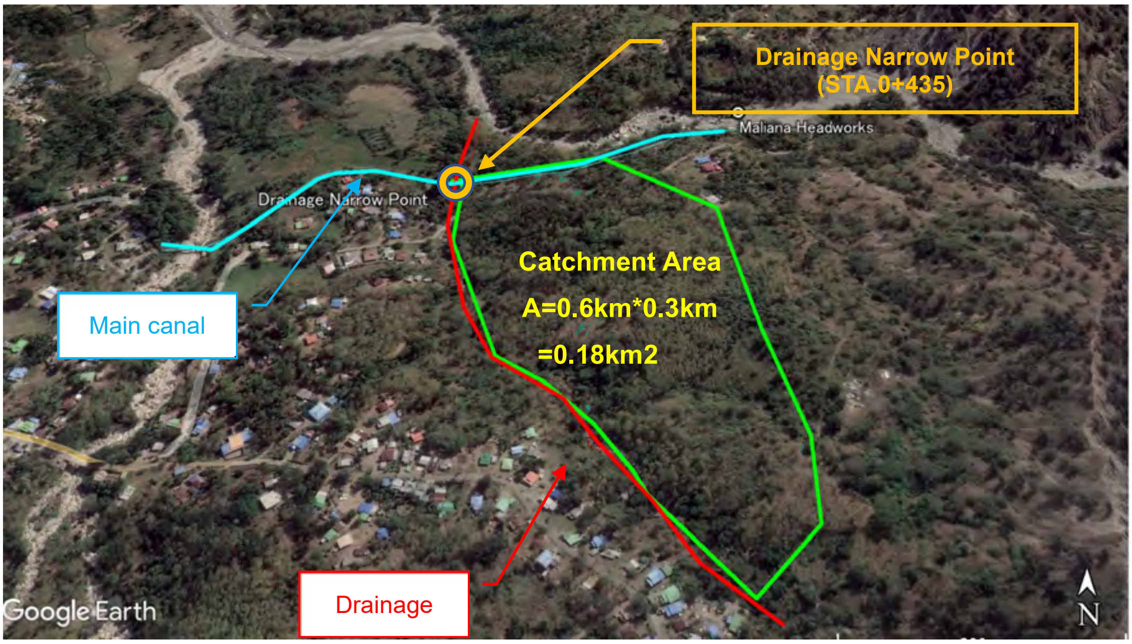
Demolish the unreinforced and reinforced concrete (high strength concrete σ=35N/mm2) downstream of the sand sluiceway and replace it with new unreinforced and reinforced concrete (same high strength).

③ Rehabilitation of administrative corridor

Backfill the scoured administrative corridor and repair with unreinforced concrete.

2) Widening of narrowed drainage

In the narrowed point of the drainage canal intersecting the main canal (STA.0+435), the drainage capacity is exceeded during floods and the canal overflows into the main canal, scouring the cross-section of the main canal.



Source: JICA Survey Team

Figure 3.4-13 Catchment Area at narrowed drainage point

① Calculation of drainage flow rate

Catchment area A=0.6km*0.3km=0.18 (km2)
Runoff coefficient f=0.3 (mountainous area with gentle slope)
Rainfall intensity during flood arrival time r=100 (mm/h) (assumed)
Rational equation $Q=1/3.6*f*r*A=1/3.6*0.3*100*0.18=0.83$ (m3/s)

② Calculation of drainage pipe size

The current drainage pipe will be demolished, and the pipe diameter of the new proposed reinforced concrete pipe will be calculated.

Hazen William
C: Flow counting =130 (centrifugal reinforced concrete pipe)
Q: Flow rate =0.83 (m3/s)
I: Hydraulic gradient = 1/300 (make the drainage pipe a gradient of about 1/300)
D: Tube diameter = $1.626 \cdot C^{-0.38} \cdot Q^{0.38} \cdot I^{-0.21} = 0.789 \rightarrow 0.80$ (m)

③ Drainage pipe installation plan

Two (2) centrifugal reinforced concrete pipes (φ800) shall be arranged in the narrow point of the drainage canal intersecting the main canal (STA.0+435). The reason for using two (2) pipes is to allow drainage without delay when an unexpected flood amount of water flows down.

3.5 Study on drainage improvement measures for Dili and 3 suburban area (Tasitolu, Hera and Tibar)

In this section, the survey for the damage situation of April flood and the current circumstances of drainage facilities in Dili and three suburbs (Tasitolu, Hera, and Tibar), which were severely flooded in April 2021 flood.

JICA Survey Team conducted flood analysis by using high-resolution topographic data AW3D. Finally, the team extracted drainage measures to be implemented in each region based on these analysis results.

3.5.1 Outline of current drainage situation and flood analysis for Dili and 3 suburban areas

In Timor-Leste, drainage channel has been developed based on Dili Sanitation and Drainage Master Plan (hereinafter referred to as "DSDMP"). On the other hand, there are no concrete drainage plan for 3 suburbs, though inland water drainage channel has been installed along the main road.

Therefore, the survey team describe drainage characteristics of each area, including the vulnerability to heavy rain based on the topographic data as shown Table3.5-1. Then, flood risk map of each area was created by conducting flood analysis that take into account only natural drainage.

Table3.5-1 Topographic data used in each area

地域	Topographical Data
Dili	AW3D DTM0.5m grid (Acquired on Sep 10th 2020 and May 9th 2021)
Tasitolu	AW3D DTM0.5m grid (Acquired on May 9th 2021)
Hera	AW3D DTM0.5m grid (Acquired on May 9th 2021)
Tibar	AW3D DTM0.5m grid (Acquired on May 9th 2021) AW3D30

(1) Dili

1) Drainage characteristics in Dili

An elevation map of Dili is shown in Figure 3.5-1. Urban areas and dwellings are concentrated in areas below 20 m elevation. In the 4-5 km behind the plains, there are mountains with elevations over 500 m above sea level.

Source: JICA Survey Team based on AW3D and AW3D30 topographic data

Figure 3.5-1 Topographical features in Dili

Figure 3.5-2 shows the river channel network in Dili. In watershed of the Becora, Taibesi-Santana River, watershed of the Lahane-Kuluhun River, and watershed of the Maloa River, flood flow flows down and discharge into the sea, if there's no overflow from the channel. The Manleu-ana River, which is connected to a drainage channel and river channel disappears on the way, has the topographical characteristic that the flood flow flows down along the west side the Maloa River. In the western and eastern parts of the Dili low-lying area, there are no rivers that discharge directly to the sea, but flood flow pass through these area.

Source: JICA Survey Team

Figure 3.5-2 River channel networks and their catchment area in Dili

Figure 3.5-3 shows the location of depressions extracted from the topographical data in the eastern part of Dili low-lying area. Depressions are concentrated mainly Caicoli area, where flood occurs if existing drainage channels cannot be drained properly.

Source: JICA Survey Team based on AW3D and materials provided by BTL

Figure 3.5-3 Depression area in Dili, extracted from AW3D

2) Outline of Dili Drainage and Infrastructure Upgrading Program

The Dili Drainage and Infrastructure Upgrading Program (hereinafter referred to as "DDIUP") is planned for Dili inland water drainage measures with the support of Aqua de Portugal (hereinafter referred to as "AdP").

The project plans to install a total of about 70km length of drainage channels in Dili by rehabilitating existing ones and constructing new ones. Existing drainage channel was installed with the capacity of 5 years return, period, but this project plans to install facilities with the capacity of 25 years for drainage channels (158mm/day at Dili airport, rainfall amount varies with elevation[1]), and 100 years

[1] Implementation of the Dili sanitation and drainage master plan -phase 2, January 2015, AdP

for diversion channel and rivers (200mm/day at Dili airport, rainfall amount varies with elevation [1]) in Dili. In addition, a flood retention basin（RB-1, RB-3 is canceled to construct) to help control the flow in the middle of Dili. Figure 3.5-4 shows the scope of DDIUP.

Source: DDIUP Environmental Impact Statement by DNSB,March 2020

Figure 3.5-4 Scope of DDIUP

① Rehabilitation of existing drainage channels and construction of new drainage channels

The drainage channels are planned for rehabilitation and new construction as shown in Figure 3.5-4. Note that roadside ditches and drainage channels within residential areas are not included in the DDIUP.

② Rehabilitation of small rivers in Dili

The cross-sectional widths of each river are designed as shown in Figure 3.5-2.

Table3.5-2 Topographic data used in each area

	Maloa	Kuluhun	Becora	Bemori	Santana
Cross-sectional width	12 m	10 m	12-15 m	12 m	20 m

Source: IMPLEMENTATION OF THE DILI SANITATION AND DRAINAGE MASTERPLAN-PHASE2 FINAL REPORT

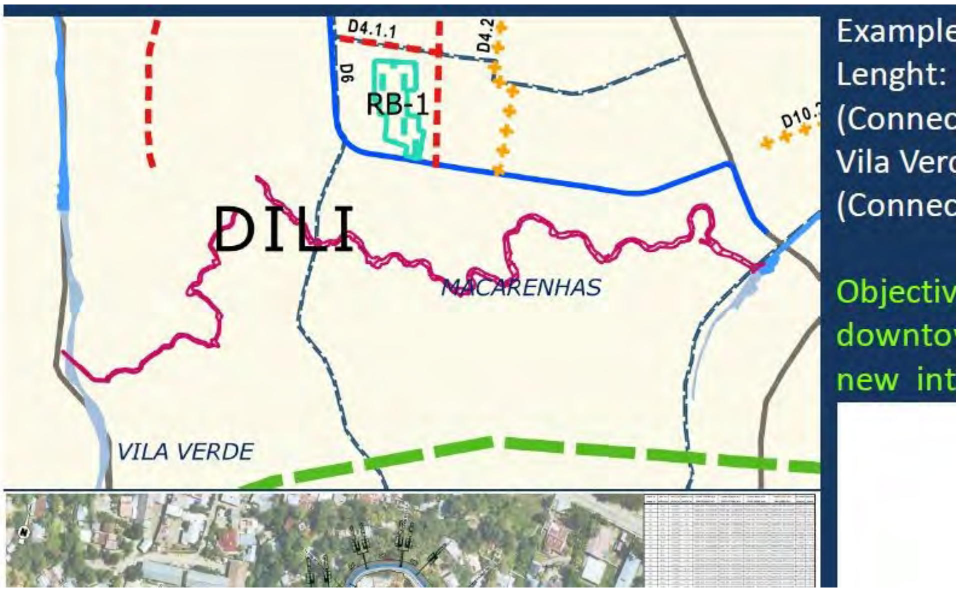
Mainly due to location limitation, excavating the riverbed are planed instead of widening the channel in the cross-sectional direction to increase the channel capacity. An example of Kuluhun River is shown in Figure 3.5-5.

Source: JICA Survey Team from DDIUP's material

Figure 3.5-5 Area of Rehabilitation in Kuluhun River

③ Constructing of Diversion channels

At the foot of the hill behind the Caicoli area, a 2048-meter diversion channel connecting to the Kuluhun River and a 925-meter channel connecting to the Maloa River are planned. In the Manleuana river.



Source: DDIUP Environmental Impact Statement by DNSB, March 2020

Figure 3.5-6 Planned Manleu-ana tunnel at the foot of the hill behind the Caicoli area

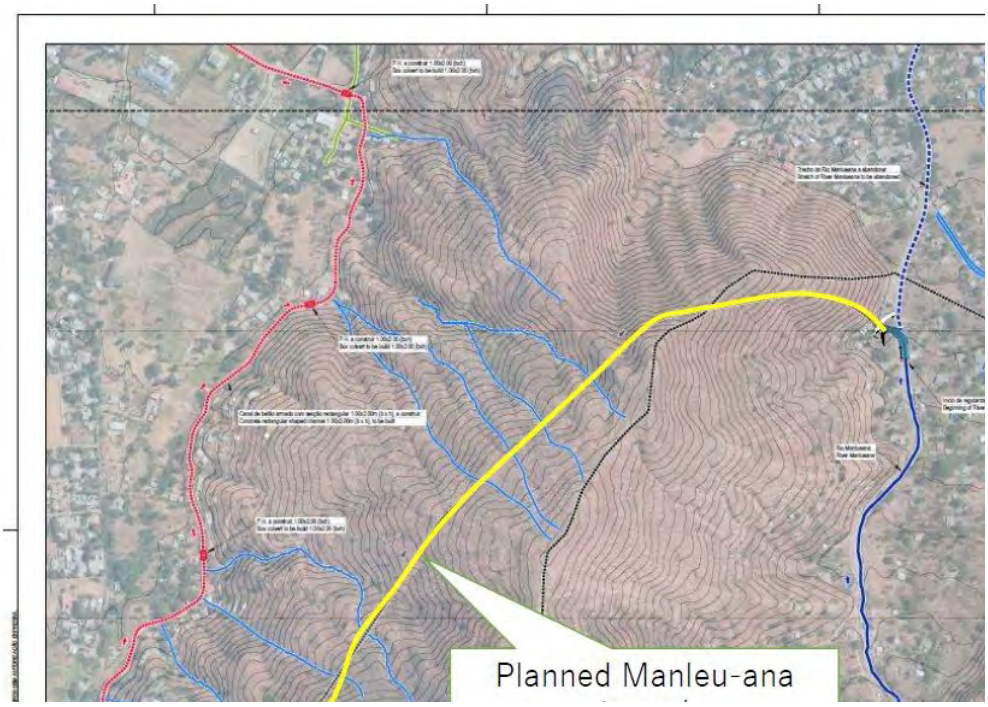


Figure 3.5-7 Planned Manleu-ana tunnel at the foot of the hill behind the Caicoli area

④ Construction of Retention Basin

Retention Basin is planned at RB1 in Figure 3.5-4. RB3 was also originally planned, but was cancelled in light of the impact of resettlement.

3) Drainage condition around Dili Airport

Dili airport is the area where flood flow from the left bank of Comoro River reaches. From topographical condition, the airport is lower than surroundings and is prone to flooding if not properly drained.

The area around the Nicolau Lobat Roundabout (hereinafter referred to as the "Roundabout") in front of the Dili Airport entrance has a topographic shape that allows flood flow from the southeastern side, which is relatively higher in elevation, to reach. In addition, the water accumulated around the Roundabout during flood is considered to be drained from the drainage channel of the runway in the airport to the sea.

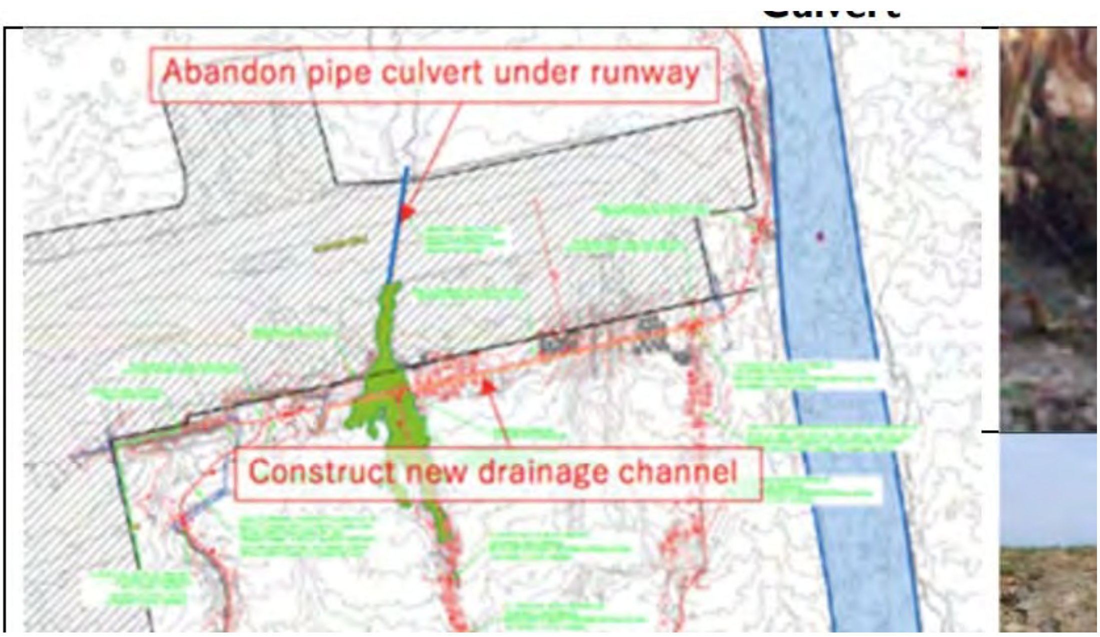
Source: JICA Survey Team

Figure 3.5-8 Flood flow direction around the Roundabout

The drainage channel in the airport is shown in Figure 3.5-9. Until today, drainage was done by a conduit that runs underground in the runway, but DDIUP plans to install new drainage channels that bypasses the runway (Figure 3.5-10).

Source: Environmental Impact Assessment／Timor-Leste : Presidente Nicolau Lobato International Airport Expansion Project

Figure 3.5-9 Drainage channels in Dili airport



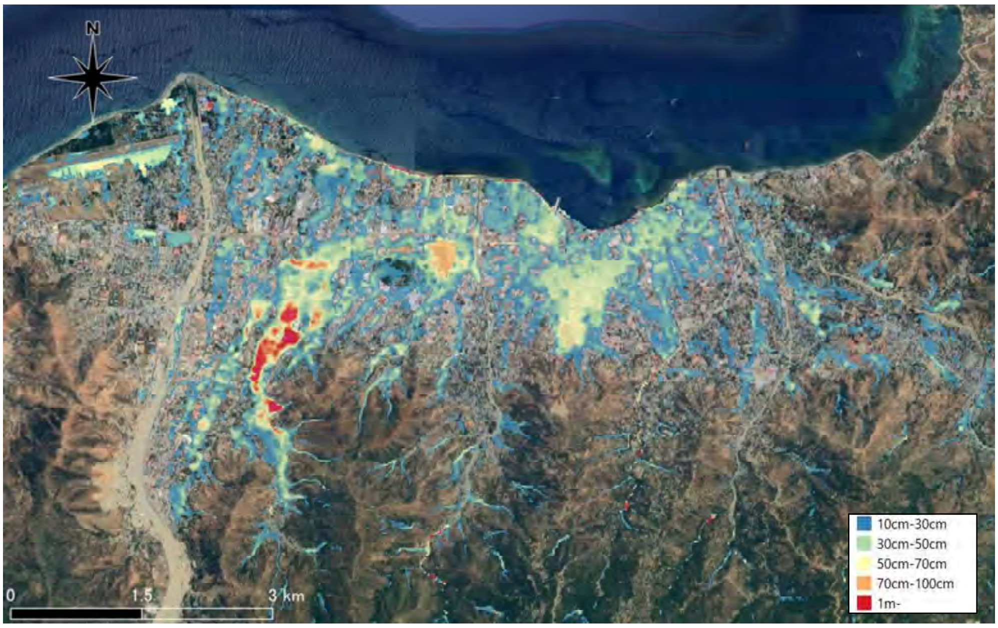
Source: Environmental Impact Assessment／Timor-Leste : Presidente Nicolau Lobato International Airport Expansion Project

Figure 3.5-10 Drainage channels at Dili airport planned by DDIUP

4）Making flood maps for ***This Flood***

Regarding Dili's flood map, flood analysis was carried out by considering various small river and drainage channels referring to the drainage channel network planned by DDIUP (Figure 3.5-4). The crossing width and depth of small rivers were set based on AW3D, drone surveys and information obtained from existing materials.

Figure 3.5-11Show a map of estimated flooded area for ***This Flood*** (hereinafter referred to as "the Result of ***This Flood***").



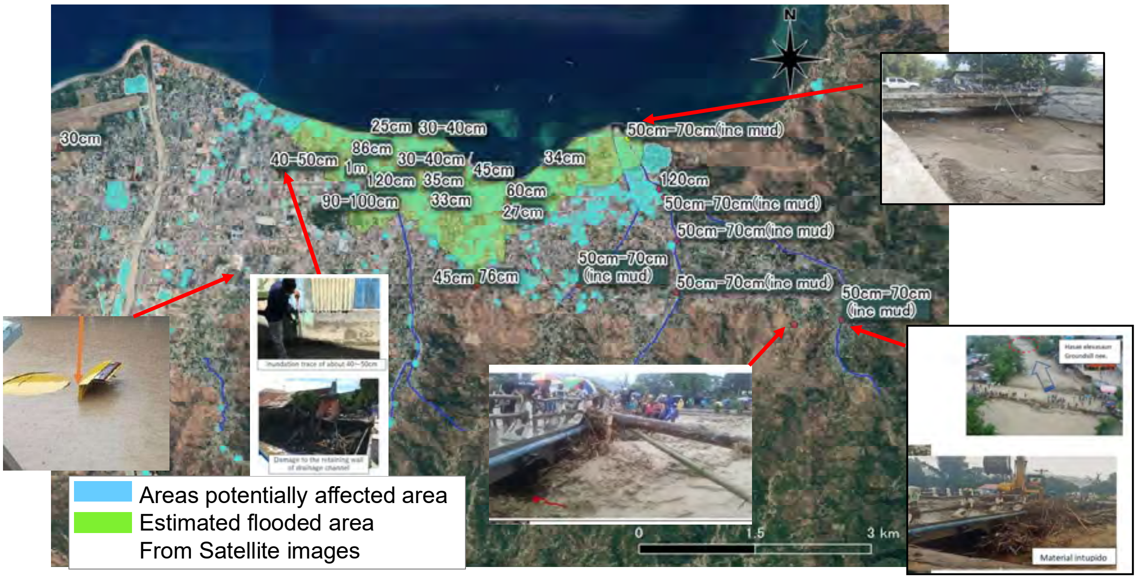
Source: JICA Survey Team

Figure 3.5-11 Estimated flood map at the time of *This Flood* ("the Result of *This Flood*")

Figure 3.5-12 shows the floodmarks of flood depth described in the flood report materials in Timor-Leste and the estimated affected area based on the satellite images immediately after ***This Flood***, released by Copernicus Programme.

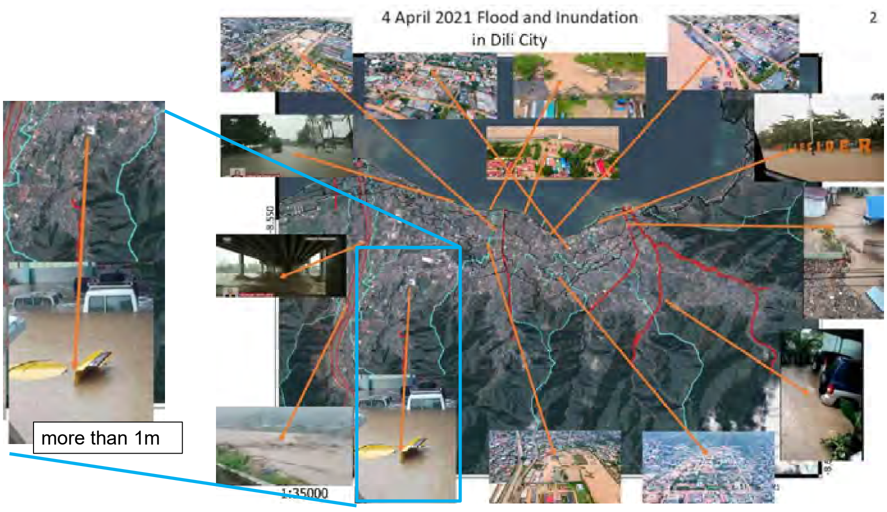
By comparing both of the above, the following tendencies were confirmed.

- In the vicinity of President office on the west side of the Maloa River, flood depth is the largest in both Figure 3.5-11 and Figure 3.5-12.
- According to the calculation results, flood depth was relatively large in the Maleuana River and its lower reaches. Although information regarding the damage is limited from the observation, the Manleuana River is an area where sediment-related disaster occurred at the time of ***This Flood***, and there is a possibility that the mudflow reached the downstream area.
- According to the observation, mudflow due to flooding occurred at the bridge at the road-river intersection, but the calculation result shows that the flooded area is local.



Source: Flood depth and estimated flooded area are based on materials provided by MPSand UNTL, floodmarks from satellite images is collected from Copernics project.

Figure 3.5-12 Floodmarks of flood depth and others during *This Flood*

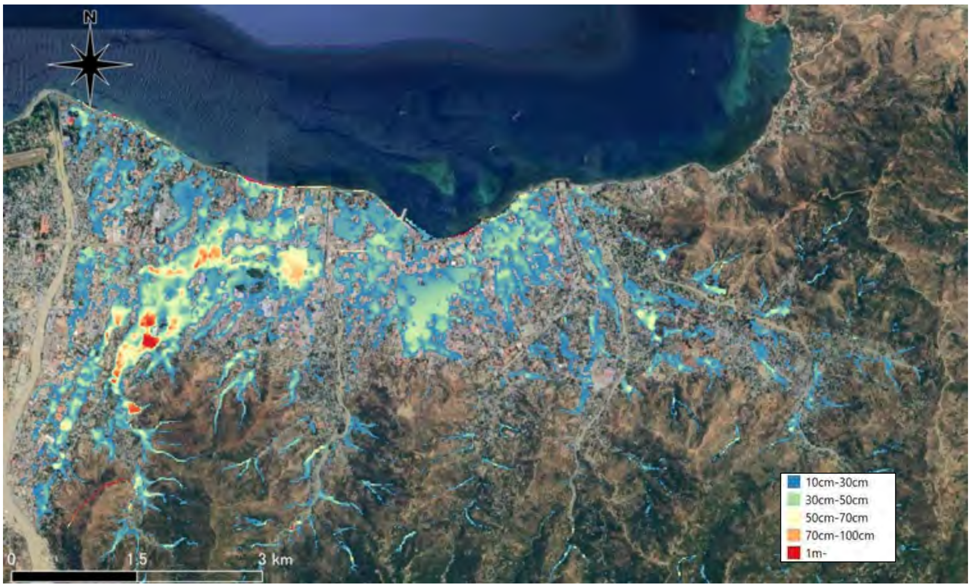


Source: Dr.Benjamim(UNTL-FEST)'s Presentaion Material

Figure 3.5-13 Flood situation during *This Flood*

① East of the Comoro River

In addition to “the result of ***This Flood***”, the following estimation was carried out based on the DDIUP considerations, in the central part of Dili, on the east side of the Comoro River. The result was shown in Figure 3.5-14.



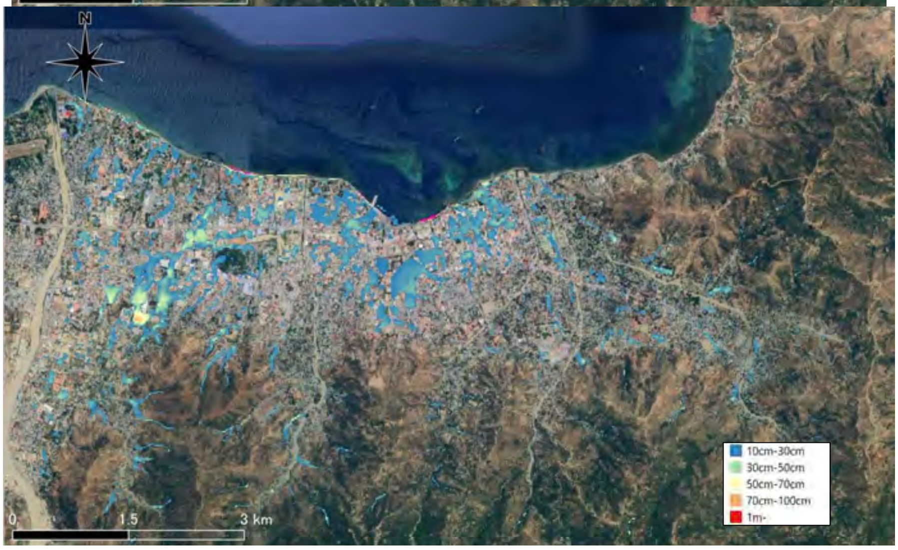
Source: JICA Survey Team

Figure 3.5-14 Estimated flood map at the time of *This Flood* with DDIUP measures

The above result suggests that the ***This Flood*** level will result in a wide area of flooding even if main measures in the DDIUP are implemented.

On the other hand, even in the case of rainfall of the DDIUP's planned rainfall am (about150 mm/day), the flood depth is mostly less than 50 cm except for the lower reaches of the Manleuana River, suggesting that the flooded area extends over a wide area, and even if DDIUP measures are considered, the area is not eliminated completely (Figure 3.5-15). It was assumed that the roadside channels and channels in residential areas are not taken into account in DDIUP. Figure 3.5-15 shows the results when these small drainage channels were partially taken into account on a trial basis.

The results indicate that the risk of flooding can be reduced by implementing measures not only for the main drainage channels covered by the DDIUP, but also for smaller drainage channels.



Source: JICA Survey Team

Figure 3.5-15 Estimated flood map in the case of about 150mm/day rainfall (Upper: without DDIUP measures, Lower: with DDIUP measures)

Source: JICA Survey Team

Figure 3.5-16 Estimated flood map in the case of about 150mm/day rainfall, partially considering small drainage channels

② Around Dili airport

JICA Survey Team conducted a drainage analysis of the case that the drainage channel near the airport is installed as planned by DDIUP. The right figure of Figure 3.5-17 shows the estimated flood area of this analysis. It is assumed that the flood flow from the south side of the airport will not reach the center of the airport including runway due to the installation of the drainage channel.

Source: JICA Survey Team

Figure 3.5-17 Estimaetd lood map around Dili Airport at the time of *This Flood*
(Left: the same as Figure 3.5-11, Right: Considering planed drainage by DDIUP)

(2) Tasitolu

1) Drainage characteristics in Tasitolu

In Tasitolu, only roadside ditches exists so far though D37 drainage channel is planned along the national road.

Figure 3.5-19 shows the topographic features of Tasitolu based on AW3D. Lake Tasitolu is surrounded by mountains with a maximum altitude of about 400m, and when rainfall occurs, the inflow from the mountains is concentrated in Lake Tasitolu. The north of Lake Tasitolu is along the national road and there is no direct inflow from the area to Lake Tasitolu, but the area affect the risk of flood of the low-lying area around the road.

Source: Material provided by BTL

Figure 3.5-18 Existing drainage channel around Tasitolu

Source: JICA Survey Team

Figure 3.5-19 Topographic features in Tasitolu

2）Making flood maps for ***This Flood***

Figure 3.5-20 shows the changes in the flooded area based on the topographical conditions around Lake Tasitolu during heavy rainfall assuming ***This Flood.***

In the area around No.1 Tasitolu and No.2 Tasitolu, the slope flow mainly from the hill from the south reaches the lake and rises the lake water level. At the same time, the flood flow that occurred in the low-lying area on the north side of Tasitolu1 and Tasitolu2 flow down in the west-southwest direction slowly.

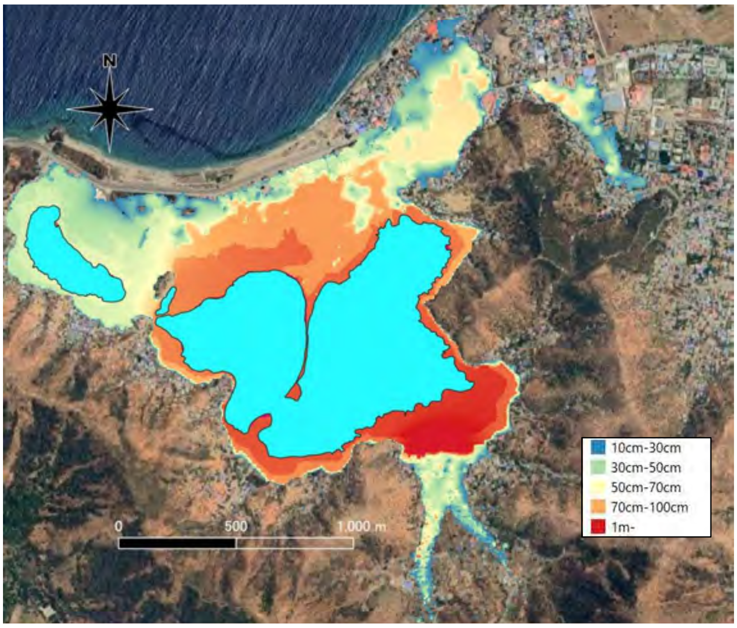
When the lake water level rises in a certain level the flooded are moves in the - southwest direction by merging with the flood flow from the north side.

In addition, there is a record of flooded area as of April 9th based on satellite images around Lake Tasitolu, and when comparing it with the flood analysis result, flooded area of flood analysis result is wider than record from satellite images, on the other hand, flooded area of flood analysis result is smaller than satellite images near No3 Tasitolu(Figure 3.5-21).

These differences are considered to be the following two.

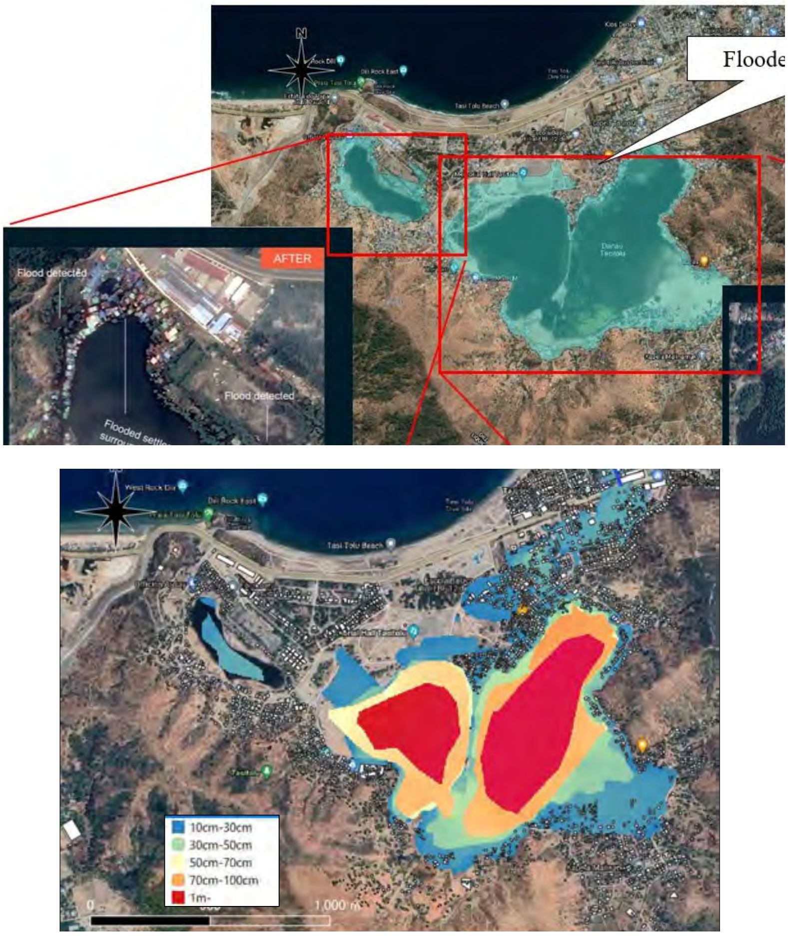
① There is a difference between the rainfall used for ***This Flood*** analysis and the actual rainfall.

② Calculated water depth of Lake Tasitolu is different from actual depth.



Source: JICA Survey Team

Figure 3.5-20 Estimated flood map at the time of *This Flood* in Tasitolu (Estimated Maximum flood depth during *This Flood*)



Source: Satellite images are collected from UNOSAT materials, flooded area is made by JICA Survey Team

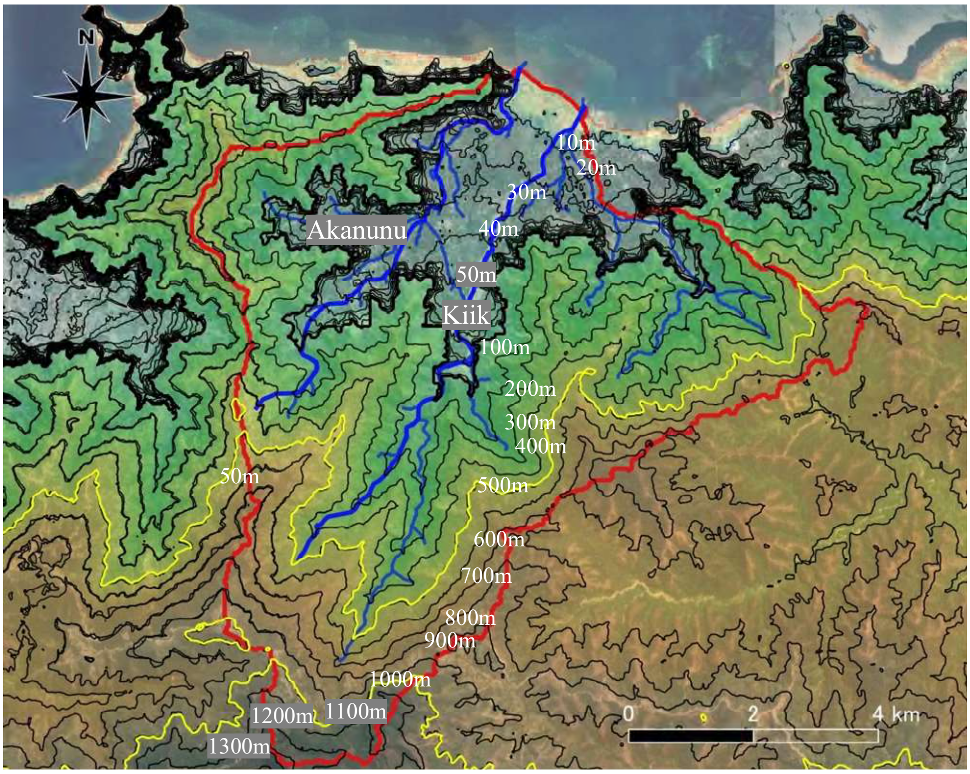
Figure 3.5-21 Estimated lood map at the time of *This Flood* in Tasitolu (9th April, 2021)

(3) Hera

1）Drainage characteristics in Hera

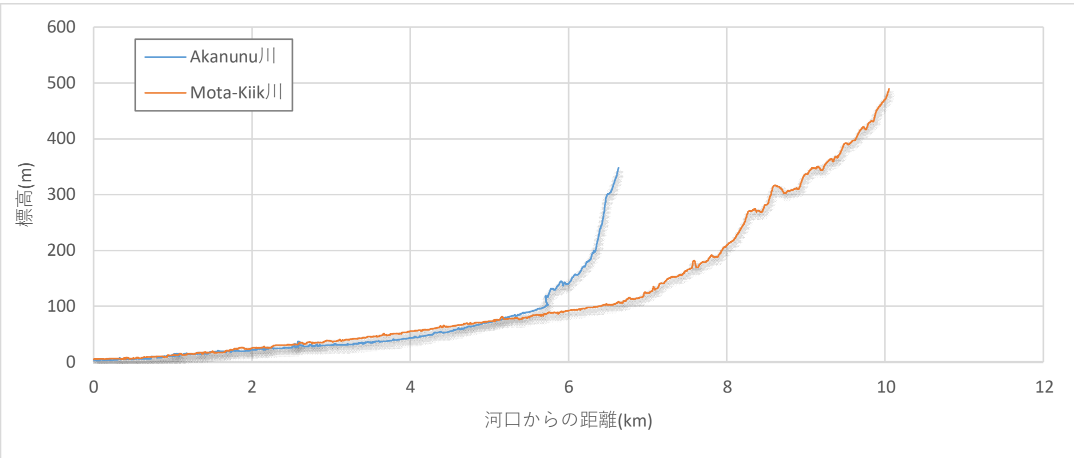
Figure 3.5-22 shows the topographic features in Hera based on AW3D. In Hera, small rivers of Mota-Kiik and Akanunu play the roles of drainage channels of rainwater.

The relationship between the distance from the mouths of the Mota-Kiik and Akanunu and the elevation is shown in Figure 3.5-23. Both of which have steep slopes of more than 1/10 of gradient in the upstream area.



Source: JICA Survey Team

Figure 3.5-22 Topographic features in Hera



Source: JICA Survey Team

Figure 3.5-23 Riverbed longitudinal curve of Mota-Kiik and Akanunu

The intersection of the Akanunu River with the national highway (about 3.7km from the river mouth) is a narrowed part and driftwood clogged the box-culvert bridge during the ***This Flood***, and which caused flood damage.

Source: A Material provided by UNTL

Figure 3.5-24 Damage situation at the intersection of Akanunu River and the National road

At the intersection of the Mota-Kiik and national road, the width of river is about 40 m and the water depth can be secured up to about 6m, so flood damage seems is unlikely to occur.

Source: JICA Survey Team

Figure 3.5-25 Intersection of Mota-Kiik and the National road

On the other hand, at the river mouth, the river join the stream from the east side. The embankment is filled and the crossing width is about 30m, which is narrower than the road intersection area as shown in Figure 3.5-26.

The mouth or the Mota-kiik is farmland and low-lying area, was damaged by flash floods and storm surges during ***This Flood***. If the crossing width is narrower in the downstream than in the upstream, the water levels tends to rise during floods, and the risk of flooding becomes high.

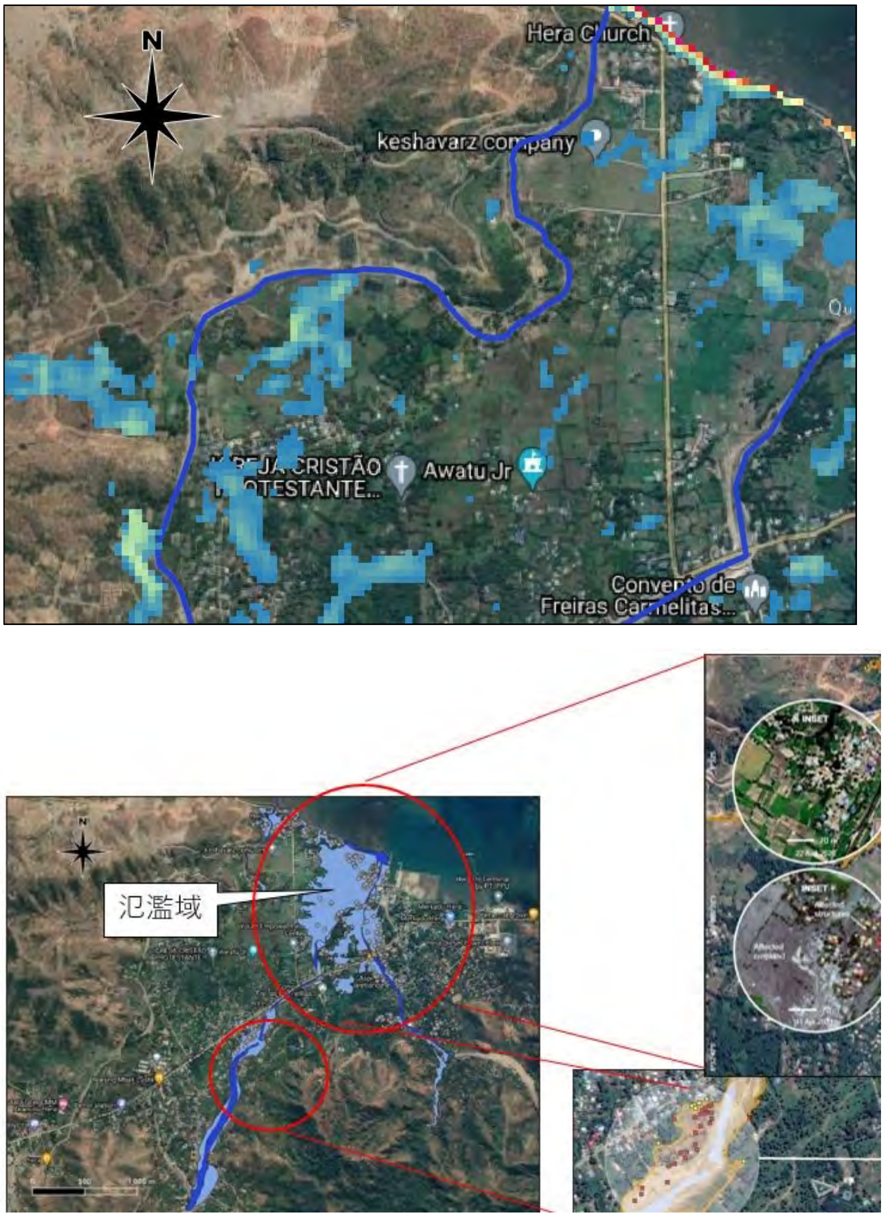
Source: Google Earth

Figure 3.5-26 Aerial photograph of the mouth of the Mota-kiik as of April 9th 2021

2) Making flood maps for ***This Flood***

Figure 3.5-27 shows a map of the estimated flooded map for ***This Flood*** in Hera with floodmarks of satellite image released by UNOSAT. ***This Flood*** analysis can't evaluate the large-scale riverbank erosion that occurred at a point approximately 2.5km from the mouth of the Mota-Kii, because this analysis uses topographical data as of May 2021, after the occurrence of the erosion.

Even in the river mouth, the team was could not reproduce the large-scale flood damage that actually occurred. It is presumed that the main factors are that the influence of storm surge and topographical changes caused by flashflood are not taken into consideration in ***This Flood*** analysis.



Source: Satellite images are collected from UNOSAT materials, flooded area is made by JICA Survey Team

Figure 3.5-27 Estimated flood map at the time of *This Flood* in Hera

At the intersection of the Akanunu River and the national road, where driftwood caused flood damage during ***This Flood*** due to the obstruction of the river channel, flooding was confirmed from the flood analysis results, but the damage was local because it was originally a place where water was difficult to collect. On the other hand, there are multiple flooded areas in the neighboring areas. Assuming from “High Susceptibility Zone” for landslide risk around Akanunu and Mota-Kiik, there is a possibility that small-scale flooding and mudflow associated with flood flow occurred in several areas in the middle reaches of the Akanunu and Mota-Kiik.

※The arrows in the figure indicate the direction in which the photo was taken, with north facing up.

Source: JICA Survey Team

Figure 3.5-28 Photos of the intersection of the national road, Akanunu and Mota-kiik

Source: JICA Survey Team

Figure 3.5-29 Estimated flood analysis of the location where driftwood damage occurred during *This Flood*

(4) Tibar

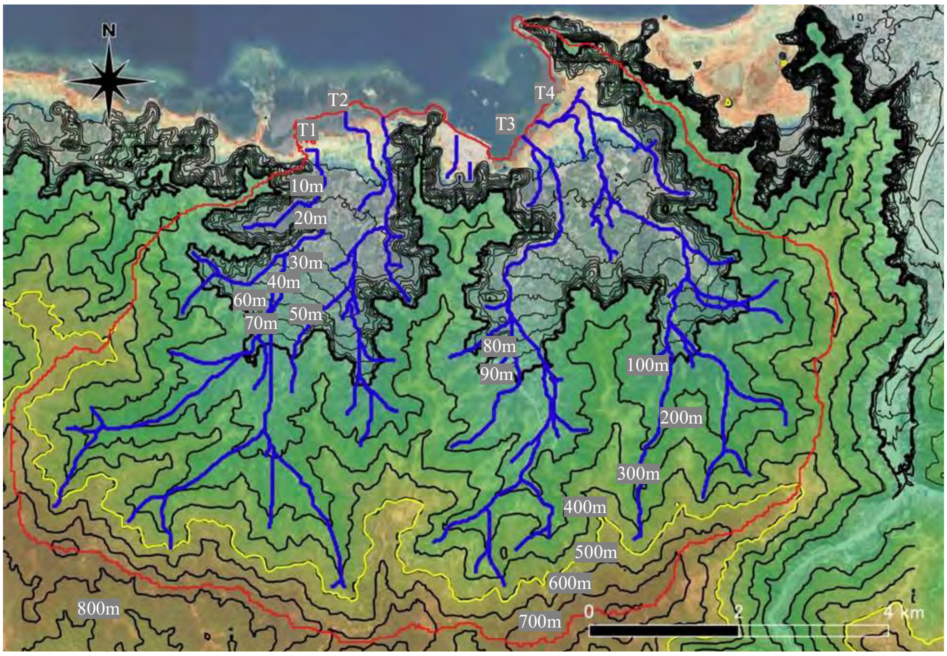
1）Drainage characteristics in Tibar

Figure 3.5-30 shows the topographic features in Tibar. It is assumed that the part used as traffic routes in the dry season plays the role of a stormwater drainage channel in the rainy season.

Damage to the mouth of T2 has been confirmed from satellite images during ***This Flood***.

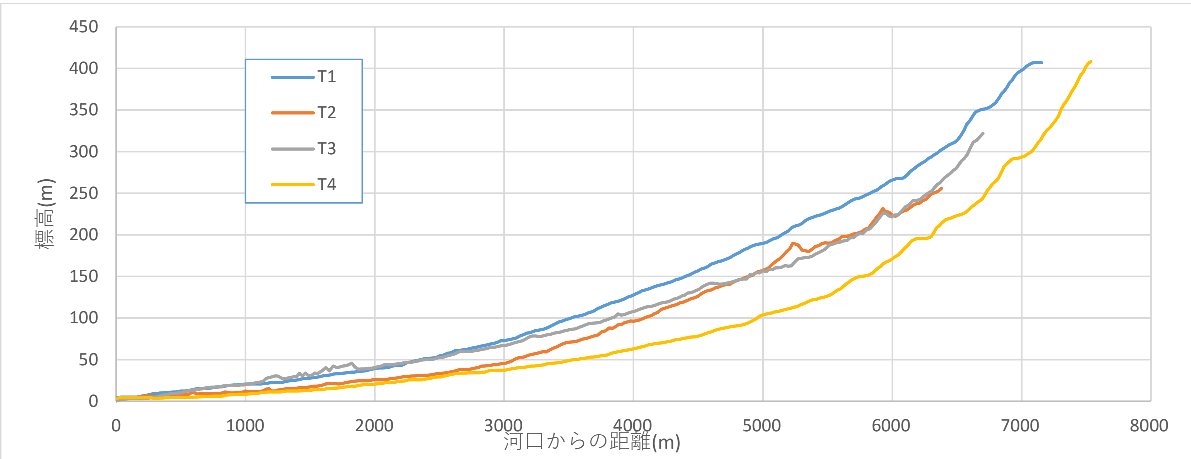
No clear damage has been confirmed at Tibar Port, but there is an small hill on the south side of the port, and the flood flow from there flows into Tibar Port due to topographical conditions.

In T4 river, the damage was confirmed in the middle of basin and the intersection with the national road from the satellite image at the time of ***This Flood***.



Source: JICA Survey Team

Figure 3.5-30 Pseudo drainage in Tibar



Source: JICA Survey Team

Figure 3.5-31 Riverbed longitudinal curve of T1-T4

2）Making flood maps for ***This Flood***

Figure 3.5-32 shows the map of estimated flooded area of ***This Flood***. In Tibar, in each small river area as shown in Figure 3.5-30, water first accumulated in a small valley, flowed into drainage channels, and then flow downstream.

In the downstream, flooded area is confirmed at flat lands along T2, T4, intersections among national road and small river and river mouths.

Source: JICA Survey Team

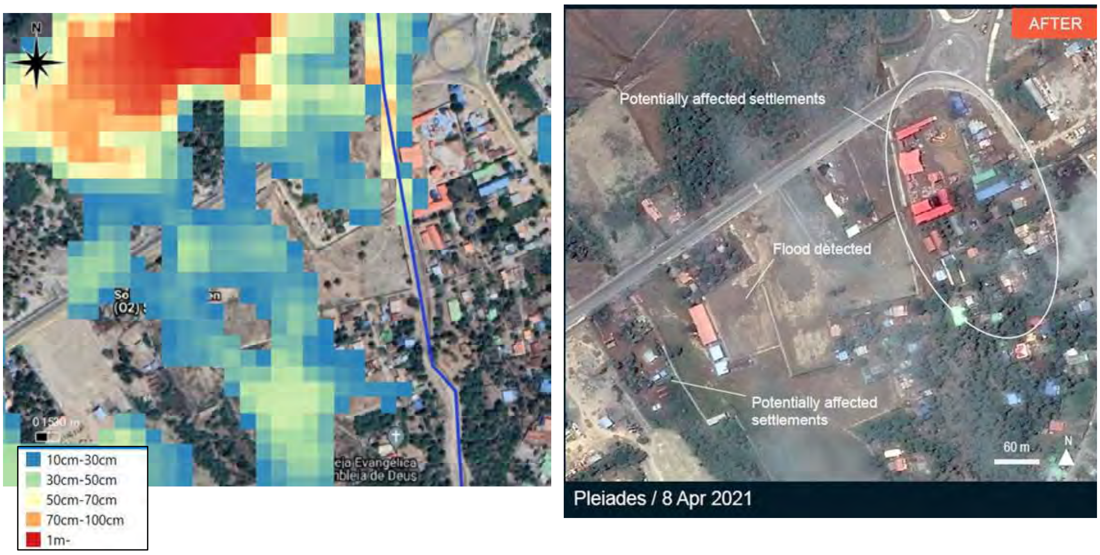
Figure 3.5-32 Estimtaed flood map at the time of *This Flood* (the result of *This Flood*)

Figure 3.5-33 shows a map of the estimated flooded area in the river mouth of T2 and a satellite interpretation map during floods by UNOSAT. Flooded area is different from left figure and right figure of Figure 3.5-33, and there are some parts that cannot be reproduced by flood analysis, but there's a possibility that the satellite interpretation map identify the increase in soil water content due to heavy rain as the flooded area.

Source: Left Figure/JICA survey team, Right Figure/Materials open to the public by UNOSAT

Figure 3.5-33 Estimated Flood map at the time of *This Flood* (the Result of *This Flood*)

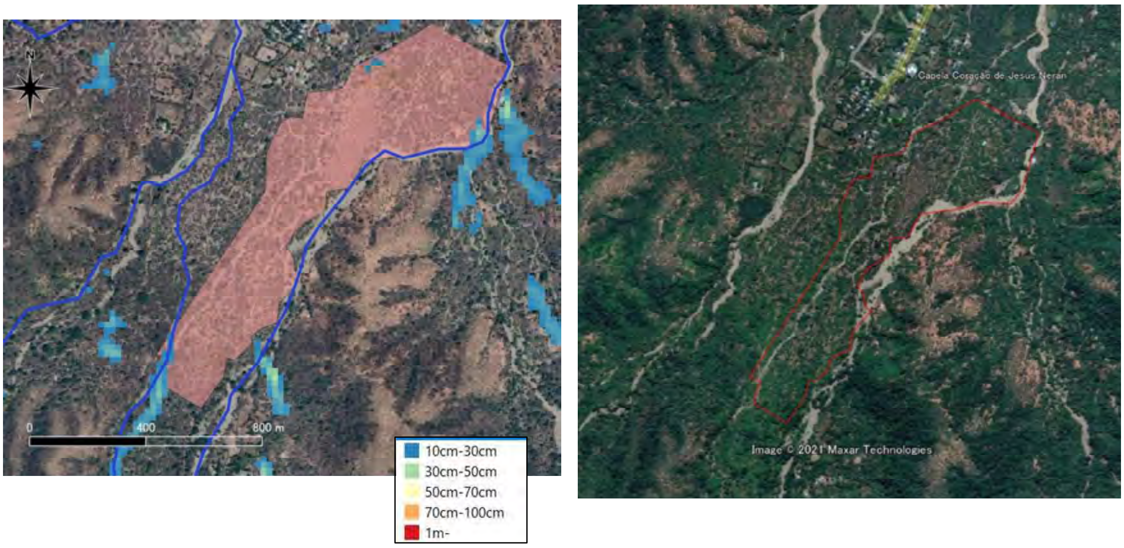
Figure 3.5-34 shows a comparison between the estimate flood analysis and the satellite image as of 8th April, 2021 around the intersection between national road and T4. From the left figure of Figure 3.5-34, it is assumed that flood occurred at the intersection of T4 and the road, and then it spread to the neighborhood.



Source: Left Figure/JICA Survey Team, Right Figure/Materials open to the public by UNOSAT

Figure 3.5-34 Estimated Flood map at the time of *This Flood* (the result of *This Flood*)

Figure 3.5-35 shows the flood analysis result around planned industrial park area. No noticeable damage has been confirmed on Google Earth, but there is a possibility that flood flow during floods there, because the boundary of the park site is adjacent to the road and drainage channel. It is necessary to take measures such as installing a revetment at the boundary between the road.



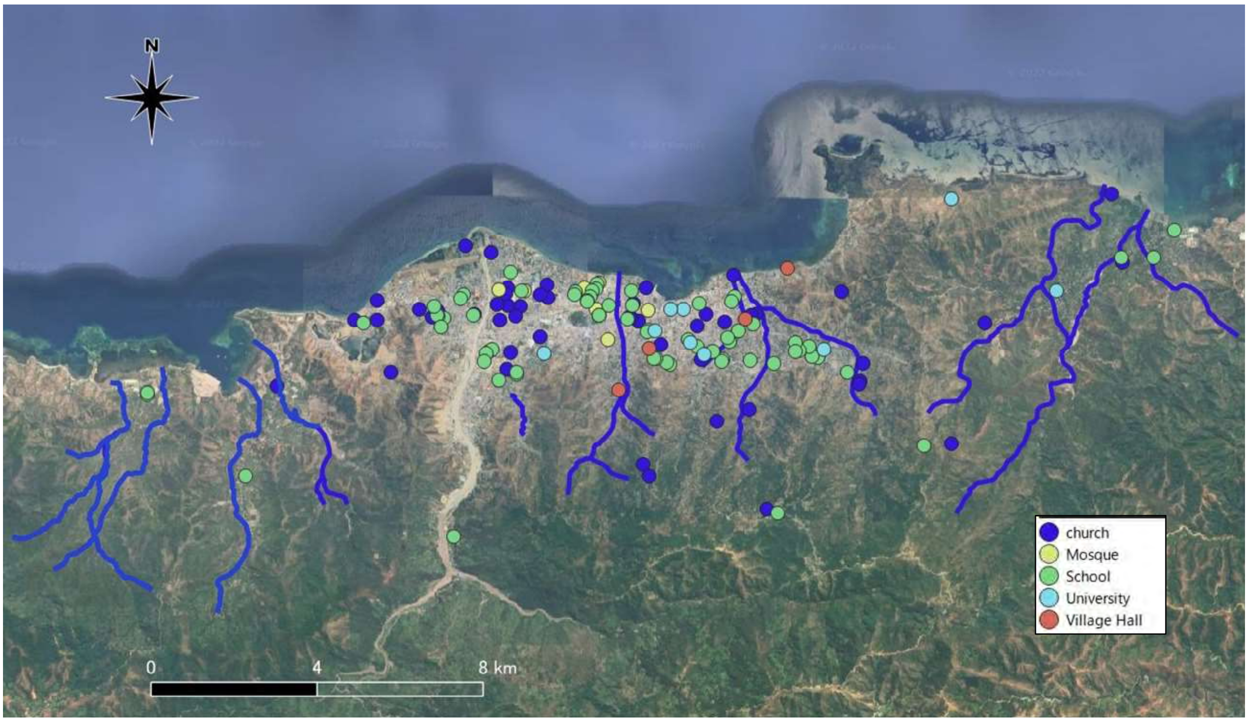
Source: Left Figure/JICA Survey Team, Right Figure/Google Earth image as of April 8th, 2021

Figure 3.5-35 Flood map at the time of *This Flood* (the result of *This Flood*)

3.5.2 Examination of pre-evacuation plan

As far as JICA Survey Team searched, there are no designated evacuation facilities in the event of disaster in Timor-Leste. Therefore, JICA Survey Team firstly identify candidate temporary evacuation places for considering pre-evacuation plan.

The main characteristics of candidate evacuation places include: (*1)"a location where safety can be ensured even during flooding, (2) "a location where a large number of people can be accommodated and supplies can be stored in case of disaster"*. Regarding (1), TL-government has not yet considered their specifics. Regarding (2), schools, religious facilities (Churches, monasteries, and mosques, etc.), meeting halls, etc. can be considered as candidates. The distribution of these facilities in Dili, Tasitolu, Hera, Tibar is shown in Figure 3.5-36.



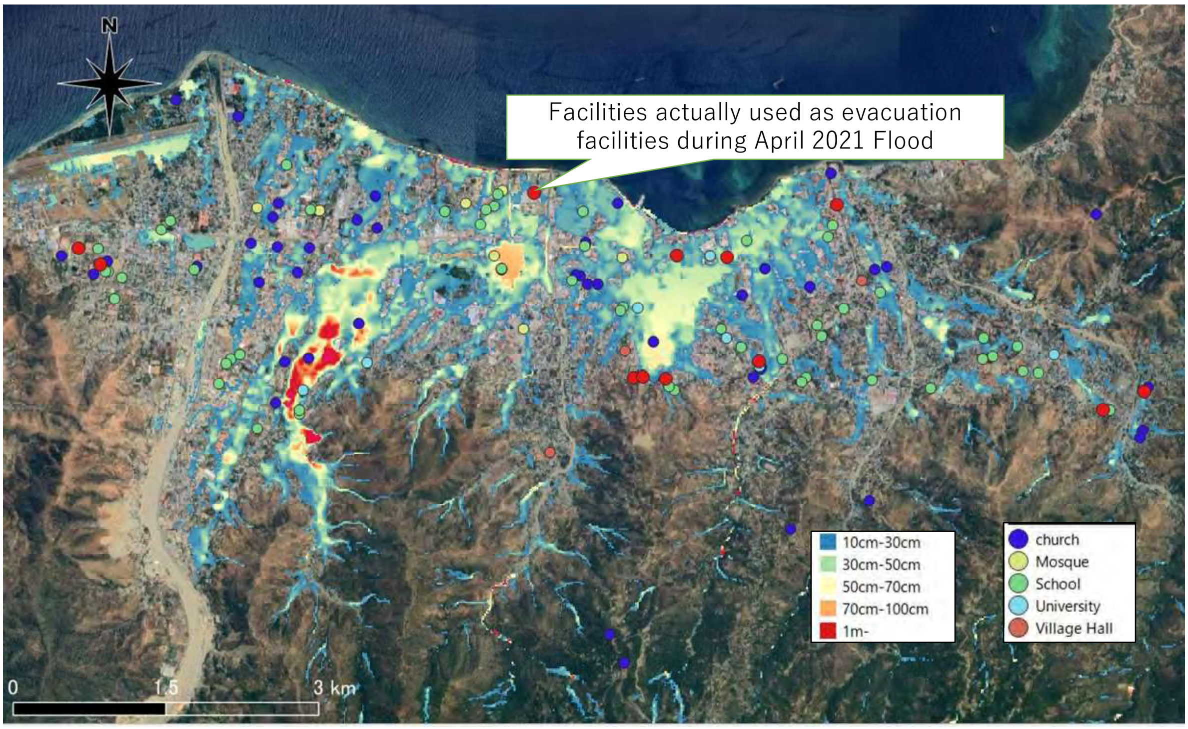
Sourc: JICA Survey Team

Figure 3.5-36 Distribution of candidate evacuation places

(1) Dili

Figure 3.5-37 shows the potential evacuation facilities in the vicinity of Dili overlaid on the map of the area expected to be inundated by the current flood event. The red circles indicate facilities with records of actual use as evacuation facilities. While facilities with records alone are clearly insufficient for evacuation place, it is assumed that if candidate evacuation site are included, it is possible to secure facilities from which residents can evacuate.

On the other hand, many of the candidate evacuation places are located within the high risk of flood zone. If they are to be actually used as evacuation centers, it is necessary to take measures to reduce the flood risk.



Source: JICA Survey Team, facilities used as evacuation place during ***This Flood*** were extracted from UNRCO Material

Figure 3.5-37 Distribution of candidate evacuation places in Dili with Estimated flood map at the time of *This Flood*

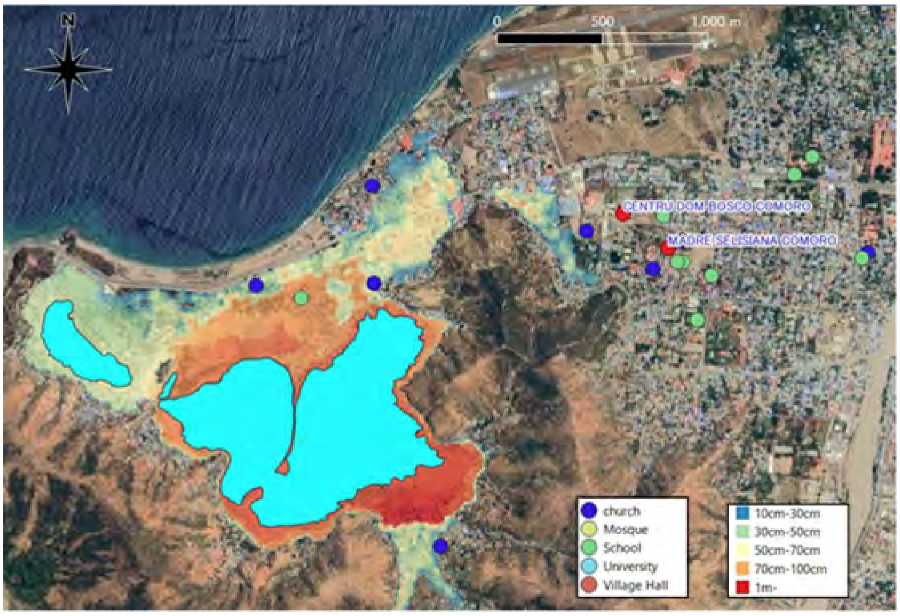
(2) Tasitolu

At the time of ***This Flood***, two facilities in the eastern part of Lake Tasitolu watershed were used as evacuation facilities (Figure 3.5-38). These facilities are suitable as location because they are located in the upper reaches of the Lake Tasitolu and considered to be low risk of flooding. On the other hand, it can be difficult for the inhabitants around Lake Tasitolu to move the area during heavy rain.

There are several candidate sites as evacuation places such as churches and schools in the vicinity of Lake Tasitolu, but they are located in a flood risk zone. Measures need to be implemented to use them as evacuation places.

Due to the topographical characteristics, the area around Lake Tasitolu is not suitable as residential area, because flood is likely to continue for a long time once the heavy rain occur.

In the future, it is desirable to establish a place to ensure safety in the area near Lake Tasitolu, while promoting the prohibition of residence as restricted residential area as soon as possible.



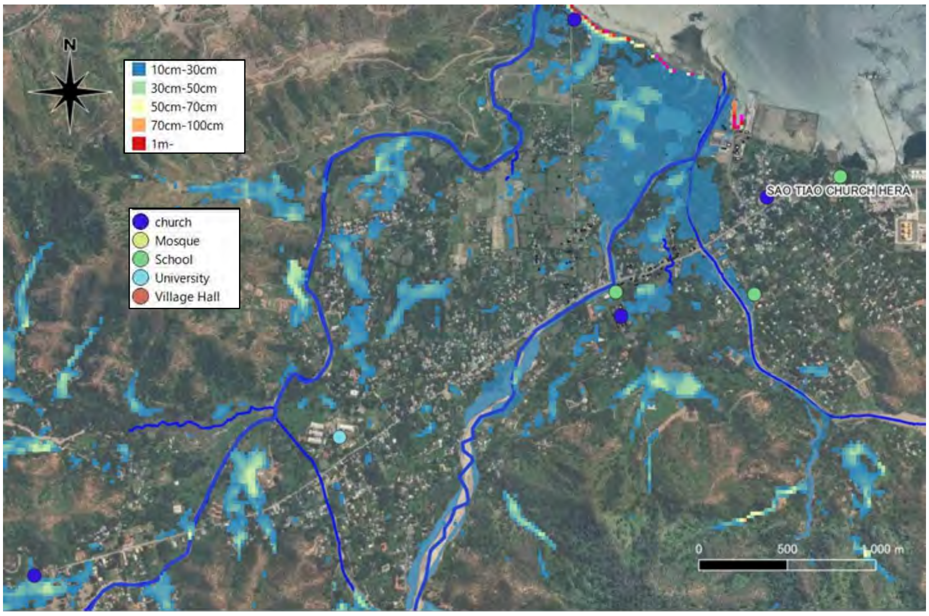
Source: JICA Survey Team, facilities used as evacuation place during ***This Flood*** (places of red circles) were extracted from UNRCO Material

Figure 3.5-38 Location of the building used as an evacuation facility around Lake Tasitolu with Estimated flood map at the time of *This Flood*

(3) Hera

In Hera, there is a record that residents evacuated to a church near the port of Hella (SAO TIAO CHURCH HERA) during ***This Flood***. According to an interview with residents living along the Akanunu River, they evacuated to an elementary school along the Mota-Kiik River and the national highway intersection before flooding was occurred.

There is no problem if the local residents of Hella can evacuate to these evacuation facilities in advance, but if it is difficult, residents should evacuate to relatively safe places such as UNTL's Hella campus. In order to ensure that, it is necessary to coordinate with the parties concerned in advance.



Source: JICA Survey Team based on the material opened by UNRCO

Figure 3.5-39 Distribution of candidate evacuation places in Hera with Estimated flood map at the time of *This Flood*

(4) Tibar

Tibar has an elementary school and a high school to the west of T2, which can be evacuation sites. On the other hand, since the elementary school is located along the riverbank of T2, it is necessary to confirm whether it has flood risk.

From the topographical conditions, it is assumed that the river mouth tends to be flooded frequently, but there is also a mangrove forest in the area, and if there are no residents, there is no problem even if it is flooded.

3.5.3 Direction of drainage measures in Dili and three suburban areas

Based on the disaster occurrence situation, and disaster occurrence mechanism of ***This Flood*** arranged in 3.1.2, the outline of current drainage situation and the flood analysis results conducted in 3.5.1, the direction of drainage measures were considered.

(1) Dili

In Dili, drainage measures will be implemented by DDIUP. On the other hand, flood analysis suggests that flood may not be completely prevented in the low-lying area, though the measures being considered by DDIUP are expected to have some effect.

In light of these circumstances, JICA Survey Team propose the implementation of the following measures to reduce disaster risk as much as possible from the viewpoint of disaster risk reduction.

① <u>Measures for sediment in rivers of Dili</u>

It has been reported that the check dams in the upper reaches of the small rivers in Dili are not managed and functioning, and it is not possible to easily implement measures for their accessibility. It is considered appropriate so far to preferentially excavate river channels from areas that are relatively easy to access on the middle and downstream sides and areas with high risk (locations where the water flow area tend to be small, such as bridges or narrowed areas). While implementing these measures, as a mid-term and/or long-term measure, it is necessary to find out the direction of sediment control measures in the middle and upper reaches of urban areas while conducting soil runoff monitoring.

② <u>Replacement of bridges that intersect rivers in urban area</u>

The fact that floods are likely to occur at bridges where roads and rivers intersect has been regarded as a problem for years, but concrete measures have not yet been done.

If overflows cannot be avoided due to sediment transport from upstream areas during flooding even with the channel excavation described in ①, it is necessary to implement measures to increase the water conveyance area by replacing bridges, etc.

The candidate locations are as shown in Figure 3.5-40.

Source: JICA Survey Team

Figure 3.5-40 Proposed sites for bridge replacement in Dili

③ <u>Re-examination of drainage measures in the lower reaches of Manleu-ana</u>

Drainage from the Manleuana River and Comoro River can be expected to reduce the risk of flooding in western Dili to some extent. On the other hand, north of Manleuana River remains an area at high risk of flooding. The reasons for this are that the area is flat and the existing drainage canals do not have sufficient drainage capacity. Widening of the main drainage channel is necessary.

④ Measures in areas with frequent flooding

Considering the results of ***This Flood*** and topographic characteristics, it is assumed that the area from the north of Manleuana River to the Presidential Palace and Caicoli district are likely to be flooded. At present, the following measures are expected to be implemented in each area.

Table 3.5-3 Assumed measures for each area

Candidate area	Assumed measures
The area of Presidential Palace	・Raising of the Presidential Palace ・Implementation of pump drainage to the Maloa River
Caicoli District	・Considering the expansion the capacity of retention Basin(RB1) ・Implementation of natural drainage and mechanical drainage at RB3 ・Examination of the possibility of increasing drainage capacity of the Maloa River in consideration of the resettlement

⑤ Implementation of regular monitoring and maintenance

Sediment dynamics monitoring, patrols and inspections should be carried out regularly and before the rainy season in the rivers and drainage channels by UAV etc. throughout Dili. Based on the information obtained from these surveys, it is proposed to examine the countermeasure points, examine the schedule until the countermeasures are implemented, and implement the countermeasures (River channel excavation in cooperation with IGE, etc.).

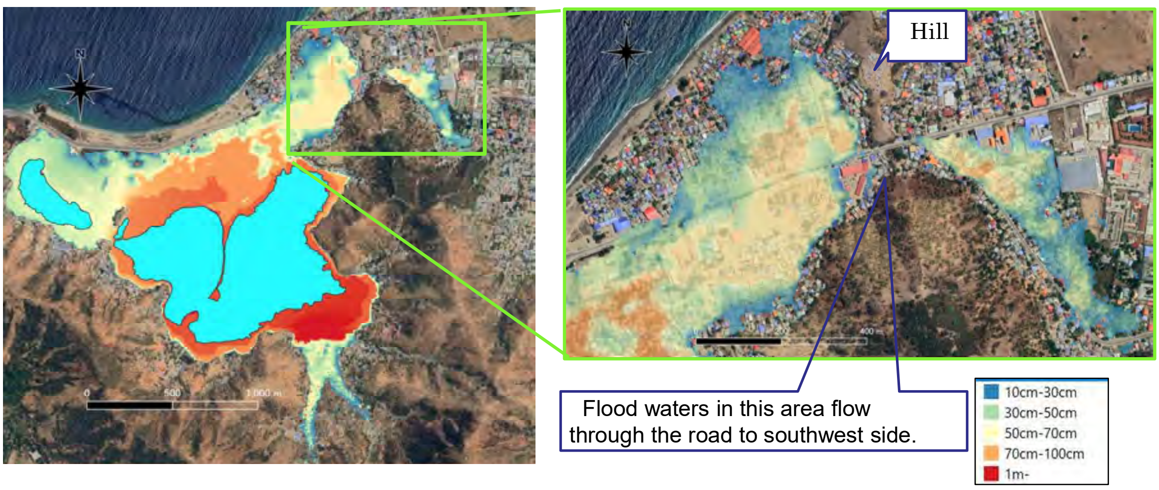
(2) Tasitolu

① Around Lake Tasitolu area

Since the area around Lake Tasitolu is a depression, inundation is likely to continue due to its topographical characteristics. Since such an area is not suitable as a residential area, it is considered that residential restricted areas should be set up to avoid future flood risks. At present, it is considered realistic to use a drainage pump to drain water when flooding occurs.

② National Road No.3

Currently, the national road between Raikotu and Tasitolu serves as a channel for rainwater during floods, and has the characteristic of flowing down toward Lake Tasitolu. It is necessary to conduct raising the national road as necessary. When doing so, it is necessary to pay attention not to block the drainage to the sea area.



Source: JICA Survey Team

Figure 3.5-41 National Road around Tasitolu with estimated flood map at the time of *This Flood*

(3) Hera

① Development of drainage channels from the viewpoint of reducing the risk of flood damage

Both the Akanunu and Mota-KiiK have an unbalanced upstream and downstream drainage form, with the downstream channel width narrower than the upstream channel (road) width. In the lower reaches, river channel blockages and floods due to sediment accumulation are more likely to occur. As a countermeasure for this, 1. "narrowing the drainage channel in the upstream area" or 2. "widening the drainage channel in the downstream area" can be considered. If it is difficult to implement these measures, restricting the residence of the river mouth can be considered.

② Measures for steep slopes

The Akanunu River has a narrowed part at the intersection with the national highway in the middle course about 2.5 to 3 km from the mouth of the river and has a shape in which driftwood easily accumulates. To prevent driftwood damage at this location, measures to prevent driftwood from occurring in the upstream area (control measures: forest / soil management etc.) and measures to prevent damage to the downstream even if driftwood occurs (deterrence measures: installation of check dams etc.) are necessary. Both require medium to long-term studies. First of all, it is necessary to identify the area where measures are required.

(4) Tibar

① Improvement of drainage channels and repair of girder height of bridges from the viewpoint of reducing the risk of flood damage

The width of the waterways (roads) in the upstream area are wide, while the waterways are narrow in the downstream area. In addition, some downstream national road -waterways crossing bridges have low girder heights and are prone to blockages of drainage channel.

As countermeasures for these problems, 1. "Reduce the drainage channel in the upstream area" or 2. "Wide the drainage channel in the downstream area", and 3. "Repair the girder height of the bridge". can be considered. If it is difficult to implement these measures, measures such as restricting the residence of the drain outlet can be considered.

② Installation of new drainage channels

From the JICA Survey team's analysis result, flooding was confirmed in the middle and downstream plains of T2 and T4. It is considered that rainwater tends to be accumulated in these areas instead of flowing into small streams. Therefore, new drainage channels need to be constructed.

③ Installation of revetment at the boundary of the site of the candidate industrial park

The area near the boundary of the planned industrial park site is a road and drainage channel, and there is a possibility that floodwater will flow in during floods. It is necessary to take measures such as installing revetments at the boundary between the road and drainage channel.

3.6 Study of rehabilitation plan by Japan's grant aid

3.6.1 Rehabilitation plan for Comoro River Retaining wall

3.6.1.1 Preliminary plan of the Rehabilitation plan for Comoro River Retaining wall

Two sites, R5 (3.8km point, damage length 100m) and R6 (4.1km point, damage length 110m), will be candidate subjects to rehabilitation by Japan's Grant Aid. The standard cross-sections for rehabilitation of R5 and R6 are as shown below.

It is recommended that the design of rehabilitation for R5 and R6 is adopted to other sites and projects.

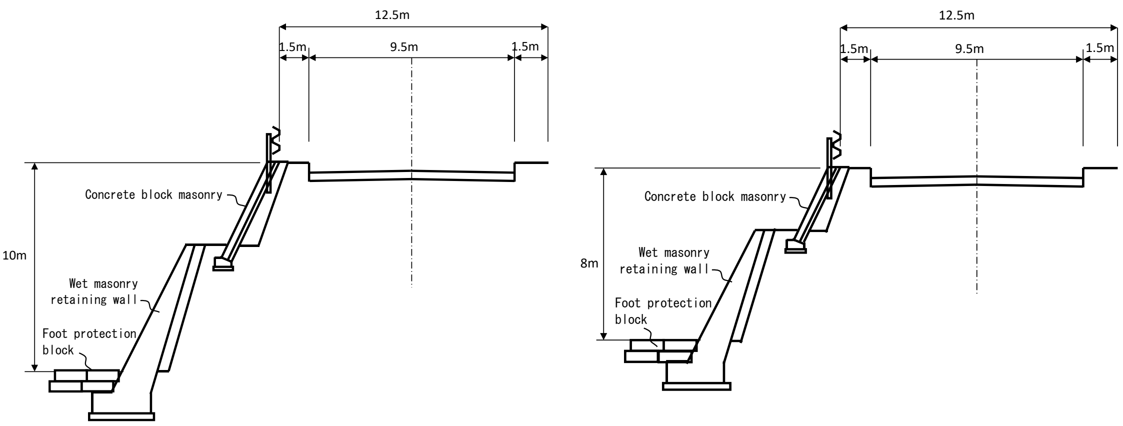


Figure 3.6-1 Standard Cross Section for Rehabilitation

3.6.1.2 Preliminary cost estimation of the Rehabilitation plan for Comoro River Retaining wall

Since the Comoro River revetment collapsed at the two locations shown in Figure 1, the estimated construction cost to restore the revetment was calculated as follows.

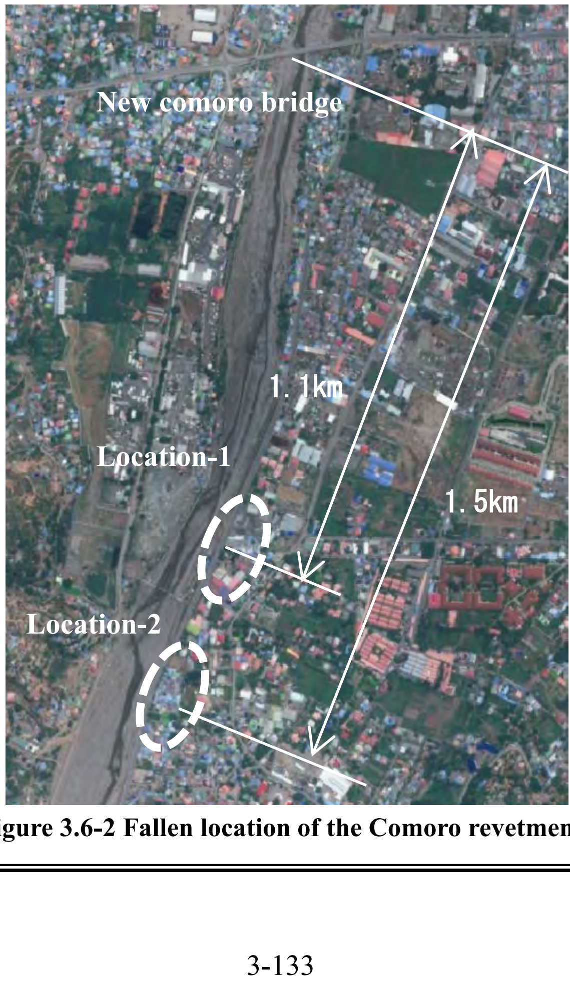


Figure 3.6-2 Fallen location of the Comoro revetment

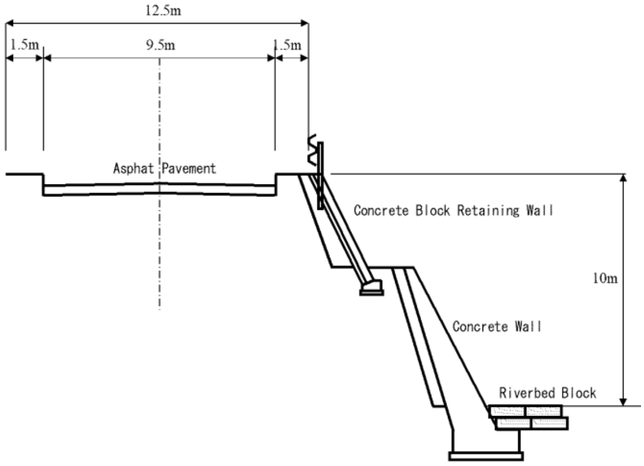


Figure 3.6-3 Countermeasure of Fallen location

Table 3.6-1 Approximate construction cost

Location-1

Item		Unite	Quantity	Cost
Concrete wall	H=8m	m	110	※※※
Concrete block wall	H=4.5m	m	110	※※※
Riverbed		no.	306	※※※
Steps		no.	1	※※※
Guard rail		m	110	※※※
Road pavement	Wearing course 5cm Binder course 5cm	m2	468	※※※
Footpath pavement	Interlocking block	m2	165	※※※
Kerb stone		m	110	※※※
Drinage		m	110	※※※
Pit		no.	1	※※※
Concrete Pipe	900mm	m	20	※※※
Earth retaining wall	Steel	m	90	※※※
Removed existing mat gabion		m3	1,210	※※※
Removed existing pavement		m3	31	※※※
Excavation		m3	2,695	※※※
General fill		m3	3,850	※※※
Soil disposal		m3	2,695	※※※
Direct cost		yen		※※※
Overhead cost	45%	yen		※※※
Approximate construction cost		yen		※※※

Location-2

Item		Unite	Quantity	Cost
Concrete wall	H=8m	m	120	※※※
Concrete block wall	H=4.5m	m	120	※※※
Riverbed		no.	329	※※※
Guard rail		m	120	※※※
Road pavement	Wearing course 5cm Binder course 5cm	m2	510	※※※
Footpath pavement	Interlocking block	m2	360	※※※
Kerb stone		m	240	※※※
Drinage		m	240	※※※
Earth retaining wall		m	100	※※※
Removed existing concrete		m3	1260	※※※
Removed existing pavement		m3	34	※※※
Excavation		m3	2100	※※※
General fill		m3	3000	※※※
Soil disposal		m3	2100	※※※
Direct cost		yen		※※※
Overhead cost	45%	yen		※※※
Approximate construction cost		yen		※※※

3.6.1.3 Preliminary study on EIA Screaming of the Rehabilitation plan for Comoro River Retaining wall

The Comoro River (within Dili Municipal) is located in Don Alexio County on the administrative subdivision, and five villages are located both banks of the Comoro River. In these villages, most of the inhabitants use the inland.

Around the CPLP Bridge and Hinode Bridge, mostly the land is using for residential propose, and there are also household goods stores and gasoline stores along the road is parallel to the river.

Upstream above the Fomento III area (right bank) and Moris Foun area (left bank) in Comoro village, there are few residential lots, and people are using lands for small-scale farming for self-consumption. Other than the above, there are particular river users that gravel collectors mining waterside land. They have built simple embankment slopes on both banks that go down to the river, and transport collecting gravel using dump trucks. In addition to small-scale miners using dump trucks, there are commercial-level of gravel pits and warehouses upstream, and they frequently collect gravel.

3.6.2 Rehabilitation plan for Bemos Water Supply System

3.6.2.1 Preliminary plan of the Rehabilitation plan for Bemos Water Supply System

As shown in 3.3, the Japanese side proposes the restoration of the intake work. In the same way as the BTL repair plan, the intake works shall be reinforced and repaired without changing the structural section of the current facility. The repair plan is summarized in Table 3.6-2 and Figure 3.6-4. The repair plan shown in Table 3.6-2 can be roughly classified into reinforcement, restoration (re-installation or replacement), and repair. Reinforcement refers to the strengthening of the structure to make it tougher, restoration refers to the restoration of the original structure, and repair refers to minor repairs such as surface repair. In the table, the reinforcement to a tougher structure applies to ①, ②, ⑤, ⑥, ⑰, ⑳, and ㉒, and the structure is less likely to be severely damaged by a flood of the same level. In this disaster, falling rocks from the top of the facility and rocks from upstream were one of the factors that caused damage to the facility. In order to prevent rock fall, the slope will be protected with concrete up to the planned water level. As for measures to prevent rocks from flowing down rivers, protection works and erosion control dams are assumed to reduce the flow of sediment. Although berms can prevent small rocks from flowing downstream, they are almost ineffective when large rocks flow downstream, as in this case, and the berms themselves are likely to be damaged, resulting in serious damage to the facilities. In addition, erosion control dams, including permeable dams, are not expected to be included in this restoration plan because of their high construction cost, the need to remove rocks after each rainy season, and the possibility of collapse depending on river flow. In the future, it is desirable to consider a river improvement plan and implement measures for revetment and stone runoff.

Table 3.6-2 Details of improvements to the Bemos water supply System

№	Structural classification	Target Facilities	Damage	Reconstruction Policy	Classification
①	Water intake	Wing walls	Megalithic deposition	Extension of wing wall	Reinforcement
②				Raising of RC at the top of wing wall	Reinforcement
③				Removal of rocks and other sediments	Restoration
④		Inlet side wall	All damage	Front wall reinstallation	Restoration
⑤				Front wall strengthen	Reinforcement
⑥				Reinforcement of gravity type retaining wall at side wall	Reinforcement
⑦				Repair of side wall above the opening (removal and restoration)	Restoration
⑧		Water intake	Damage	Reconstruction	Restoration
⑨	Channel of approach	Sluice gate	Damage	Gate replacement (including guide)	Restoration
⑩		Waterway	Step breakage	Step replacement	Restoration
⑪			Damage to the top	Reconstruction upper 50cm of side wall	Restoration
⑫			Falling lid	Reinstallation of approach channel lid	Restoration
⑬	Fixed weir	Water flow section	Wear	Re-placing high-strength concrete	Restoration
⑭		Still water pond	Stone accumulation	Sediment removal	Restoration
⑮			Drifting away (from the floor)	Re-placing of floor protection works	Restoration
⑯	Right bank revetment	Protection of Stillwater Pond	Damage	Restoration by masonry blocks	Restoration
⑰			Slope protection	Concrete up to bedrock line	Reinforcement
⑱		Top concrete	Partially damaged	Re-placing high-strength concrete	Restoration

⑲	Left bank revetment	Bank protection top edge concrete	Damage	Demolition and high strength C restoration	restoration
⑳		Stone retaining wall at the bottom of the Stillwater Pond	Partially damaged	Restoration with RC leaning retaining wall	Reinforcement
㉑		Upper level of the stairs at the Pond	Damage	Restoration by masonry	Restoration
㉒			Slope protection	Concrete up to bedrock line	Reinforcement
㉓	Whole	Whole	Crack	Epoxy injection	Maintenance
㉔			Surface deterioration	Repair with high-strength mortar	Maintenance
㉕		Basin, channel, on top of concrete	Sedimentation	Removal of rock and sand	Restoration

Source: JICA survey team

Source: JICA survey team
Note: The coloring indicates the position of the repair shown in table 3.6-2 and dose not classify the repair method by color coding

Figure 3.6-4 Planned renovation of the Bemos water supply facility

3.6.2.2 Preliminary cost of the Rehabilitation plan for Bemos Water Supply System

Preliminary cost of the project is calculated, it will be about 144,743thousand JPY, as shown in Table 3.6-3.

Table 3.6-3 Estimated Project Cost of Bemos Water Supply Facility

Facility to be renovated	Construction cost (thousand JPY)	Remarks
(Direct construction cost)		The project cost in 2006 and 2009 was referred to and calculated as follows.
Intake	※※※	(Price increase)
Approach channel	※※※	From Table 3.6-4, the rate of price increase was set at

fixed gates	※※※	105.52/67.25 = 1.57, the price ratio between 2009 and 2023, and 1.57x 1.2 = 1.9, an increase of 20%, taking into account the rapid price increase in recent years due to the Corona disaster. (Exchange rate fluctuations) The current exchange rate, JPY111.36 equiv. to 1USD is lower than 2009, JPY96.53 equiv. to 1USD by 15.35%.
Right bank revetment	※※※	
Left bank revetment	※※※	
whole	※※※	
temporary road	※※※	
(Total direct construction cost)	※※※	
Other expenses	※※※	45% of direct construction cost (as temporary installation cost, machinery cost, and transportation cost)
overhead	※※※	45% of direct construction cost
Total project cost	※※※	

Source: JICA survey team

Table 3.6-4 Price Change Index

2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
67.25	70.73	80.05	80.05	88.80	97.1	98.02	97.2	97.71	98.02	97.2	101.33	102.95	105.52

Source: International Monetary Fund, World Economic Outlook Database, October 2021
(https://www.imf.org/en/Publications/WEO/weo-database/2021/October/weo-report?c=537,&s=PCPI,&sy=2008&ey=2024&ssm=0&scsm=1&scc=0&ssd=1&ssc=0&sic=0&sort=country&ds=. &br=1)

3.6.2.3 Preliminary study on EIA Screaming for rehabilitation plan of Bemos Water Supply System

It is difficult to access to Bemos Intake Weir due to bad roads condition that access the upper reaches of the Bemos River, and it is located far from the roads along the Comoros River. In the dry season, it is possible drive up the river halfway and access to the site on foot; however, in the rainy season, access will be limited to walking. Therefore, there are few permanent residents around the intake weir.

There was a simple access road opened after the flood in April 2021 by an Australian research team to carry heavy equipment around the intake weir, and the JICA Study Team used that path to conduct site survey. At that time, only small garden that residents living in the surrounding mountainous areas were planting crops for self-consumption on the flat land of the small steps was identified.

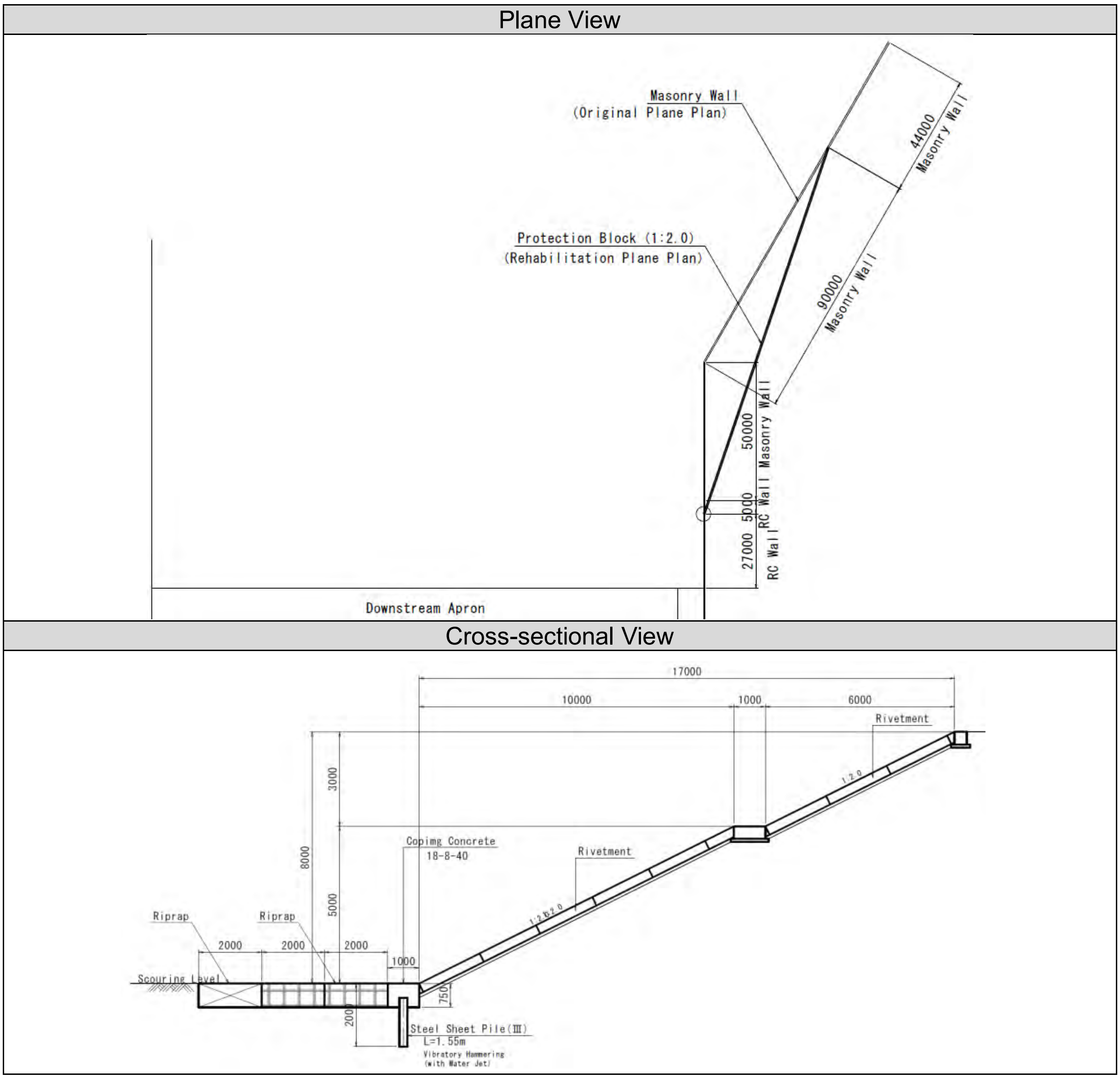
3.6.3 Rehabilitation plan for Buruto/Maliana Irrigation Facilities

3.6.3.1 Preliminary plan of the Rehabilitation plan for Buruto/Maliana Irrigation Facilities

(1) Buluto irrigation facilities

1) The retaining wall at the downstream of Buluto Headworks

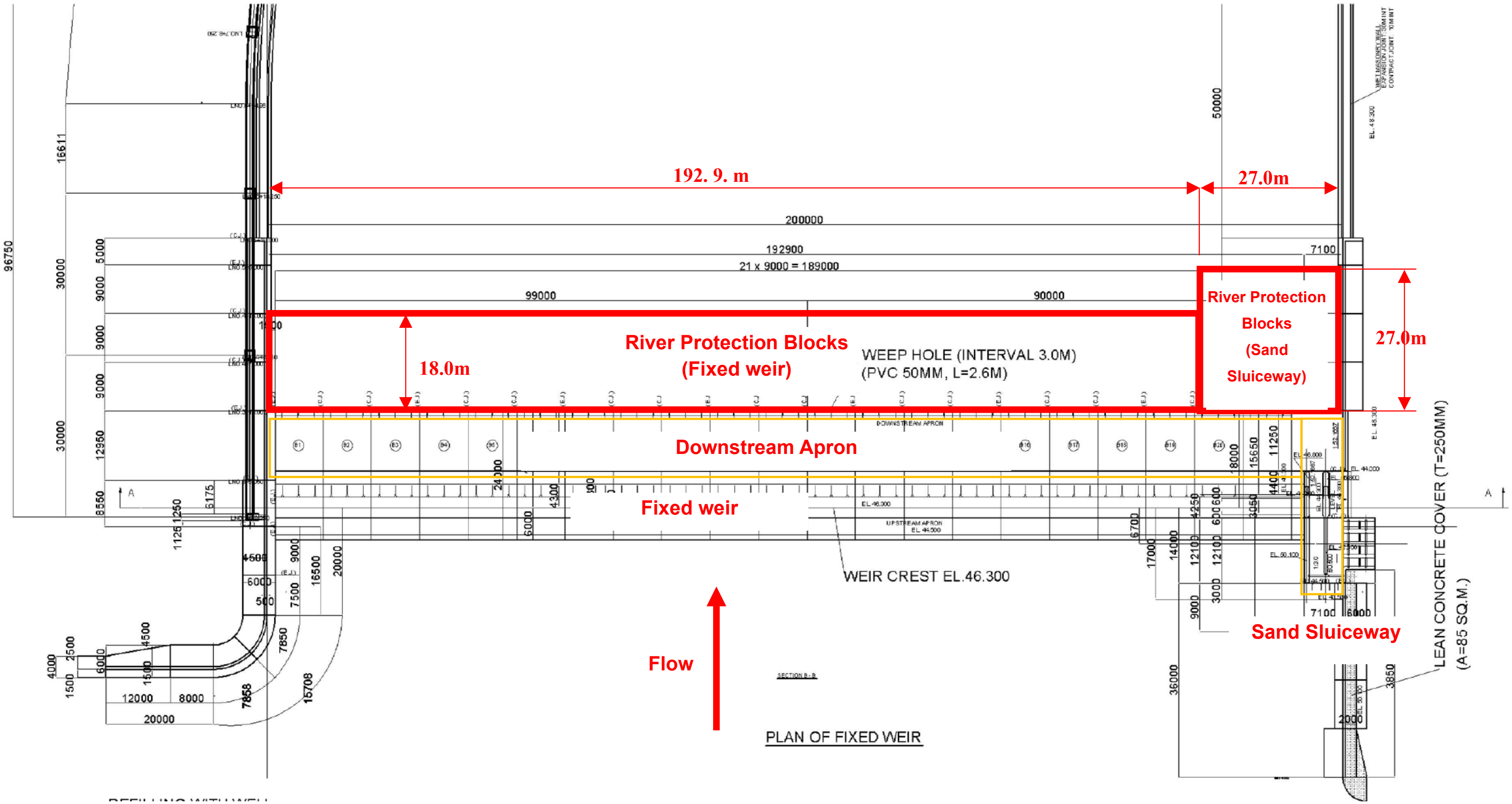
We propose the revetment blocks +Scour prevention measures as the rehabilitation plan of the retaining wall at the downstream of Buluto Headworks.



Source: JICA Survey Team

Figure 3.6-5 Rehabilitation plan of the retaining wall at the downstream of Buluto Headworks

2) River protection block at the apron downstream for the Buluto headworks



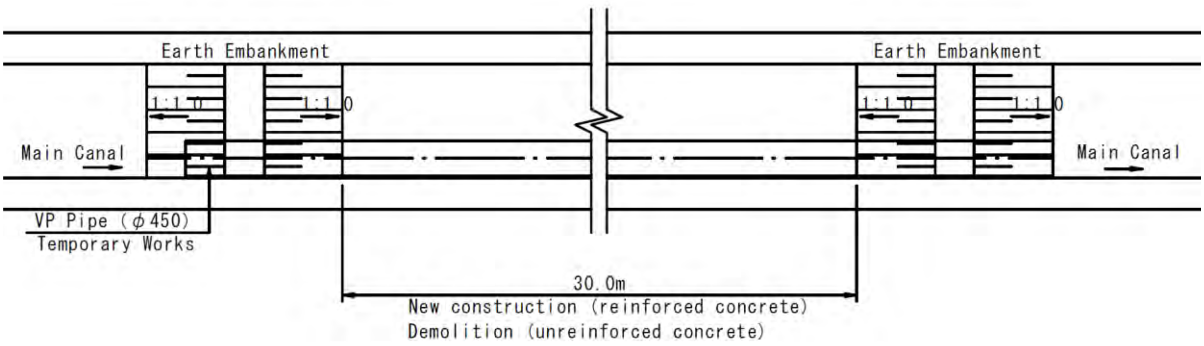
Source: JICA Survey Team

Figure 3.6-6 Rehabilitation plan of the river protection blocks for the Buluto headworks

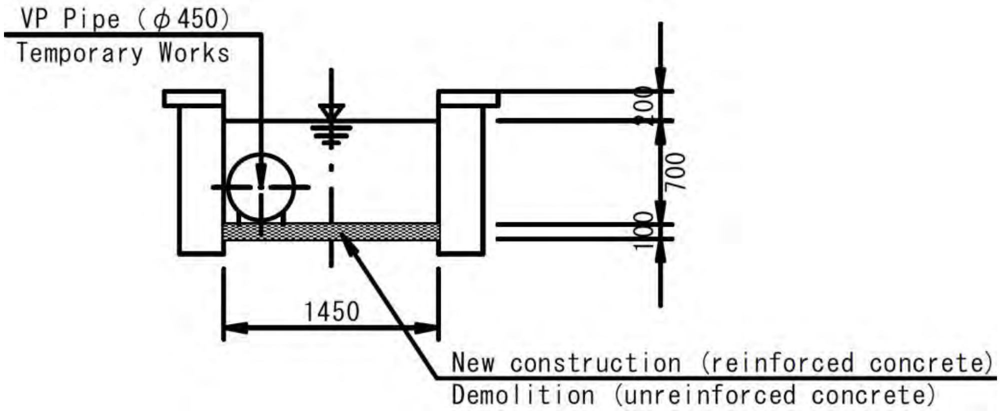
3) Main channel (embankment section)

We propose Bottom slab concrete replacement (unreinforced concrete to reinforced concrete) as the rehabilitation plan of the bottom slab concrete of in the main canal of the Buluto irrigation.

Plane View



Cross-sectional View



Source: JICA Survey Team

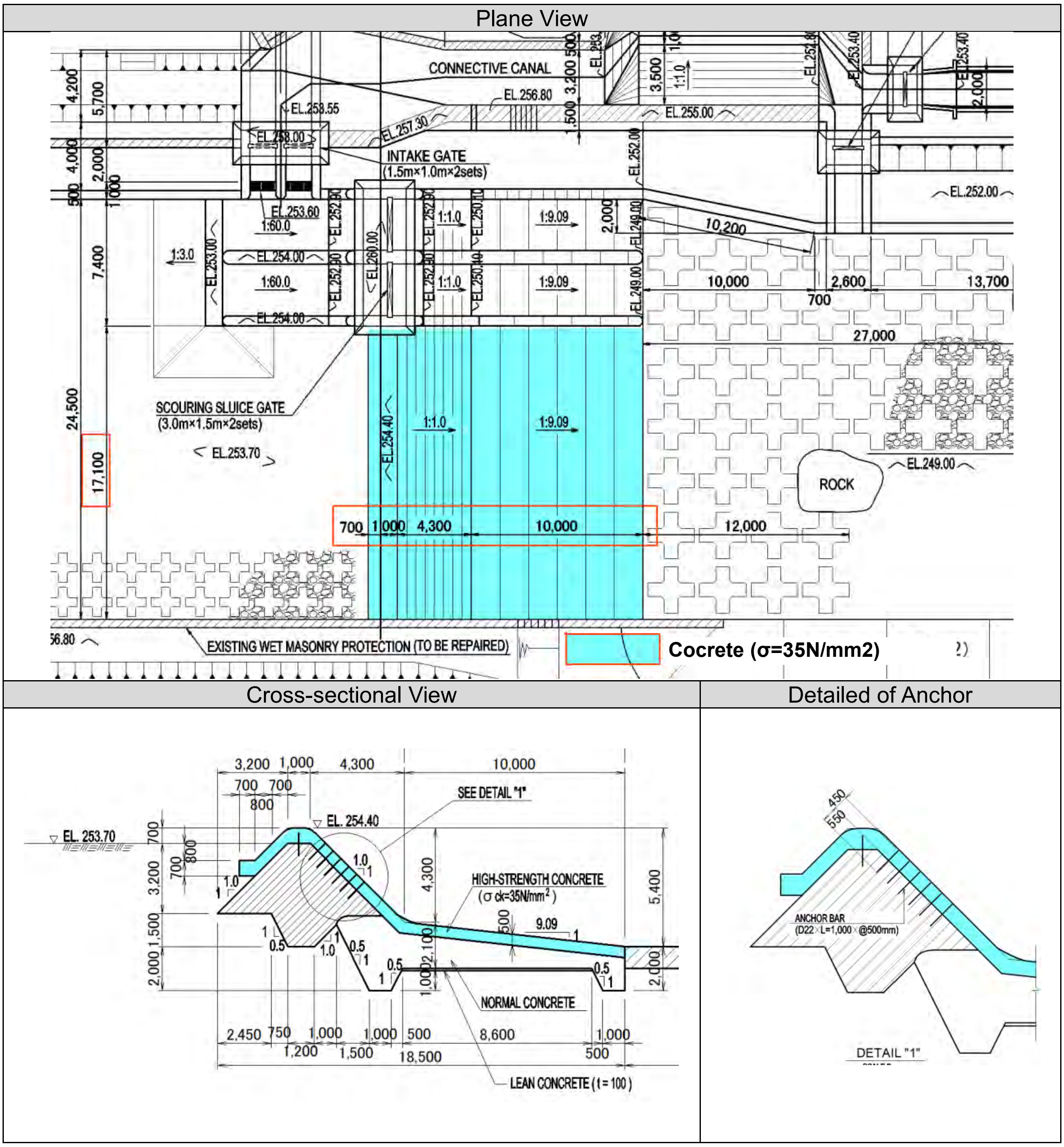
Figure 3.6-7 Rehabilitation plan of the bottom slab concrete of the main canal of the Buluto irrigation

(2) Maliana irrigation facility

1) Maliana headworks fixed weir, sand sluiceway, and administrative corridor

① Rehabilitation of fixed weirs

The unreinforced concrete (high strength concrete σ=35N/mm2) of the fixed weir shall be demolished and replaced with new unreinforced concrete (same high strength).

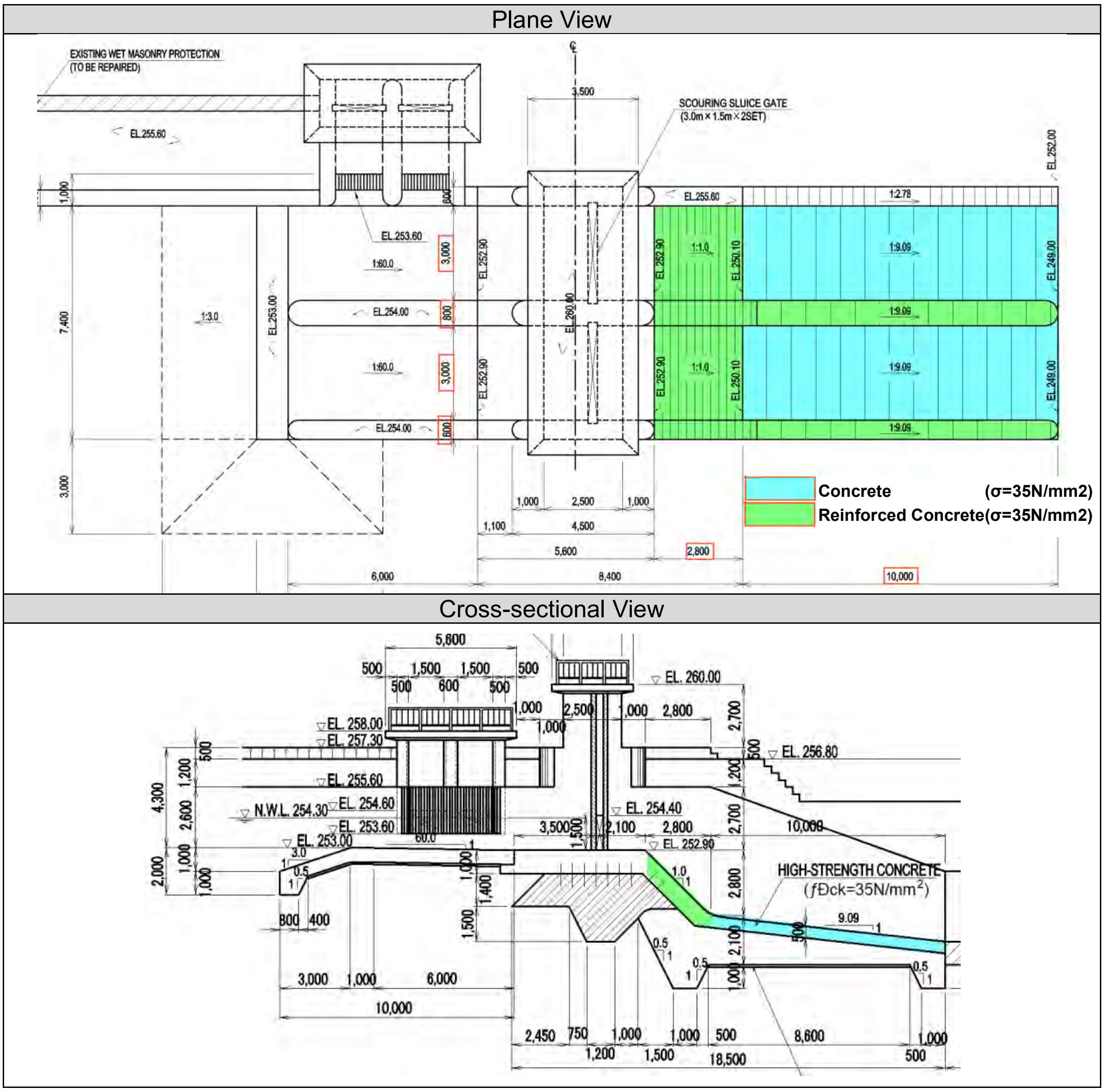


Source: JICA Survey Team

Figure 3.6-8 Rehabilitation plan of the fixed weir in Maliana Headworks

② Rehabilitation of sand sluiceway

Demolish the unreinforced and reinforced concrete (high strength concrete σ=35N/mm2) downstream of the sand sluiceway and replace it with new unreinforced and reinforced concrete (same high strength).



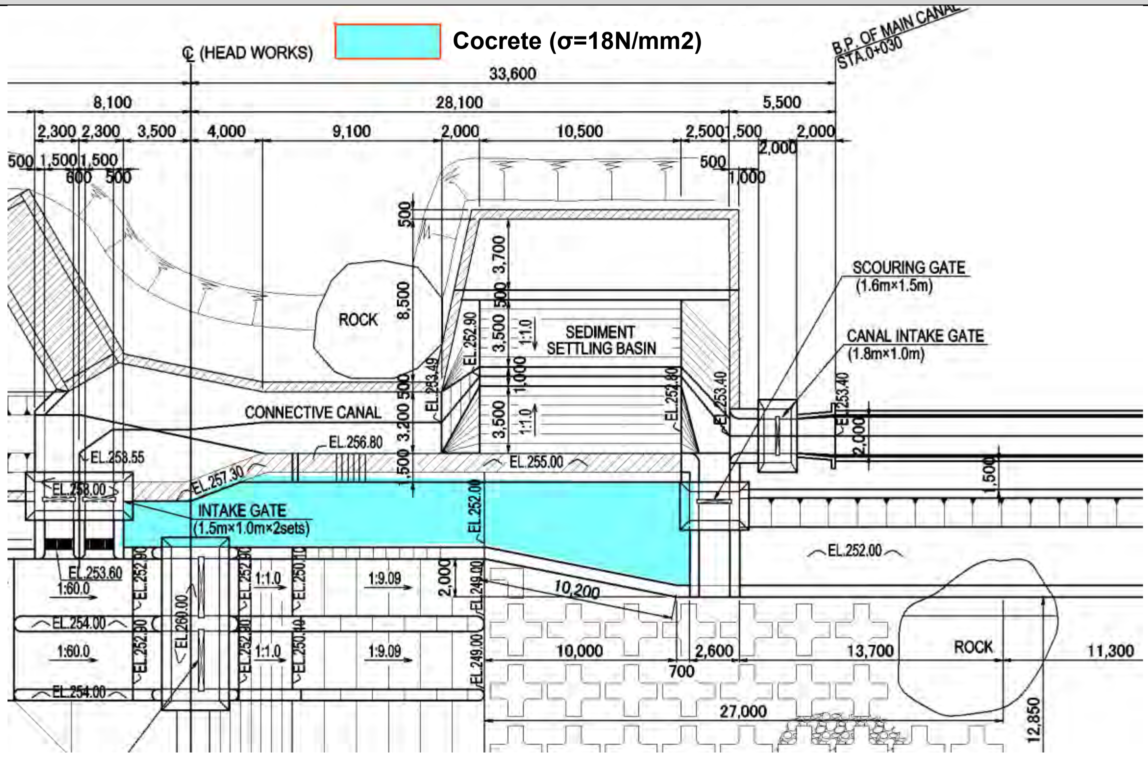
Source: JICA Survey Team

Fig. 3.6-9 Rehabilitation plan of the sand sluiceway in Maliana Headworks

③ Rehabilitation of administrative corridor

Backfill the scoured administrative corridor and repair with unreinforced concrete.

Plane View

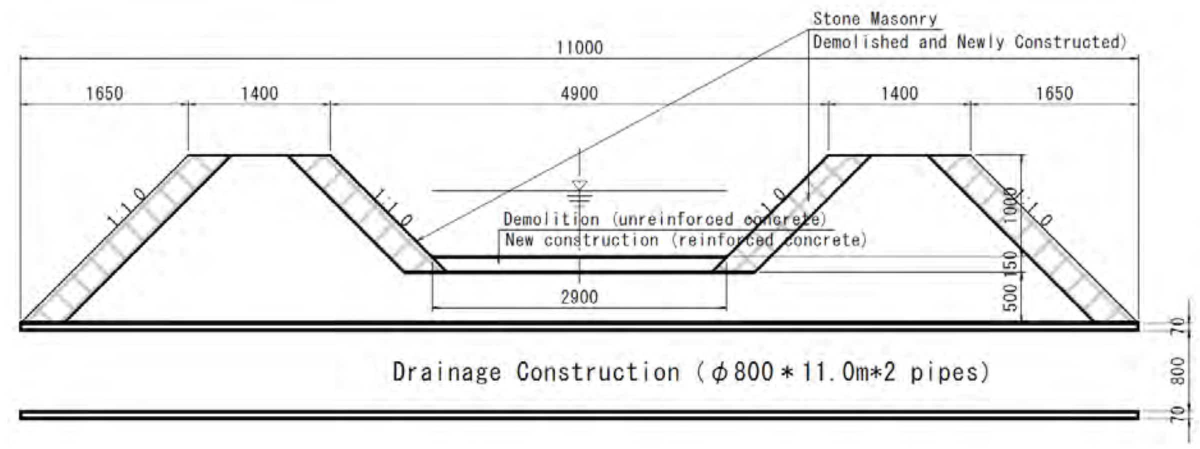


Source: JICA Survey Team

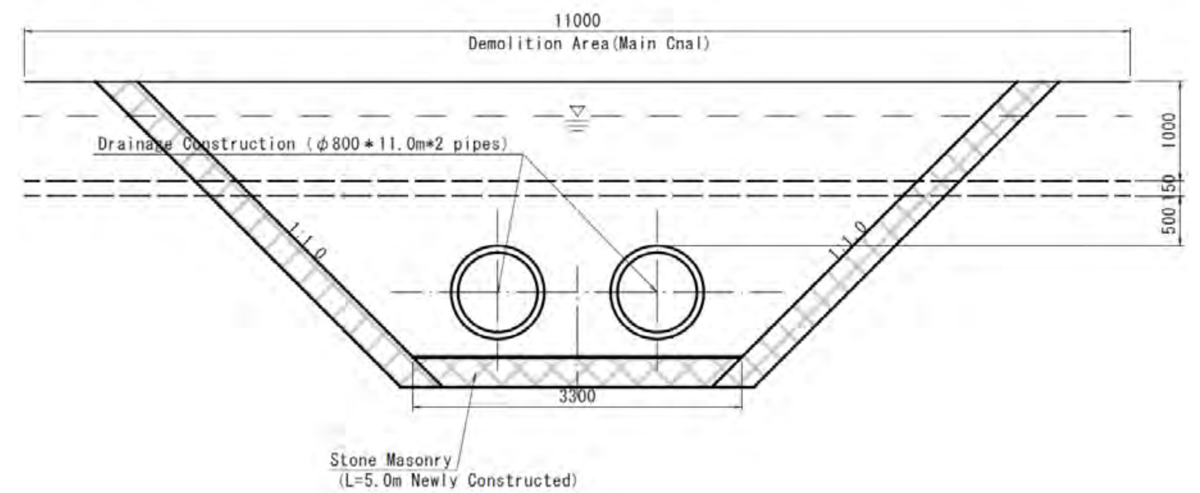
Figure 3.6-10 Rehabilitation plan of the administrative corridor in Maliana Headworks

2) Widening of narrowed drainage

Drainage (Side View)



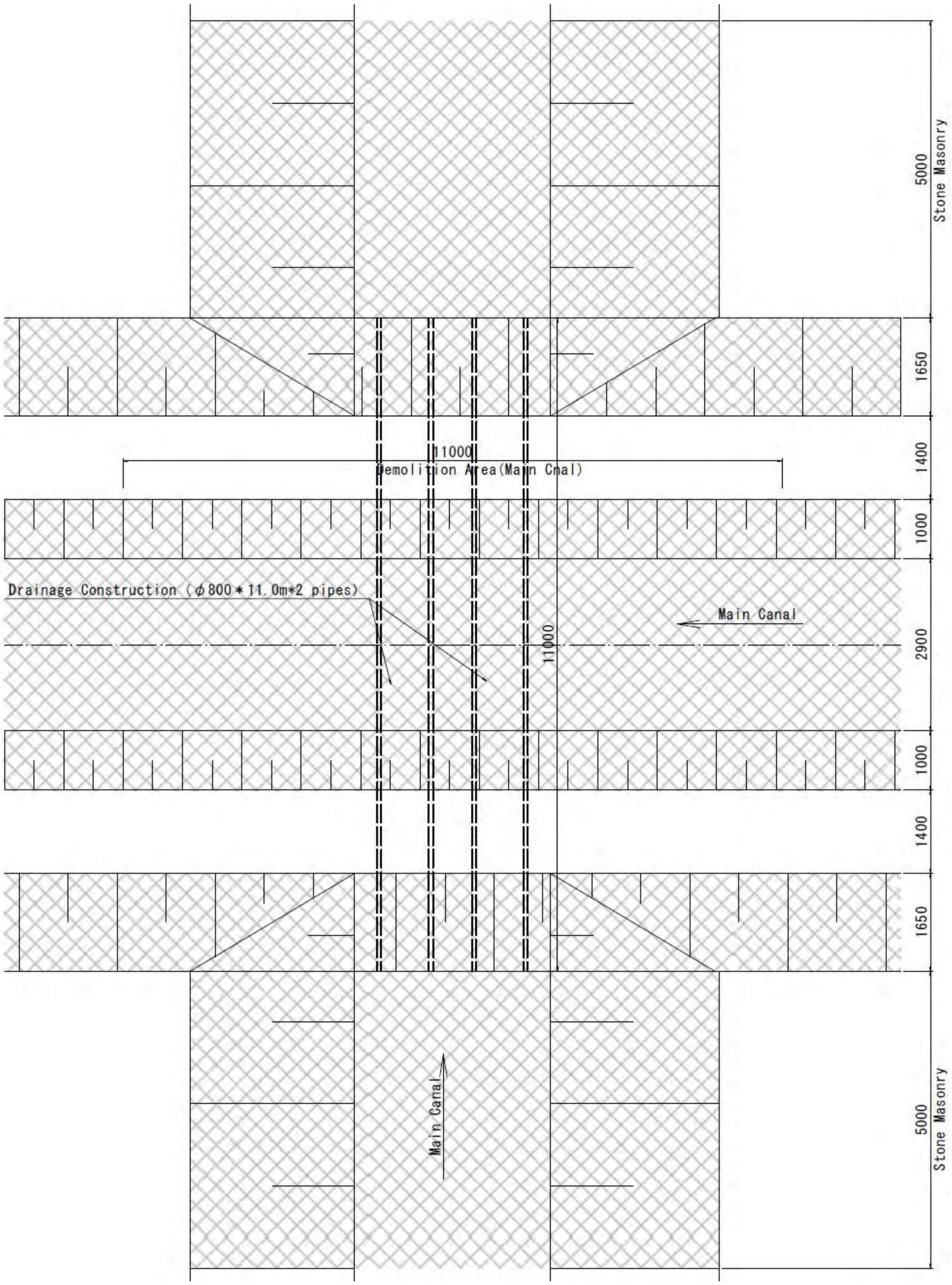
Drainage (Front View)



Source: JICA Survey Team

Figure 3.6-11 Rehabilitation plan of the drainage pipe (Side view, Front view)

Drainage (Plan iew)



Source: JICA Survey Team

Figure 3.6-12 Rehabilitation plan of drainage pipe (Plan view)

3.6.3.2 Preliminary cost estimation of the Rehabilitation plan for Buruto/Maliana Irrigation Facilities

Table3.6-5 shows the preliminary cost estimation of the rehabilitation plan for Buruto/Maliana irrigation facilities.

Table3.6-5 Preliminary cost estimation of the Rehabilitation plan for Buruto/Maliana Irrigation Facilities

	Direct construction cost（Yen）	Temporary works cost（Yen）	Other cost（Yen）	Construction cost（Yen）
(1) Buruto irrigation facilities				
1) Rehabilitation of the retaining wall at the downstream of Buluto Headworks	※※※	※※※	※※※	※※※
2) River protection block at the apron downstream for the Buluto headworks	※※※	※※※	※※※	※※※
3) Bottom slab concrete replacement in the main canal	※※※	※※※	※※※	※※※
(2) Maliana irrigation facilities				
1) Rehabilitation of fixed weir, sand sluiceway, and administrative corridor of the Maliana Headworks	※※※	※※※	※※※	※※※
2) Widening of narrowed drainage	※※※	※※※	※※※	※※※
Total				※※※

3.6.3.3 Preliminary study on EIA Screaming for rehabilitation Plan of Buluto/Maliana Irrigation Facilities

(1) Buluto Irrigation Scheme

Buluto Irrigation Scheme is located in the Laleia River, that separates Manatuto and Baucau Municipal, and around site, there are paddy fields extend along the canal. Near the confluence section with National Road No. 1, there are small village and a public-school building; however, around intake area as Proposed Japan’s Grant Aid Projects site, there are only small building to manage water gate, and there is no private house.

(2) Maliana I Irrigation Facility

The Maliana I Irrigation Facility is located in the Bulobo River in Bobonaro Municipal. Maliana is one of the principal rice-producing areas in Timor-Leste, and many residents cultivate rice around the waterways of existing facilities. Proposed Japan’s Grant Aid Project is considering to rehabilitate the damaged bed protection work and passageway of downstream side that located nearby scouring sluice gates. Intake gate area is away from the village, and there are no rice fields or private house to be affected.

As mentioned above, the target facilities of the Proposed Japan’s Grant Aid Projects are all located inside respective rivers, moreover, regarding project plan under consideration will not be expected large-scale new construction.

In addition, since the target facilities are existing facilities that are used locally, it will be not expected to have a significant negative impact on involuntary resettlement and socio-economic aspects. In the future, in order to scrutinize the above outline, JICA Study Team will conduct field surveys in order to conduct a preliminary study of EIA. The considered scope and result of respective items are shown below.

Table 3.6-6 Results of preliminary screening for EIA of target facilities

Scope of EIA	Considered items	Impact	
		Negative	Positive
(1) Impact on human health, safety and natural environment	Pollutions of air, water and soil; Waste control; Accidents; Water use; Metrological changes; Ecosystems, animals and plans; etc.	Small	Small
(2) Social consideration	Involuntary resettlement	N/A	N/A
	Local economy	Small	Large
	Land use and resources use	Small	Large
	Existing social infrastructure and services	Small	Large
	Indigenous peoples	N/A	N/A
	Vulnerable groups (gender and children's rights)	Small	Large
	Cultural heritage	N/A	N/A
	Conflicts of interest in the community	Medium	Small
	Infectious diseases	Small	Small
	Labor Environment	Medium	Small

Source: JICA Survey Team

Target projects are mainly to rehabilitate existing equipment, it is though that factor to be cause pollution during construction will be almost non-existent.

In addition, all of the target facilities are far from the Tasi-Tolu Conservation Area, and the impact on the natural environment is extremely small.

At the further steps such as a stage of screening of sub-projects and preparatory survey, regarding scope of (1) Impact on human health, safety and natural environment are expected to be extremely minor.

Moreover, the objects of this project are to expand the benefits of existing facility users, improvement of living environment, and revitalization of local economies; therefore, scope of (2) Social consideration will be emphasized in the further EIA process, and it is necessary to carry out evaluation with focus on it.

3.6.4 Items to be confirmed for implementation of Japan's grant aid

This Programme is assumed to be implemented with the following 3 components under a Japan's grant aid, i.e., "The Programme for Urgent Rehabilitation of Flood Damaged Infrastructure in Timor-Leste".

- Rehabilitation plan for Comoro River Retaining wall
- Rehabilitation plan for Bemos Water Supply System
- Rehabilitation plan for Buluto/Maliana Irrigation Facilities

Table 3.6-4 shows "the Project Descriptions and estimated project cost for the Grant Aid (Plan)、as of February, 2021". And Table 3.6.4-5 shows "Planned implementing schedule of the Grant Aid, as of February, 2021".

It is expected that the scope of the Programme will be reconsidered at the time of project cost estimation by the preparatory survey of the Programme, in consideration with price escalation as well as exchange rate of Japanese Yen.

The main points that Timor-Leste side should pay particular attention to in implementing this project are as follows.

(1) General Items

1) Organization of Executing Agencies

① Representative ministry of executing agencies.: Ministry of Public Works (MPW)
② Executing agencies: Refer to Table 3.6-7.

Table 3.6-7 Executing agencies for the Project

Department Name	Activity / Role	Component in charge
Ministry of Public Works／Directorate of Road, Bridge and Flood Control (MPW-DRBFC)	・Representative implementing agency on the Timor-Leste side ・Overall management of the project. ・Coordination with all related organizations. ・Implementation management of the component in charge.	・Rehabilitation plan for Comoro River Retaining wall ・
Ministry of Public Works／Bee Timor-Leste （MPW-BTL）	・Implementing agency on the Timor-Leste side ・Cooperation with the representative implementing agency ・Implementation management of the component in charge.	・Rehabilitation plan for Bemos Water Supply System
Ministry of Agriculture and Fishery／Department of Irrigation and Water Management) （MAF-DIWM）	・Implementing agency on the Timor-Leste side ・Cooperation with the representative implementing agency ・Implementation management of the component in charge.	・Rehabilitation plan for Buluto/Maliana Irrigation Facilities

Source: Preparatory survey of the Programme

2) Establishment and operation of Coordinating Committee for the Project

The Government of Timor-Leste shall establish a consultantee for the Programme (hereinafter referred to as "the Committee") in order to discuss any matter, at the Programme level.

Table 3.6-8 Committee for the Programme

Item	Description	Remarks
1. Member of Committee	・Ministry of Foreign Affairs and Cooperation ・Ministry of Finance (MoF) ・MPW-DRBFC ・MPW-BTL ・MAF-DIWM	Ministry of Finance and MPW-DRBFC shall be Co-chair.

	・ Representative(s) of JICA Timor-Leste Office	
2. Observer of the Committee	・ Representative(s) of Embassy of Japan	
3. Meetings	・ Regular meeting of the Committee shall be held in Timor-Leste semiannually	Other meetings may be held upon the request of either JICA or the Recipient whenever JICA deems it necessary to call such meetings
3. Terms of Reference	① to confirm an implementation schedule for the Programme for the smooth and effective disbursement of Japanese Grant (hereinafter referred to as "the Grant"); ② to discuss modifications of the Programme, including modifications of the allocation of the Grant for the Subprojects; ③ to identify problems that may delay the implementation of the Programme or the disbursement of the Grant, and to explore solutions to such problems; ④ to exchange views on publicity related to the Programme; and ⑤ to discuss any other matters that may arise from or in connection with the G/A.	

Source: Preparatory survey of the Programme

3) Undertaking of Agreement and contract document

① Exchange of Notes (E/N) and Grant Aid Agreement (G/A)	Signer
・E/N	Embassy of Japan — Ministry of Foreign Affairs and Cooperation
・G/A	JICA — Ministry of Finance
② Banking Arrangement (B/A) and Authorization to Pay (A/P)	Signer
・B/A (One time about JPY 6,000)	MoF
・A/P (Nine times total about JPY 1M)	MoF
・Custom duty, tax, etc. (about JPY 22M)	MoF (Consignee of imported goods and materials is MoF.)
③ Contracts	Signer
・Contract for Consulting Service (One contract for three sub-components)	MPW (witness by MAF)
・Contract for Construction (One contract for three sub-components)	MPW (witness by MAF)

Source: Preparatory survey of the Programme

4) Undertaking of modification of contract

- It is expected that the preconditions of the Programme will have to be changed due to the tender results of the construction work and the occurrence of unforeseen circumstances during the construction.
- In that case, MPW, as the representative ministry of executing agencies, needs to carry out modification of design and contract, in coordination with related agencies.

5) Coordination with other donors, etc.

- The executing agencies will have to manage the contents of the Programme appropriately so that it does not duplicate with the assistance by other donors, etc.
- In particular, rehabilitation of the Bemos water supply facility needs to be well coordinated so that it does not duplicate with the ongoing Australian assistance project.

6) Appointment of dedicated counterparts and technical transfer

- In this project, urgent rehabilitation measures will be implemented as a pilot project.
- It is necessary to transfer the design and construction technology of the pilot project to the Timor-Leste side, and the implementing agencies will appoint dedicated counterparts of this project.
- The counterparts will have to transfer the technology into the relative agencies for the capacity building of the agencies.

(2) Banking Arrangement

1) Opening Bank Account

- The MoF will have to open a bank account necessary for consultant contract and construction contract, in coordination with related agencies.

2) Banking Commission

- The MoF will bear commissions to Japanese bank for banking arrangements of consultant and construction contract in coordination with the related organizations.

(3) Tax Exemption and Entry Permit

1) Tax exemption for the good of the project

- The tax exemption will be executed by MoF. MoF will arrange the tax exemption procedure for the construction contractor based on the information of construction materials and equipment provided by the contractor, in coordination with related organizations.
- MoF will need to ensure prompt tax exemption and custom clearance, in coordination with related agencies.

2) Entry permit, tax exemption for Japanese physical persons and/or physical persons of third countries

MPW, as a representative ministry of the executing agencies, will undertake the following permissions through related agencies:

- To accord Japanese physical persons and/or physical persons of third countries whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the country of the Recipient and stay therein for the performance of their work

(4) Construction Supervision

1) Obtaining approval of the project plan for environmental and social considerations

- Submission of an environmental and social consideration project plan based on the East Timor national system to the Ministry of the Environment. (It is necessary to confirm the necessity of submitting the plan)

2) Securing the temporary construction sites

- At each construction site, it is necessary to secure temporary construction sites such as construction equipment and material storage, and construction site offices.

3) Traffic control for the Rehabilitation plan for Comoro River Retaining wall

- In the Rehabilitation plan for Comoro River Retaining wall, the national highway No. 2 bypass road at the top of the retaining wall will also be restored.
- It is necessary to implement road traffic regulations to ensure safety during the construction.

4) Restrictions on water flow for Rehabilitation plan for Buluto/Maliana Irrigation Facilities

- It is necessary to limit the water flow of the irrigation facilities for ensure safety during the restoration work of the irrigation facilities.

Table 3.6-9 Project Descriptions and estimated project cost for the Grant Aid (Plan)

A. Construction cost

Component（Implementing agencies）	Outline of the component	Description of the work	Estimated Cost	Remarks
1． Rehabilitation plan for Comoro River Retaining wall 【MPW-DRBFC】	・ Urgently rehabilitation for retaining wall will be carried construct at most dangerous places where were collapsed by the April 2021floods, in terms of civic life. ・ This work will be a pilot project, and the technology will be transferred to other restoration works that will be carried out by Timor-Leste side.	① Rehabilitation of Retaining walls R5（110ｍ）and R6(120m) ② Bypass road of National Road No. 2（at retaining wall R5、R6、Total about 230m）	About ※※※ JPY	
2． Rehabilitation plan for Bemos Water Supply System 【MPW-BTL】	・ The existing water intake facilities have been collapsed and spilled due to the April 2021 floods, and it is in a situation where it cannot be operated safely. ・ Emergency restoration of facilities that are particularly severely damaged, and reinforcement of strength in preparation for floods.	① Rehabilitation of Intake facilities (Water Intake gate, pond, waterway, etc.) ② More resilient structural reinforcement against floods	About ※※※ JPY	・ Australia support plan is in progress (repair of water channel pit). Pay attention to overlapping support. ・ Temporary road construction is required.
3． Rehabilitation plan for Buluto/Maliana Irrigation Facilities 【MAF-DIWM】	・ Due to the April 2021 floods, damage is spreading at the deteriorated parts of existing facilities. ・ Repair and restore the facilities.	A. Buluto Irrigation Facility ① The masonry wall at downstream of the headworks will be rehabilitated. ② River protection block at the apron downstream for the headworks will be constructed. ③ The bottom slab concrete in the main canal will be rehabilitated	About ※※※ JPY	・ Including the stone masonry walls which were rehabilitated under the follow-up grant aid.
		B. Maliana Irrigation Scheme ① Rehabilitation of the Maliana headworks ② Rehabilitation of the drainage	About ※※※ JPY	
		Total	About ※※※ JPY	

B. Consulting services

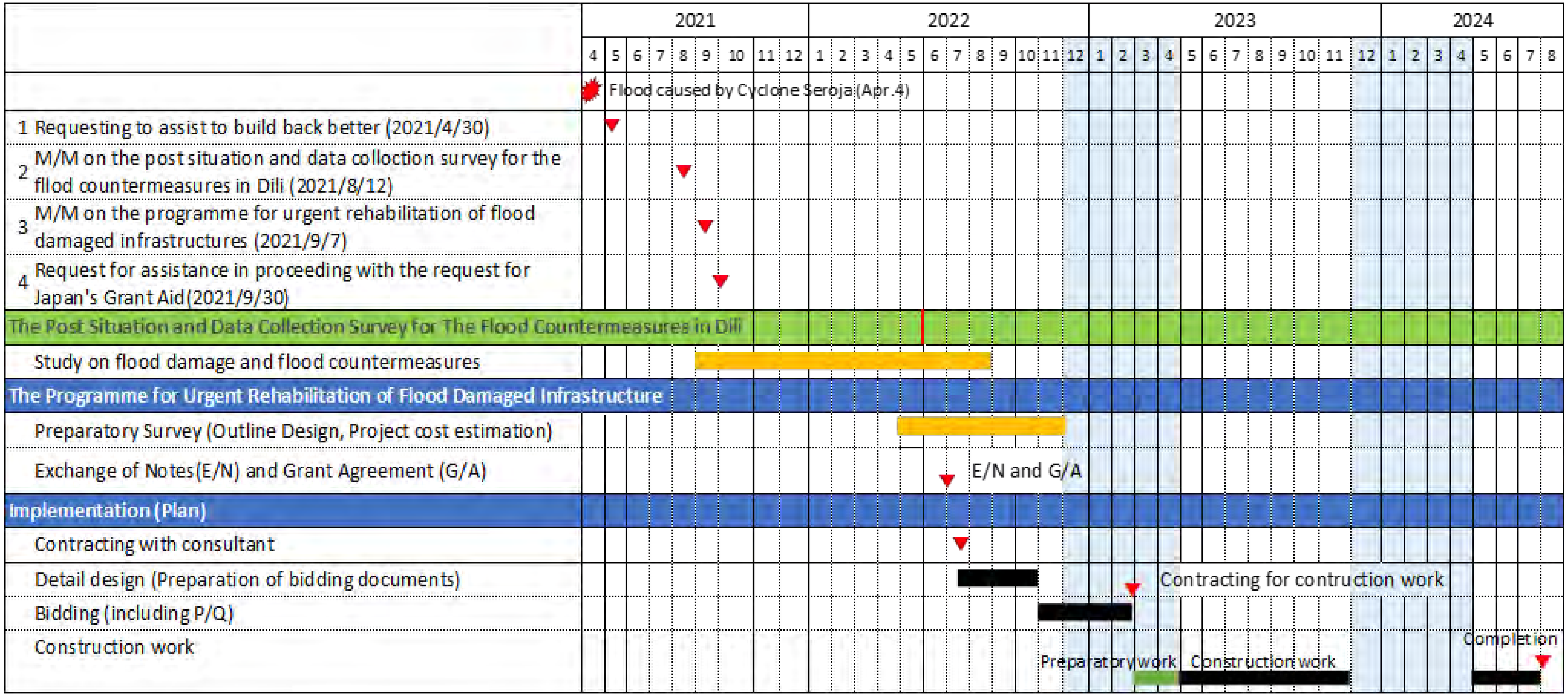
Component（Implementing agencies）	Outline of the component	Description of the work	Estimated Cost	Remarks
Consultant Fee 【MPW-DRBFC）】 【MPW-BTL】 【MAF-DIWM】	・ Detailed design and Construction Supervision	① Detailed Design（Preparation of Tender Documents） ② Tendering Support ③ Construction Contract Support ④ Construction Supervision	About ※※※ JPY	

C. Grand Total of the Project (A+B): ※※※ million JPY

Source: JICA Survey Team

Remarks: This table was prepared as of February, 2022. It is expected that the scope of the project will be reconsidered at the time of project cost estimation by the preparatory survey of the Programme, in consideration with price escalation as well as exchange rate of Japanese Yen.

Table 3.6-10 Planned Implementing Schedule of the Grant Aid Project



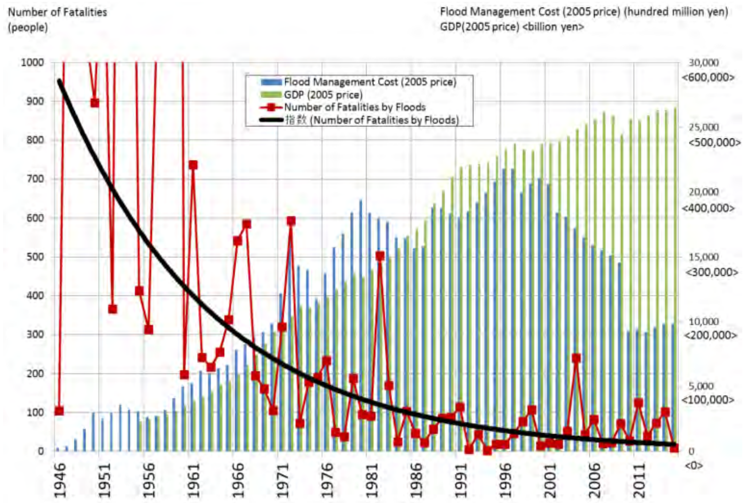
Source: JICA Survey Team
Remarks: This construction schedule was prepared based on the information as of February 2022. The schedule will be revised at the time of preparatory survey of the Programme,

Chapter 4. Recommendation for disaster risk reduction

4.1 Importance to promote investment in disaster risk reduction

In Timor-Leste, the flood of April 4, 2021 killed 48 people nationwide, affected more than 30,000 households, and temporarily forced the evacuation of 14,000 people in the capital Dili. This disaster was caused by the record rainfall that occurs more than the once in a hundred years, and there are concerns that flood disasters will become larger and more frequent in the future due to climate change.

In the past, Japan suffered from large-scale floods caused by typhoons every year, often resulting in thousands of casualties. In recent years, however, the number of flood victims has been reduced to a range of tens to hundreds. This has been achieved through continuous investment in disaster risk reduction. Figure 4.1-1 shows the relationship between the number of fatalities due to flood disasters, GDP and investment in flood control in Japan. It can be seen that the number of victims has been decreasing with continuous investment in flood management.



Source: High-level Experts and Leaders Panel on Water and Disasters (HELP)

Figure 4.1-1 Flood disaster fatalities, GDP and investment in flood control in Japan

Figure 4.1-2 shows the disaster risk management cycle. In many developing countries, a large amount of budget is spent on the repetition of disaster, response and recovery, and they are stuck in a vicious cycle of disaster and poverty. Instead of spending money on disaster response and recovery in the right half of the disaster management cycle, more money should be invested in disaster risk reduction (enhancement, prevention and mitigation, and preparedness) in the left half.

Source: JICA

Figure 4.1-2 Disaster Risk Management Cycle

4.2 To make the capital Dili a "Safe, Resilient and Attractive City"

In order for the capital Dili to further develop in the future as a destination for visiting tourists and various private companies, it must become a "Safe, Resilient, and Attractive City". To this end, various measures for "disaster risk reduction" must be implemented as described in 4.1 above. Key measures

Source: JICA Survey Team

Figure 4.2-1 Image of Measures to make Dili a "Safe, Resilient and Attractive City"

include: 1) Improving flood management systems; 2) Strengthening the critical infrastructures; 3) Enhancement of hydrological and meteorological observations; 4) Promotion of urban planning; 5) Development of legal systems for urban planning, river management, forest conservation, land use, and disaster risk reduction; and 6) Capacity development for DRR. Figure 4.2-1 shows a conceptual image of "Dili, a Safe, Resilient, and Attractive City. It is important to establish a cooperative framework among the Civil Protection Authority (CPA), the Ministry of Finance, and the Ministry of Public Works to promote the "Safe, Resilient and Attractive City" concept.

Table 4.2-1 shows various disaster risk reduction measures and progress toward realizing the concept, making Dili a "Safe, Resilient, and Attractive City". Some of the proposed measures shown here are already being implemented and others are planned to be implemented in the future. However, there are also many important measures that have not yet been implemented. It is expected that the Government of Timor-Leste will define the responsible ministries, and systematically implement them in collaboration with the development partners in the future.

Table 4.2-1 Measures need to be implemented to make Dili a "Safe, Resilient and Attractive City"

Sector	Measures	Current Status
1. Flood management	**①Flood Risk Analysis**	
	1.1 Comoro River basin	Implemented in this survey (JICA)
	1.2 **Flood risk analyses for other river basins**	**Required to be implemented**
	②River Management Planning	
	2.1 Dili and surrounding areas	Proposed for future project (Japan's Technical Assistance)
	③Rehabilitation of the Comoro River retaining walls	
	3.1 Emergency Rehabilitation of the selected part	To be implemented by Japan's grant aid
	3.2 **Rehabilitation of the Comoro River retaining walls at the remaining damaged part**	**Required to be implemented**
	④Forest (Catchment Area) Management and Conservation	
	4.1 Forest (catchment areas) management and conservation	In progress (GoTL, JICA, EU/GIZ, WB, FAO)
	⑤Drainage improvement to mitigate inland floods	
	5.1 **Drainage improvement in Dili**	**Required to be implemented**
	⑥Retention basin development to mitigate inland floods	
	6.1 **Retention basin development in Dili to mitigate inland floods**	**Required to be implemented**
	⑦Enhancement of heavy equipment for DRR and recovery	
	7.1 Enhancement of heavy equipment for disaster risk reduction and recovery	To be implemented by Japan's grant aid
2. Strengthening critical infrastructure	**⑧Rehabilitation of Irrigation Facilities**	
	8.1 Buluto/ Maliana emergency rehabilitation	To be implemented by Japan's grant aid
	8.2 **Rehabilitation of other damaged irrigation facilities**	**Required to be implemented**
	⑨Rehabilitation of water supply facilities	
	9.1 Bemos WTP emergency rehabilitation	To be implemented by Japan's grant aid
	9.2 **Rehabilitation of other damaged water supply facilities**	**Required to be implemented**
	⑩Flood-resistant road structures	

Sector	Measures	Current Status
	10.1 **Rehabilitation and reinforcement of roads and bridges against flooding**	**Required to be implemented**
	⑪Development of ports and airports	
	11.1 Development and improvement of ports and airports	In progress (GoTL, JICA, ADB, DFAT)
	⑫DRR strengthened hospitals, government buildings, schools, etc.	
	12.1 **Development/ reinforcement for flood and earthquake resistant buildings**	**Required to be implemented**
3. Enhancement of meteorological and terrestrial observation	**⑬Development of flood early warning systems**	
	13.1 In selected river basins	In progress (Mercy Corp (KOICA), UNTL (JICA), UNEP (GCF))
	13.2 **Development of flood early warning systems for other river basins**	**Required to be implemented**
	⑭Nationwide automatic hydrometeorological observation system	
	14.1 **Development of nationwide automatic hydrometeorological observation system**	**Required to be implemented**
	⑮Earthquake observation	
	15.1 Human resources development for seismology, earthquake engineering and tsunami disaster mitigation	In progress (JICA)
	⑯Strengthening tide level observation	
	16.1 **Strengthening tide level observation**	**Required to be implemented**
4. Urban Planning	**⑰Updating of Dili urban masterplan**	
	17.1 Updating of Dili urban masterplan	In progress (GoTL, JICA)
	⑱Preparation of flood hazard map	
	18.1 Flood hazard map for Dili and suburb areas	In progress (GoTL, this study (JICA))
5. Improvement of laws and institutions	**⑲Urban planning related law**	
	19.1 Laws and regulations for urban planning	In progress (GoTL, JICA)
	⑳Land property related law	
	20.1 Laws and regulations for land property	In progress (GoTL, JICA)
	㉑Forest management roadmap	
	21.1 Reduction of forest degradation and deforestation by applying the CBNRM approach	In progress (GoTL, JICA)
	㉒River management related law	
	22.1 Formulation of river management related laws and regulations	Proposed for future project (JICA)
	㉓Update of Disaster Risk Management Policy 2008	
	23.1 Updating of the Disaster Risk Management Policy 2008	In progress (UNDP/ SEPC)
	㉔Development of Disaster Risk Reduction Investment Plan	
	24.1 **Development of Disaster Risk Reduction Investment Plan**	**Required to be implemented**
6. Capacity development for disaster risk reduction	**㉕ Capacity development for disaster risk management (development of the disaster response plan)**	
	25.1 Capacity development for disaster risk management (development of the disaster response plan)	In progress (UN CADRI, IOM (Japan, USAID))
	㉖Table-top disaster exercise (simulation training)	
	26.1 Table-top exercise for disaster response involving all the line ministries and NGOs	In progress (Australia)
	㉗Evacuation drills	

Sector	Measures	Current Status
	21.1 Training of Community-based Disaster Risk Management including evacuation drills	In progress (CVTL, IOM (Japan, USAID), NGOs)
	㉘ Establishment of Disaster Learning Center	
	28.1 **Establishment of Disaster Learning Center**	**Required to be implemented**
	㉙ Establishment of Disaster Research Institute	
	29.1 **Establishment of Disaster Research Institute**	**Required to be implemented**

Note: **The measures in red** indicate those required to be implemented by the Timor-Leste government and/or with the development partners. Red squares indicate higher priority measures.
Source: JICA Survey Team

Appendix 1. List of parties concerned in the recipient country

Organization and Name	Position
Ministry of Finance, MOF	
Mr. Antonio Freitas	Vice Minister
Mr. Francisco Alves	Director General of External Resources Mobilization and Management
Mr. Elson da Costa	National Director of Aid Mobilization
Ms. Sitalina M Tilman	
Mr. Diamantino Soarres	Head of Section
Mr. Liboro Alves	Loan Advisor
Ministry of Foreign Affairs and Cooperation, MNEC	
Mr. Marcos dos Reis da Costa	National Director under National Directorate for West, Central, South and Far-East Asia
Mr. Hernani Magno	Program Officer under National Directorate for West, Central, South and Far-East
Ministry of Public Works, MPW	
H.E. Dr. Abel da Silva Pires	Minister of Public Works
Mr. Nicolau Lino Freitas Belo	Vice Minister of Public Works
Mr. Rui Hernani F. Guterres	Director General of Public Works
Ministry of Public Works, National Directorate of Road, Bridge and Flood Control, MPW DRBFC	
Mr. Milton Ramanata Monteiro	National Director
Mr. Nene Lobato	Former National Director
Mr. Vital Nai Quei Pereira Araujo	Coordinator of Adhoc unit
Ministry of Agriculture and Fisheries, MAF	
Mr. Pedro dos Reis	Minister
Ms. Maria Odete do Ceu Guterres	Director General
Mr. Martinho Laurentino Soares	National Director
Bee Timor Leste, BTL	
Mr. Carlos Peloi dos Reis	President
Mr. Joao Piedade Braz	National Director
Mr. Avelt Dos Santos	Director of Engineer
National Electricity Company, EDTL	
Dr. Paulo da Silva	President
National Authority for Water and Sanitation, ANAS	
Dr. Domingos Pinto	President
Mr. Francisco Xavier Pereirx	Director Water Resource Management and Water Supply
Mr. Rui de Sousa	Cordinator for Development Partner (Previous Director of DNAS)
MPW Institute of Equipment Management, IGE	
Ms. Ermenegilda Da Costa Laurentina	President
Mr. Jose Diamantino De Oliveira	Vice President
Mr. Abrao Pereira	Vice President
Mr. Puintiliano A. Belo	Executive Director

Organization and Name	Position
Ministry of Planning and Territory General Directorate of Spatial Planning, MPT-GDPS	
Eng. Deolindo da Silva (dos Santos)	Director General
Mr. Jaime Dias Fernandes	National Director
MPT Major Project Secretariat, MPT-MPS	
Mr. Jaime Dias Fernandes	National Director
Mr. Krispin Rego Fernandes	Executive Director
Ms. Odete de Costa	Advisor
Mr. Koki Kaneda	JICA Expert
Dr. Konstantin Borisov	UNDP Chief Technical Advisor
Civil Protection Authority (CPA), Ministry of Interior	
Mr. Ismael da Costa Babo	President of CPA
Mr. Agostinho Cosme	National Director of Disaster Management
Mr. Martinho Filipe	Chief Department of Disaster Preparedness, Mitigation and Prevention
Mr. Neil Doherty	Advisor
Mr. Joao Carlos Sing	NDOC-GIS
Mr. Mariano Ana Lopes	Chief of Section of Disaster Preparedness and Prevention
Ministry of Transport and Communication, Dept. of Meteorology and Geophisics, MTC-DNMG	
Mr. Gaspar de Araujo	Director General
Mr. Terencio Tiborcio T. Fernandes Moniz	National Director
Ms. Flaviana Pinto Fernandes	Chief of Department
Ministry of Petroleum and Natural Resources, Institute of Petroleum and Geology, MPNR-IPG	
Mr. Oktoviano Viegas Tilman de Jesus	Vice President
Mr. Eugenio Soares	Director
National University Timor Lorosae, UNTL	
Dr. Benjamim de Oliveira Hopffer Rego Silveira Martins	Professor
Prof. Alfred Ferreira	Director
Dili Municipality	
Ms. Emiliana Soares	Director
Ms. Maria	Municipality Development Advisor
UN Resident Coordinator	
Ms. Kanako Mabuchi	Head of UNRCO
Mr. Alex Tilman	Development Coordination Officer
Asian Development Bank, ADB	
Mr. Pedro Aquino	Development Coordination Officer
Mr. Witoon Tawisook	Senior Project Officer for Infrastructure
Mr. Ronald Mark G. Omana	Principal Transport Specialist
Mr. Takeshi Fukayama	Project Analyst
Mr. Shinichiro Nagao	Transport Analyst
Engineer without Boarders, Australia	
Mr. Richard Warren	Project Director
Mr. Anor Sihombing	Technical Advisor
Ms. Britt Hendriks	Project Operations Engineer
Mr. Ouver Heyward	Senior Designs Engineer
Mr. Paulus da Silva	Water Coodinator（DFAT）
Ms. Fiona Hamilton	Team Leader（DFAT）

Organization and Name	Position
US Agency for International Development, USAID	
Mr. Fonseca Miranda	Coordinator
NPO Mercy Corps	
Mr. Valentino Gusmao Ornai da Silva	Deputy Program Manager
Aqua De Portugues, ADP	
Mr. Mário Jorge Andrade Ministro Santos	Project Director
Embassy of Japan	
Mr. KINEFUCHI Masami	Ambassador Extraordinary and Plenipotentiary
Ms. YAMADA Kazumi	Counsellor
Ms. TAKI Misato	Second Secretary
Japan International Cooperation Agency (JICA) Timor-Leste Office	
Mr. GOTO Ko	Chief Representative
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Appendix 2 Community Survey on Disaster Risk Information and Behavior

1. Background

In Timor-Leste, the flood on April 4, 2021 killed 48 people nationwide, affected more than 30,000 households, and temporarily displaced 14,000 people in the capital Dili. This disaster was brought about by torrential rains that were close to a 200-year occurrence probability. Due to climate change, there is concern that flood disasters will become larger and more frequent in the future.

To prevent and mitigate the damage caused by such disasters, it is important to reduce local disaster risks through systematic infrastructure investment, but in parallel with infrastructure development, it is important to save lives through early evacuation by disseminating appropriate disaster risk information and community-based disaster risk management.

2. Objective of the Survey

The objective of this study is to interview community leaders and residents in the areas affected by the April 2021 floods to understand the current status of disaster information dissemination and the actions taken by the community and residents, and to identify issues.

3. implementation method

Survey forms were prepared for community leaders and for residents. UNTL students conducted an interview survey on the dissemination of disaster risk information to residents and residents' behavior based on the information. Due to the limited sample size of the survey, no statistical analysis was conducted, but a qualitative analysis of the actual situation was conducted.

(1) Questionnaire

Two types of questionnaires were prepared, one for community leaders and another for residents, and were pre-translated into the Tetum language. The structure of the questionnaire is shown in Table 1.

Table 1: Structure of the Questionnaire

For Community Leaders	For Community Residents
1. Basic information 2. Emergency evacuation 3. Voluntary disaster prevention organizations 4. Disaster information 5. Raising residents' awareness 6. About the April 4, 2021 flood	1. Basic information 2. Community status 3. About the April 4, 2021 flood 4. Residents' awareness of disaster prevention

(2) Survey period: Early October to mid-November 2021

(3) Survey sites:

The survey was conducted in eight districts affected by the April 4, 2021 flood: 1) Culuhun, 2) Comoro, 3) Caicoli, 4) Becora, 5) Bidau Santa Ana, 6) Camea, 7) Tibar and 8) Hera. Figure 1 shows the survey sites.

(4) Method of implementation:

After obtaining consent from the head of the Suco in the target district to conduct the survey, interviews were conducted with community leaders and residents. Basically, two students were assigned to each group, and three groups of six students visited the sites and interviewed the community leaders and residences.

The reasons for appointing UNTL students as surveyors are as follows:

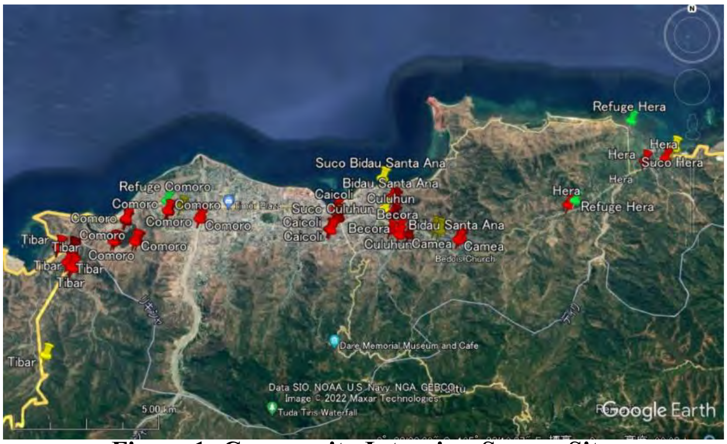

Figure 1: Community Interview Survey Sites

- Efficient surveys can be conducted because the students are aware of the situation in the affected areas through prior flood damage assessments.
- Students are able to obtain the cooperation of residents more easily, and get more candid answers,
- This is an opportunity to develop human resources by giving UNTL engineering students, who will be responsible for future disaster management, hands-on experience.

(5) Number of investigations

- Community leaders: 20
- Community residents: 59

4. Survey results

Table 2 shows the challenges and proposed countermeasures in terms of disaster risk information and residents' behavior that were identified through this survey.

Table 2: Issues and proposed countermeasures in terms of disaster information communication and residents' behavior

Challenges	Proposed Countermeasure
1. Emergency Evacuation	
1-1 Evacuation orders were issued partly through loudspeakers and direct calls after occurrence of the flooding.	• The CPA, as the central agency for disaster risk management, is obliged to issue evacuation orders to the people in risk area based on hydrometeorological information from DNMG, IPG, etc. based on Civil Protection Law Article 4 2. d). A risk assessment committee should be organized within the CPA and evaluate the hazard information to issue evacuation orders at an early stage before a disaster occurs. • It is important that disaster risks information be disseminated in easy-to-understand language to the residents, with redundancy through cell phones, TV, radio, social media and also through SMS broadcasts.
1-2 Although the residents recognize nearby schools and churches as temporary evacuation places, there is no place safe from flooding designated by	• According to the Disaster Risk Management Policy 2008-2012, "Village (Suco) committees must identify safe evacuation sites and safe evacuation

the government or local authorities as an emergency evacuation site.	routes for floods and other hazards as part of disaster and critical emergency preparedness. Since it is difficult for Suco to identify safe evacuation sites from a technical perspective, a mechanism is needed for CPAs, universities, etc. to assist Suco technically..
2. Disaster Risk Management Organization	
2-1 While some villages have voluntary disaster risk management organizations, many do not.	• As indicated in the "Disaster Risk Management Policy 2008-2012," disaster management committees should be organized in the Municipality and Suco to implement disaster management measures at their respective levels. • Community-based disaster risk management (CBDRM) activities should be implemented in high-risk areas with the cooperation of CVTLs and other organizations (e.g., formation of disaster management organizations, preparation of evacuation plans, conducting drills, etc.). • All of the above activities should be continued, and a budget for these activities should be secured every year.
3. Dissemination of Disaster Risk Information	
3-1 Many residents had received DNMG forecasts of the cyclone before the disaster through TV, radio, social media, etc., but did not take special precautions because they considered the event to be the same as usual.	• Information on what scale of disaster is likely to occur and the potential impact of the disaster should be conveyed to residents from the forecast stage. • It is important to issue warnings with sufficient lead time for vulnerable populations such as the elderly and disabled, as it takes time for them to evacuate.
3-2 Residents get information about disasters from TV, social media (FB), and radio.	• After the April 2021 floods, SMS broadcasts became available through agreements between three mobile carriers and the CPA. With a cell phone line, information can be sent by push type without an internet connection, which is expected to be utilized effectively in emergency situations.
4. Awareness Raising and Disaster Education	
4-1 Some villages have received training and guidelines on how to evacuate, but many have not received such training. Evacuation drills are held in some villages, but not in many villages.	• In villages that have already received training, it is important to continue the activity by securing a budget and conducting evacuation drills every year. • In districts where disaster risk is high and no evacuation drills or guides have yet been developed, evacuation plans should be developed in cooperation with the CPA and CVTL and

	evacuation drills should be conducted at least once a year.

Table 3 provides a summary of the results of interviews with community leaders, and Table 4 provides a summary of the results of interviews with residents.

Table 3: Summary of Results of Interviews with Community Leaders

District	1. Emergency evacuation	2. Voluntary disaster risk management organizations	3. Disaster risk information	4. Awareness raising and disaster education	5. About April 2021 Floods
Kuluhun	• Residents receive information about evacuation through loudspeakers, calls, television, and radio. • Suco offices, churches, and relatives not affected by the flooding are being used as evacuation place. These places are still housing displaced persons even at this time. • In villages that have an evacuation system, they understand what to do when they hear the instructions to evacuate. • In villages without evacuation systems, they stayed in their homes and waited for the water to recede. • During the disaster, residents received support from the government, NGOs, local businesses, and political parties.	• Several villages have voluntary organizations to manage disasters. Provides information on how to deal with disasters, clean-up the environment, and dispose of garbage in designated areas. • The organization's necessary expenses are obtained from churches, political parties, and local and NGO sources. • Some villages do not have organizations to deal with disasters and receive direct assistance from Civil Protection. • During the emergency, many organizations were assisted with food, water and blankets.	• DNMG provides weather information through social media (FB), television, and radio. • Chefe Aldeia will provide information to the government where the disaster occurred. • Residents can be informed about disasters that occur if they have access to television, social media (FB), and radio. • Some villages maintain data on disasters, including maps showing the location of past disasters. • After the disaster, the government provided training on how to prevent flooding and provided information on how to dispose of garbage.	• Some villages have received training on how to evacuate and have guidelines for evacuation, while others do not.	• Before the disaster struck, residents had received information about the forecast for the cyclone from the Meteorological Service via social media, television, and radio. • During the flood, evacuations were ordered by government agencies (Chefe Suco, Aldeia, Civil Protection), Mercy Corp. and the Red Cross, as well as at their own discretion. • After the flooding, they used loudspeakers to give direct instructions and lead residents to evacuation sites. • After the flood, some activities were carried out to clean waterways and houses and to encourage residents not to dump garbage.

	• Causes of delayed evacuation include (1) delayed information, (2) fear of theft, (3) lack of knowledge, and (4) fear.				
Comoro	• Residents get information about evacuation via loudspeaker. • Dom Bosco, a school, and the former Radio Lorosae office were used as evacuation centers, and the evacuation centers are still housing survivors. • There is guidance for emergency evacuation. • During the disaster, residents received support from NGOs, local businesses, political parties, and politicians. • The reason for the delay in evacuation is due to concerns about theft.	• Several villages have voluntary organizations to manage disasters. They provide information on how to respond to disasters, encourage residents to clean-up their environment, and encourage waste management. Funding for these organizations comes from the government and NGOs. • During the emergency, many organizations (ACBTL Association, NGOs) provided assistance in the form of food, water and blankets.	• DNMG provides weather information through social media (FB), TV, and radio. • Chefe Aldeia will provide information to the local government where the disaster occurred. • Residents can obtain disaster information from television, social media (FB), and radio. • The village has data on past disasters and has maps of risk areas. • After the disaster, the government has no plan for disaster prevention.	• Some villages have received training on evacuation methods and have evacuation guidelines.	• Prior to the disaster, residents had obtained cyclone forecasts from the JMA via television. • When the flooding occurred, evacuation was ordered by government agencies (Chefe Suco, Aldeia, and Civil Protection) and voluntary decisions were made by the residents. • After the flooding, they used loudspeakers to give direct instructions and lead residents to evacuation sites. • After the flood, some activities were carried out to clean waterways and houses, and to encourage residents not to dump garbage.
Caicoli	• Residents get information about evacuation by loudspeaker, calling out, phone, etc.	• There is no voluntary organization for disaster management. • During the emergency, many	• DNMG provides weather information through social media (FB), TV, and radio. • Chefe Aldeia provides	• Some villages have received training on evacuation methods and have evacuation guidelines.	• Prior to the disaster, residents had obtained cyclone forecasts from the JMA via television.

	• Evacuation sites include Suco offices, fire stations, UNTL (National University), schools, etc. Evacuation sites are still accommodating evacuees. • There is no guidance for emergency evacuation. • When disasters occur, residents receive assistance from the government (Civil Protection), NGOs, and local businesses. • Causes of delayed evacuation include not evacuating for fear of theft, lack of awareness, and lack of clarity about where and how to evacuate.	NGOs and political parties provided food, water, blankets, and other assistance.	information to municipalities where disasters occur • Residents can obtain disaster information from TV, social media (FB), radio, etc. • The village has data recording disasters and has maps of risk areas that have occurred in the past. • After a disaster, the government does not have a plan for disaster prevention.		• When the flooding occurred, evacuations were carried out based on instructions from government agencies (Chefe Suco, Aldeia, Civil Protection), the Red Cross, and their own judgment. • After the flooding, they used loudspeakers to give direct instructions and lead residents to evacuation sites. • After the flood, some activities were carried out to clean waterways and houses and to encourage residents not to dump garbage.
Becora	• Residents obtain information about evacuation through loudspeakers, calls, and phone calls. • Residents were evacuated to the homes of relatives who were not affected by the flooding. There is no designated shelter. • There is no guidance for	• There is no voluntary organization for disaster management. • During emergencies, many NGOs and political parties provide food, water, blankets, and other assistance.	• DNMG provides weather information through social media (FB), TV, and radio. • Chefe Aldeia provides information to the local government where the disaster occurred. • Residents obtain disaster information through television, social media	• Some villages have received training on evacuation methods and guidelines for evacuation.	• Prior to the disaster, residents get cyclone forecasts from the weather service through television, social media, and radio. • During the flooding, evacuations were carried out at the direction of government agencies (Chefe Suco, Aldeia, Civil

	emergency evacuation. • During the disaster, residents received assistance from the government (Civil Protection), NGOs, and local businesses. • Causes of delayed evacuation include not evacuating for fear of theft, lack of awareness, and not setting up evacuation sites and methods.		(FB), and radio. • The village has data documenting disasters and has maps of risk areas from past disasters. • After a disaster, the government has no plan to prevent disaster.		Protection), the Red Cross, and at their own discretion. • Evacuation instructions were provided directly to residents using loudspeakers at flooding locations. • After the flood, some sediment and mud were removed from waterways and houses.
Bidau Santa Ana	• Residents were not informed about the evacuation. • Residents took refuge in a church near the village, but it was not enough to accommodate the flood victims. • There is no guidance for emergency evacuation. • During the disaster, residents received assistance from the government church, Mother Canossian Convention, and Paulus VI School. • The delay in evacuation was caused by lack of information, resulting in lack	• There is a volunteer organization that manages disasters. The organization (Mercy Corps) works with local governments to manage disasters. • In an emergency situation, Mercy Corp. provided food, water, and other assistance.	• Residents have not received a forecast from DNMG. • The village has data recording disasters and has maps of past hazardous areas. • After the disaster, the government provided social education on disaster prevention.	• Villages are trained on how to evacuate and have guidelines for evacuation.	• After the flooding, local authorities indicated emergency evacuation sites to residents. • Local governments collected information on victims and provided it to the government in order to obtain assistance.

	of awareness of evacuation sites and evacuation methods.				
Camea	• Residents get information about evacuation by loudspeaker, calling out, or telephone. • Evacuation site used Suco office, which cannot accommodate many people. • There is no guidance for emergency evacuation. • When disaster struck, residents received support from local businesses and political parties. • The delay in evacuation is due to fear of theft.	• There is a volunteer organization for disaster management (Red Cross). The Red Cross works with local governments to manage disasters. • The Red Cross assisted in the removal of sediment and mud from the area.	• Residents have not received a forecast from DNMG. • The village has data documenting disasters and has maps of risk areas that have occurred in the past. • After a disaster strikes, there is no support from the government.	• The village has not received any training on how to evacuate or guidelines for evacuation.	• Prior to the disaster, residents had received information about the forecast regarding the cyclone from the Meteorological Agency through social media, television, and radio. • The decision to evacuate was made by the residents themselves. • After the flood, some residents cleaned up waterways and homes.
Tibar	• Residents were not informed about the evacuation. • Residents were evacuated to the homes of relatives who were not affected by the flooding. • There is no guidance for emergency evacuation. • Receive assistance from government and NGOs when disasters occur.	• There is no voluntary disaster management organization. • During emergencies, local leaders and communities work together to deal with flooding.	• Regarding disaster information, residents receive DNMG forecasts through social media (FB). • After a disaster strikes, local leaders and communities collect information on the damage caused by flooding and provide this information to the government.	• The village has not received training on evacuation procedures or evacuation guidelines.	• Prior to the disaster, residents were informed by DNMG via social media, television, and radio of the forecast regarding the hurricane. • Evacuation orders at the time of the flooding were given by the residents themselves and local leaders. • Since there was no

	• Delayed evacuation may be caused by lack of information, which may result in the lack of a defined evacuation site and evacuation method.				designated emergency shelter, they took refuge with relatives who were not affected by the flooding. • Residents clean up waterways and homes after flooding • Information on damage caused by flooding was collected to provide information to the government.
Hera.	• Residents get information about evacuation over the loudspeaker. • Evacuation sites include churches, schools, Sister's Canossian Convenient, Dominican Convenient, and the homes of relatives and neighbors who were not affected by the flooding. • There is guidance for emergency evacuation. • During the disaster, residents received support from Civil Protection, religious organizations, NGOs, local businesses, political parties,	• Several villages have voluntary organizations for disaster management. • These organizations provide information on disaster response and encourage a clean environment for residents. • Funding comes from the government, NGOs, and a British Timorese organization. • During emergencies, Civil Protection, UNDP, NGOs, and many other organizations assist with food, water, cooking oil,	• DNMG provides weather information through social media (FB), TV, and radio. • Chefe Aldeia will provide information to the local government where the disaster occurred. • Residents can obtain disaster information via TV, social media (FB), and radio. • The village has historical disaster data and maps of risk areas. • After a disaster, local leaders collect information on damage caused by flooding in order to provide	• They have not received training on evacuation procedures and evacuation guidelines.	• Before the disaster struck, residents were getting forecasts about the cyclone from DNMG via television. • During the flooding, evacuations were ordered by government agencies (Chefe Suco, Aldeia, Civil Protection) and on a voluntary basis. • In flooded areas, evacuation instructions were given directly to residents using loudspeakers to direct them to evacuation sites. • After the flood, some residents cleaned up

	and politicians. • Delayed evacuation is caused by delayed information and lack of preparation.	blankets, kitchenware, etc.	information to the government. • Local leaders encourage people to evacuate or not to work near hazardous areas.		waterways and houses.

Table 4: Summary of Results of Interviews with Community Residents

District	About the Community	About the April 2021 Floods	Disaster Preparedness and Awareness
Culuhun, Comoro, Caicoli, Becora, Bidau Santa Ana, Camea, Tibar, Hera	• Many residents live near schools (kindergartens, elementary schools, and high schools) and churches and recognize these facilities as temporary shelters. • Each Suco has a youth group, religious group, sports group, fishermen's group, and Red Cross organization. • The village heads are responsible for communicating information from the municipality to the population through Chefe Aldeia, Chefe Do Bairo, including that related to the forecasting of natural disasters. • The most important assets in a community include homes, pets, farmland, markets, and important documents. • Public facilities (churches, schools), livestock, etc. are important (Bidau Santa Ana, Camea, Hera)	• While some people were informed of the flooding through television (the weather bureau, GMNTV) and social media (DNMG's Facebook) and were informed both before and after the disaster, others were not informed about the cyclone. • Evacuation orders were given after the flooding began. • Evacuation orders were given by the municipality, the fire department, and Civil Protection (Caicoli). • Evacuations were carried out at the residents' own discretion (Becora, Bidau Santa Ana, Camea, Hera). • Affected municipalities and residents were temporarily evacuated to schools, churches, and Catholic quarters. • During the flood, residents secured only their own safety and valuable items such as documents. • After the flood, residents worked together to clean up their settlements and repair flood-damaged homes.	• If the disaster is not life-threatening, we have nothing. Since we do not have information that this situation will occur, we can do nothing. If we knew what the situation would be like, we would evacuate to a safe place. • After a discussion among family members, they decided to evacuate. • Some villages have received training on how to evacuate and some do not have guidelines for evacuation. • Special attention must be given to children and vulnerable disaster victims during the evacuation process. • Local governments should conduct regular drills on what residents should do in the event of a disaster and provide guidance on evacuation drills and volunteer activities for disaster management.