DATA COLLECTION SURVEY ON DISASTER RISK REDUCTION SECTOR IN SRI LANKA

FINAL REPORT

August 2017

Japan International Cooperation Agency (JICA)

Earth System Science Co., Ltd.
CTI Engineering International Co., Ltd.

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SUMMARY

1. Disaster Situation in Sri Lanka

Based on the records of disasters of the recent decade, the most frequent natural disaster in Sri Lanka is flood (37%) followed by strong wind, landslide and cyclone. The disaster causing most deaths and missing people is landslide (35%) followed by flood, lightning and strong wind. In percentage of affected, flood accounts for the highest percentage of affected followed by drought.

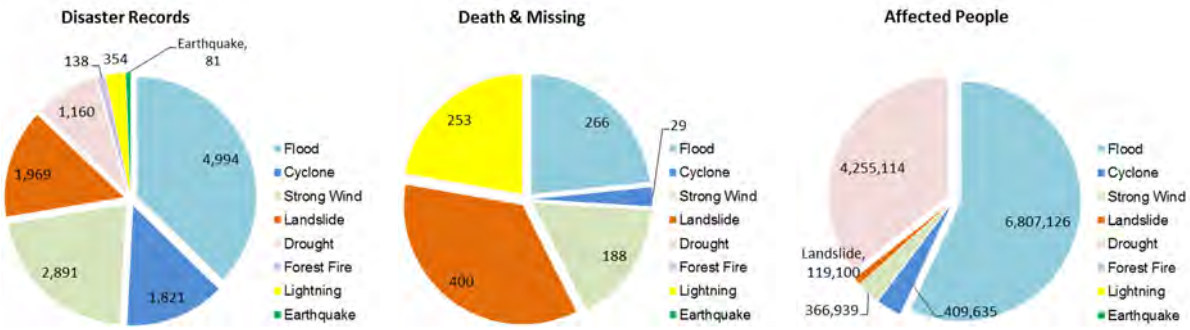

Figure 1 Disaster record in recent decade in Sri Lanka

Regarding the distribution of affected people by disaster, flood affected people was mainly distributed in plain area near the coast. The numbers of affected people in the south-western region, which is a high rainfall area, and the northern and eastern region, which is in the pathway of tropical depressions / cyclones, are large. On the other hand, sediment disaster occurrences are concentrated in the central area which is a high rainfall mountainous area. The people affected by drought are distributed all over the country except in the south-west region. Attention is called on the large numbers of affected people in the north-western, eastern region and southern region. In parts of the northern and eastern region, the numbers of people affected by both flood and drought are large. These regions face some problems of heavy rainfall in the rainy season and less rainfall in the dry season.

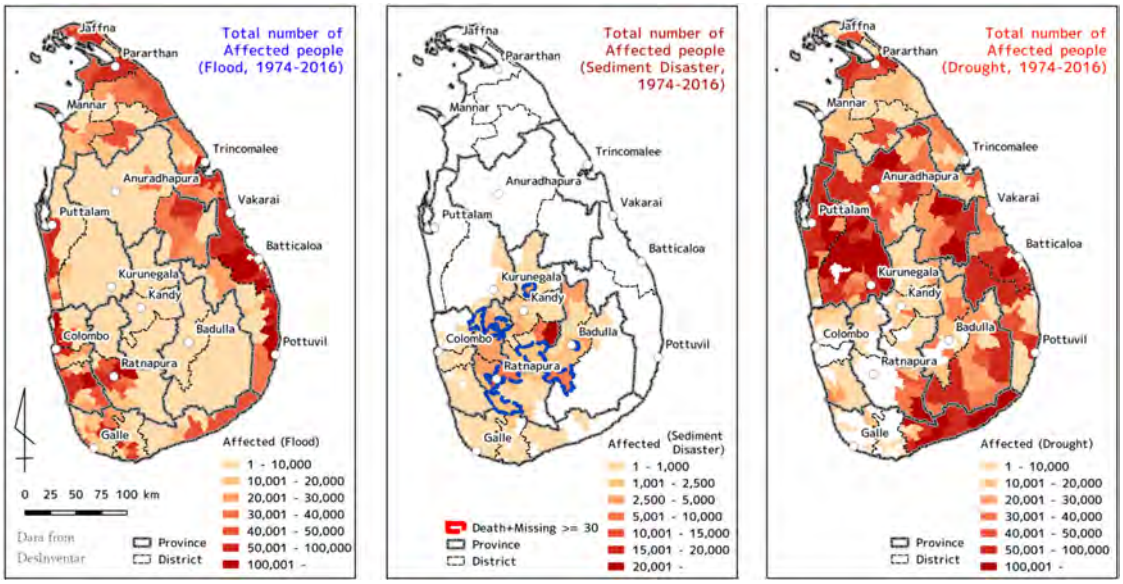

Figure 2 Distribution of people affected by disaster.

2. Legal System and Institution Structure in DRR Sector

After the tsunami attack by the Sumatra Earthquake in 2004, Sri Lankan Government emphasized the need for a policy to strengthen national DRR systems and enacted Sri Lanka Disaster Management Act, No.13 of 2005 stipulating the comprehensive DRR framework. The Act aims to establish DRR organizational structure and to shift away from emergency response toward preparedness.

Per the Disaster Management Act, National Council for Disaster Management (NCDM) as a supreme decision-making body on DRR and Disaster Management Centre (DMC) as an implementing agency on DRR measures were established in 2005. Based on the Disaster Management Act, the National Disaster Management Plan (NDMP) was formulated in 2013 and National Emergency Operation Plan (NEOP) is under formulation as of December 2016.

3. Efforts and Issues on Disaster Risk Reduction

Based on discussion with relevant agencies, existing issues and strategies / directions in each DRR sectors are summarized as follows;

(1) Comprehensive Disaster Management

- There is no unified database system on disaster records and disaster damages and losses. Basic data for disaster risk assessment is not sufficient.
- Local people are often not able to receive warning message from technical agencies. Mechanism and decision making process for warning and evacuation direction is not clear.
- Sri Lanka Comprehensive Disaster Management Programme (SLCDMP) is under implementation to promote mainstreaming of DRR. There are a number of projects that have not been funded. Monitoring and evaluation mechanism should be improved.
- NCDM has not been functioned. Coordination mechanism between relevant agencies should be strengthened.
- There is no DRR strategy in local administration line. Local DRR planning and disaster response depend on national, districts and divisions.
- There is no mid- to long-term implementation plan for community awareness activities. Therefore, the activities seem to be ad-hoc.
- Due to lack of database system, manual and plans for disaster relief, prompt activities for relief and resettlement is difficult.
- National Natural Disaster Insurance Programme does not cover compensation for drought.

(2) Flood Risk Reduction

- Recognition of flood and drought risk in details using the latest natural and social data is urgently required.
- Sharing of roles and responsibilities on flood management among relevant agencies are not clearly described in the existing flood ordinance. The existing land development law is not enough to prevent unregulated development of wetland where flood risk is high.
- It is necessary to prepare basin plans for the basins other than CRIP's priority projects in order to promote further investment.

- Many proposed projects in drainage master plan for Metropolitan Colombo area in 2003 have not yet been implemented. It is necessary to review the master plan to reflect such changes.
- There are cases that existing land use plan does not coincide with planned protected area from flood. It is necessary to update the land use plan considering flood risk area.
- Based on the enhanced hydrological monitoring systems, it is necessary to establish monitoring and flood warning system at basin level.

(3) Sediment Disaster Risk Reduction

- Estimated affected areas of debris flow are not shown on the hazard maps. Therefore, there is a difficulty on utilization of the hazard maps for land use planning.
- Legal basis of NBRO is unclear. Therefore, NBRO does not have legal authority to restrict improper developments.
- Implementation of slope protection for the main national roads and railways to strengthen core transportation system under emergency is required.
- Criteria of landslide warnings are still uniform in the entire country. Regional disaster characteristics are not reflected on the warnings.
- There are no building code and techniques on building materials considering landslide.

(4) Drought Risk Reduction

- It is necessary to gather the latest weather and hydrological data. Accurate assessment shall be scientifically conducted
- It is urgent to formulate a new national drought strategy aimed at reducing drought risk, and to formulate a national drought risk reduction plan following it.
- A large-scale water diversion schemes is planned and implemented. However, these are mainly for irrigation and hydroelectric power generation, therefore, supply of drinking water to local residents is not definitely clarified
- Emergency drought response is mainly at water supply by bowsers. Stable supply system has not been developed.
- Activities are being conducted towards a water-saving society by government agencies, donors, and NGOs, etc. However these activities are not unified at this moment.
- In many reservoirs in dry areas, sediments deposited in reservoirs are in place, and the water storage capacity and groundwater recharge function have declined.
- Systematic monitoring of surface water and groundwater in the drought area has not been implemented so far.

(5) Hydro-Met Observation and Information Dissemination

- Quantification and improvement of forecasting and warnings are required to decide starting evacuation at local level.
- Data sharing of observed hydro-met data among relevant agencies is inadequate. There is a difficulty on understanding of current hydro-met situation and warning dissemination.
- Insufficient development of legal framework and long-term strategy for hydro-met area.

4. Roadmap for DRR

As a conclusion of the Survey, a Roadmap for DRR in Sri Lanka was prepared. It is titled as "Safe and Resilient Sri Lanka", which means to promote DRR investment both structural and nonstructural measures to secure safety in urban areas and important infrastructures and to build resilient society in rural areas. The Roadmap was prepared through discussion among relevant agencies and JICA considering consistency with the Global Targets and the four Priority Actions of Sendai Framework as well as Sustainable Development Goals (SDGs).

DRR Efforts prioritizing on reducing Economic Losses

Reducing mortality is the first priority in DRR. However, even if the mortality is reduced by the efforts of early warning and/or strengthening disaster response capacity, damages of infrastructures and economic losses cannot be reduced. Consequently, the society cannot escape from repeating disasters damages. From this viewpoint, the Roadmap gives higher priority on investment for reducing economic losses by natural disasters. It is also important to prioritize each DRR effort and to invest in suitable and adequate protective targets (mortality, infrastructure or economy) depending on the situation and disaster types in order to maximize the benefit with limited budget.

Discretionary Investment considering Overall Balance

In disaster countermeasures, the impact by initial investment is relatively high, but the impact curve gradually flattens as the investment amount increases. Therefore, investment should aim to meet a certain level where an optimum investment impact ratio is ensured, instead of aiming for the highest hazard level with complete countermeasures.

Strengthening Local DRR Governance

DRR strategy and plans based on the good governance are the foundation of entire DRR activities. In Sendai Framework, therefore, the target year of Global Target (e) "national and local DRR strategy and plan" is set by 2020. To establish practical and realistic DRR strategies and plans are the most urgent task to be achieved as soon as possible.

Basin-based DRR Strategy

Disaster often occurs beyond administration boundaries. Especially in flood, several local administrations are suffered by one disaster event. To deal with the flood, therefore, holistic DRR strategy covering entire basin beyond administration boundaries is important. "Basin-based DRR strategy" which aims to maximize bulk benefit of the basin should be developed through the basin stakeholder meeting among concerned sectors and local authorities.

Monitoring Mechanism

The Roadmap for DRR is a guide to implement Sendai Framework by the Government of Sri Lanka. To ensure the implementation and promotion of the selected Priority Actions, it is important to organize periodical "DRR Roundtable Meeting" with concerned agencies under the initiative of MDM. It is to monitor individual activities by designated lead agencies.

5. Direction of Future JICA Supports in Priority Actions

Regarding the "Priority Actions" of the Roadmap for DRR, the Survey suggests the possible areas of future supports by JICA in consideration of applicability of Japanese technologies and experience as summarized below.

(1) Comprehensive Disaster Management

Proposal 1: National Disaster Management Plan

National Disaster Management Plan (NDMP) 2013-2017 will be reviewed and updated for the next period of 2018-2022. JICA and MDM agreed to dispatch a DRR Advisor to strengthen the institutional and operational capacity of MDM and the agencies under its purview.

Proposal 2: Local DRR Plans in Basin-based DRR Strategy

Developing local DRR plans which target year is set by 2020 is an urgent task to implement Sendai Framework. Supports to formulate local DRR plans in consideration of comprehensive Basin-based DRR Strategy though the pilot activities in the important river basins can be considered.

Proposal 3: Development Policy Loan to promote Roadmap for DRR

For promotion and implementation of National Disaster Management Plan 2018-2022 including new SLCDMP and Local DRR Plans based on the Basin DRR Strategy, to secure financing and monitoring structure are crucial issues in Sri Lanka. In order to support this in the long-term, "Development Policy Loan" shall be considered.

(2) Flood Risk Reduction

Proposal 1: Basin Investment Plan for Important River Basin

Among the important river basins, Kalu Ganga river basin is not selected as the target river basins in CRIP project. An integrated water resources management (IWRM) plan in Kalu Ganga river basin should be formulated by reviewing existing plans and preparation of flood and water balance modelling, with enhancing involvement of stakeholders in the basin.

Proposal 2: Flood Control Advisor for MIWRM

In order to promote formulation and implementation of basin investment plans including CRIP target rivers as well as to support Basin-based DRR Strategy and Local DRR planning, an flood control advisor shall be dispatched to the MIWRM.

Proposal 3: Master Plan for Storm Water Drainage in Colombo Metropolitan Region

The natural conditions such as rainfall and socio-economic situation and urban development scenario have already changed after the JICA Master Plan in 2003. It is, therefore, necessary to review and renew the Master Plan to reflect such changes. The comprehensive storm water drainage investment plan for Colombo Metropolitan region and surrounding areas should be formulated to promote further investment for flood mitigation measures.

(3) Sediment Disaster Risk Reduction

Proposal 1: Comprehensive Landslide Disaster Management

Since landslide does not repeatedly occur at same locations, it is not realistic approach to apply structural measures for all landslide risk area by limited financial resources. In view of cost effectiveness, therefore, JICA's cooperation for landslide mitigation shall be mainly focusing on non-structural measures such as hazard map and early warning. For the structural measures the

priory shall be given to important infrastructure, transportation networks, as Proposal 2.

Proposal 2: Strengthening Important Infrastructures

Road Development Authority (RDA) is implementing the project "Landslide Disaster Prevention Project (LDPP)". However, there still are many high-risk unstable slopes and road sections out of LDPP target sites along Class-A and Class-B national roads. Support to prioritize unstable sites in transportation and important public facilities (schools, hospitals) in the country can be considered to facilitate further investment to realize strong traffic network

(4) Drought Risk Reduction

Proposal 1: Formulation of National Strategy on Drought Risk Reduction

It is urgently required that National Strategy on Drought Risk Reduction be formulated integrating all kinds of drought risks. Prior to commencement of strategy planning, a drought risk assessment recommends detailed analysis and evaluation on the past, present and future possible drought impact on the scientific basis. Based on the risk assessment, target areas and sectors for drought risk reduction programmes are prioritized, and each programmes shall be strategically implemented in consistency with Roadmap for DRR.

Proposal 2: Water Securing Programme at Drought Affected Areas

Small scale communities without piped water supply facilities are depended on drinking and domestic water from dug wells. However, the obtainment of drinking water becomes gradually worse. The people live in the small communities vulnerable to drought should understand that there are few water sources. It is recommended that "Water Securing Programme at Drought Affected Area" be formulated aiming at forming "Drought Resilient Society" even in serious drought under the initiatives of central and local Governments.

Proposal 3: Establishment of Drinking Water Supply System and Proper Distribution Plan

In the case that drought is lasting for long time, scarcity of drinking water supply becomes a major problem. Considering water sources available in the drinking water scarcity areas, finally, it can be clarified that the stable water resource is deep groundwater existing in the fissure zone of the bed rock formation. Support to construct a new drinking water supply network for emergency purpose by appropriately combining rehabilitation of existing tube wells and development of new deep tube wells should be considered.

(5) Hydro-Meteorological Observation and Information Dissemination

Proposal 1: Modernization of Meteorological Observation Network and Regime Shift

The automated observation network is necessary for meteorological services for disaster risk reduction because real-time observation and short-term forecasting are important for disaster response. As a part of modernization of the meteorological observation network, JICA would support to install AWS / Doppler Radars with related technical transfer

Proposal 2: Improvement of forecast/warning capacities and information dissemination

Improvement of forecast and introducing Precipitation Nowcast by using meteorological data of AWS, Radar and others, quantification of weather forecasting by introducing mesoscale NWP model and using guidance, revision of warning criteria and improvement of long-term forecast are the major needs for technical supports. Technical transfer and human resource development for utilization of installed AWS/Radar are expected to be supported by JICA.

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ABBREVIATION

Abbr.	Full Name of English
ADB	Asian Development Bank
AMCDRR	Asia Ministerial Conference on Disaster Risk Reduction
AWS	Auto Weather System
CAT DDO	Catastrophe Deferred Drawdown Option Program
CBDRM	Community Based Disaster Risk Management
CBO	Community Based Organization
CEA	Central Environment Authority
CEB	Ceylon Electricity Board
CKD	Chronic Kidney Disease
CRIP	Climate Resilience Improvement Project
DDMCU	District Disaster Management Coordinating Unit
DDMP	District Disaster Management Plan
DRR	Disaster Risk Reduction
DIA	Disaster Impact Assessment
DMC	Disaster Management Center
DNCWS	Department of National Community Water Supply
DoM	Department of Meteorology
DSU	District Support Unit
DSWRPP	Dam Safety & Water Resources Planning Project
ECMWF	European Center for Medium range Weather Forecasting
EIA	Environmental Impact Assessment
ERC	Emergency Response Committee
ERD	Department of External Resources
EOC	Emergency Operation Centre
EU	European Union
FMC	Flood Monitoring Committee
GCM	Global Climate Model
GTS	Global Telecommunication System
HFA	Hyogo Framework for Action
HMIS	Hydro-Meteorological Information System
ICHARM	International Centre for Water Hazard and Risk Management
ID	Irrigation Department
IGN	Inter-Governmental Network
IFCS	International Federation of Red Cross Society
IFM	Integrated Flood Management
IMD	India Meteorological Department
ITI	Industrial Technology Institute
IWMI	International Water Management Institute
JMA	Japan Meteorological Agency
JICA	Japan International Cooperation Agency
LA	Local Authority
LRRMD	Landslide Research & Risk Management Division
MASL	Mahawei Authority of Sri Lanka
MCPWS	Ministry of City Planning and Water Supply
MCUDP	Metro Colombo Urban Development Project
MDM	Ministry of Disaster Management
MHEH	Ministry of Higher Education and Highway
MIWRM	Ministry of Irrigation & Water Resources Management

Abbr.	Full Name of English
MLLD	Ministry of Land and Land Development
MMDE	Ministry of Mahaweli Development and Environment
MMWD	Ministry of Megapolis & Western Development
MNPEA	Ministry of National Policies and Economic Affairs
MPRE	Ministry of Power and Renewable Energy
MUDWS	Ministry of Urban Development and Water Supply
NCAR	National Center for Atmospheric Research
NWCT	National Community Water Trust
NAP	National Action Plan
NBRI	National Building Research Institute
NBRO	National Building Research Organization
NCDM	National Council for Disaster Management
NCEP	National Centers for Environmental Prediction
NEOP	National Emergency Operation Plan
NDMP	National Disaster Management Plan
NDRSC	National Disaster Relief Service Center
NMC	National Meteorology Center
NPD	Department of National Planning
NITF	National Insurance Trust Fund
NWP	Numerical Weather Prediction
NWSDB	National Water Supply and Drainage Board
PDNA	Post Disaster Needs Assessment
RCM	Regional Climate Model
RDA	Road Development Authority
R.O.	Reverse Osmosis
RSC	Regional Support Centre
SDGs	Sustainable Development Goals
SLCDMP	Sri Lanka Comprehensive Disaster Management Program
SLLRDC	Sri Lanka Land Reclamation and Development Cooperation
SLRCS	Sri Lanka Read Cross Society
SLSD	Sri Lanka Survey Department
SOP	Standard Operation Procedure
SS2CDMP	Strategic Support to Comprehensive Disaster Management Program in Sri Lanka
TCLMP	Technical Cooperation for Landslide Mitigation Project
UDA	Urban Development Authority
UNDP	United Nations Development Programme
UN-Habitat	United Nations Human Settlements Programme
UNISDR	United Nations International Strategy for Disaster Reduction
WCDRR	World Conference for Disaster Risk Reduction
WB	World Bank
WFP	World Food Programme
WMO	Word Meteorological Organization
WRD	Water Resources Board

CHAPTER 1 OUTLINE OF SURVEY

1.1 Background

Sri Lanka is one of the disaster vulnerable countries that experience flood, landslide and drought because of climate change. After the tsunami attack by the Sumatra Earthquake in 2004, the government of Sri Lanka formulated the Disaster Management Act (2005) and established the Disaster Management Committee under the Ministry of Disaster Management (MDM) and Disaster Management Centre (DMC) to strengthen Disaster Risk Reduction (DRR) capacity of the country. However, because of financial limitations, most of the efforts tend to be on emergency responses rather than preparedness activities. Coordination between governmental agencies and technical capacities should be comprehensively improved to raise nationwide disaster awareness.

Mitigation of Vulnerabilities is one of the key disciplines in Japan's "Country Assistance Policy to Sri Lanka". Japan International Cooperation Agency (JICA) has implemented projects and conducted studies including the following, for about 10 years, based on the assistance policy. These projects were to support both structural and non-structural measures to apply more effective DRR structure and countermeasures in Sri Lanka.

- 2006-2009: Comprehensive Study on Disaster Management in Sri Lanka (Development Study)
- 2007-2009: Project for Improvement of Meteorological and Disaster Information Network (Grant Aid)
- 2010-2013: Disaster Management Capacity Enhancement Project Adaptable to Climate Change (Technical Cooperation)
- 2013-2017: Landslide Disaster Protection Project of the National Road Network (Loan)
- 2014-2018: Technical Cooperation for Landslide Mitigation Project (Technical Cooperation)
- 2014-2017: Project for Improving of Meteorological Observation, Weather Forecasting and Dissemination (Technical Cooperation)
- 2014-2016: Capacity Development Project for Creating Digital Elevation Model Enabling Disaster Resilience (Technical Cooperation)

Considering the Sendai Framework for Disaster Risk Reduction 2015-2030 adopted during the 3rd UN World Conference on DRR in March 2015, JICA will review all the project achievements to formulate mid- and long-term comprehensive support program for future DRR in Sri Lanka.

1.2 Purpose

The Data Collection Survey on Disaster Risk Reduction Sector in Sri Lanka (hereinafter referred to as "the Survey") aims to confirm the current situation and issues on the DRR sector in Sri Lanka as well as the achievements of the past projects by JICA and international donors. The Survey is intended to support the Sri Lankan government to formulate a medium and long-term roadmap to implement Sendai Frameworks 2015-2030. Besides, the roadmap shall serve as basic information for future support programs by JICA.

1.3 Implementation

1.3.1 Work Schedule

The Survey is implemented by JICA Consultants (hereinafter referred to as "the JICA Survey Team"). At the beginning, the work in Sri Lanka was planned from the middle of November 2016 to the middle of April 2017. Because additional survey on drought situation was requested by Sri Lanka side, the survey period was extended to July 2017 as shown in Figure1.3.1.

		2016			2017						
NAME	DISCIPLINE	11	12	1	2	3	4	5	6	7	8
Toru KOIKE	Team Leader / Comprehensive DM Plan / Forecasting & Early Warning										
Yukishi TOMIDA	Vice Team Leader / Comprehensive DM Plan										
Yasuhiko KATO	DM Administration & Institution / Recovery & Rehabilitation										
Arata SASAKI	Disaster Table-top Exercise										
Tomoyuki WADA	Hydrology and Meteorology										
Akira SASAKI	Sediment Disaster Prevention / Road Slope Management										
Tadanori KITAMURA	Comprehensive Flood Management Plan / Flood & Inland Water Control										
Yukishi TOMIDA	Drought Mitigation										
Hiroyoshi YAMADA	Groundwater Development / Local Water Supply										

WORK	11	12	1	2	3	4	5	6	7	8
(1) JAPAN										
【1-1】Analysis of Existing Data and Information										
【1-2】Preparation of Inception Report (IC/R)										
(2) SRI LANKA										
【2-1】Discussion on IC/R										
【2-2】Review of Present Status of DDR Sector										
【2-3】Review of Response to May 2016 Heavy Rainfall										
【2-4】The 1st Seminar										
(3) JAPAN										
【3-1】Preparation of Interim Report (IT/R)										
(4) SRI LANKA										
【4-1】Discussion on IT/R										
【4-2】Review of Issues on DRR Sector in Sri Lanka										
【4-3】Study on Applicability of Japanese Technology										
【4-4】2nd Seminar										
(5) JAPAN										
【5-1】Invitation of Sri Lankan Officials										
【5-2】Proposal of Future Assistance Policy by JICA										
【5-3】Preparation of Draft Final Report (DF/R)										
(6) SRI LANKA										
【6-1】Explanation and Discussion of DF/R										
(7) SRI LANKA										
【7-1】Data Collection and Analysis for Drought Mitigation										
(8) Japan										
【8-1】Preparation of Final Report (F/R)										
Report	▲ IC/R		▲ IT/R				▲ DF/R			▲ F/R

Work in Japan
Work in SL

Figure1.3.1 Dispatches and implementation plan of the survey

1.3.2 Relevant Agencies

The Survey has conducted interviews and studies in close communication with the following agencies:

Ministry of Disaster Management (MDM)

- Disaster Management Centre (DMC)
- National Disaster Relief Service Center (NDRSC)
- Department of Meteorology (DoM)
- National Building Research Organization (NBRO)

Ministry of Land and Parliament Reform (MLPR)

- Sri Lanka Survey Department (SLSD)

Ministry of Higher Education & Highways (MHEH)

- Road Development Authority (RDA)

Ministry of Irrigation & Water Resources Management (MIWRM)

- Irrigation Department (ID)
- Water Resources Board (WRB)

Ministry of Megapolis & Western Development (MMWD)

- Sri Lanka Land Reclamation and Development Corporation (SLLRDC)
- Urban Development Authority (UDA)

Ministry of City Planning and Water Supply (MCPWS)

- National Water Supply and Drainage Board (NWSDB)
- Department of National Community Water Supply (DNCWS)

Ministry of National Policies and Economic Affairs (MNPEA)

- Department of External Resources (ERD)
- Department of National Planning (NPD)

Other concerned agencies and personnel

CHAPTER 2 STATUS OF DRR SECTOR

2.1 Disaster Risk in Sri Lanka

2.1.1 Disaster Character in Sri Lanka

(1) Disasters in Recent Decade

Based on the records of disasters of the recent decade until October 2016 by DesInventar, a disaster database covering the period 1974 to the present in Sri Lanka (Figure2.1.1), the most frequent natural disaster[1] in Sri Lanka is flood (37%) followed by strong wind, landslide and cyclone.

The disaster causing most deaths and missing people is landslide (35%) followed by flood, lightning and strong wind.

In the percentage of houses damaged, flood accounts for approximately 50% of the total. The highest number of houses destroyed by cyclone resulted from 2008 flood in the eastern area. Therefore, actual percentage of flood is about 80% of total.

In percentage of affected, flood accounts for the highest percentage of affected followed by drought.

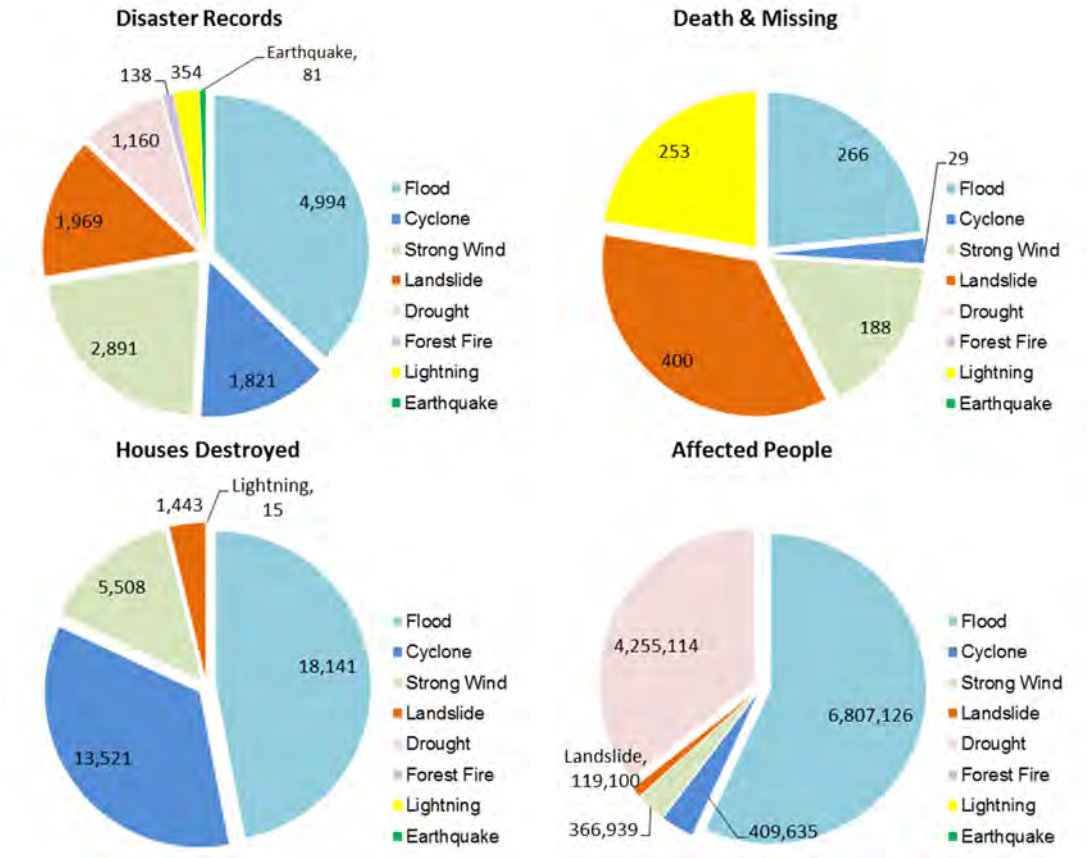


Figure2.1.1 Disaster record in recent decade in Sri Lanka
Source: Prepared by JICA Survey Team based on DesInventar

[1] Not including Epidemic and Animal Attack

(2) Climate Condition in Sri Lanka

1) Topography and Climate

Sri Lanka, south-asian island country is located in the Indian Ocean. Land area of Sri Lanka is ca. 65,000 km^2 which is 0.8 times as large as Hokkaido Island, Japan. The central area of the island is occupied by 2,000m class mountainous area, and the surrounding areas are 1,000m class high land. The coastal regions are mainly plains. Especially, large plains are located in the northern and eastern regions of Sri Lanka.

Figure2.1.2 shows the distribution of mean annual rainfall in Sri Lanka and monthly rainfall in the representative points. The annual rainfall in the south-western region is relatively high because of the influence of south-west monsoon. Over 6,000 mm/year rainfall is observed in the mountainous area of the south-western region. The annual rainfall in most parts of the mountainous area of the eastern region exceeds 1,500 mm/year. On the other hand, the annual rainfall in parts of the northern and southern region is lower than 1,000 mm/year. Particularly, large areas of low rainfall are located in the northern plain area.[2]. The pattern of seasonal rainfall in Sri Lanka is mainly dominated by the topography mentioned above and monsoon. The seasonal rainfall pattern is divided into four patterns[3].

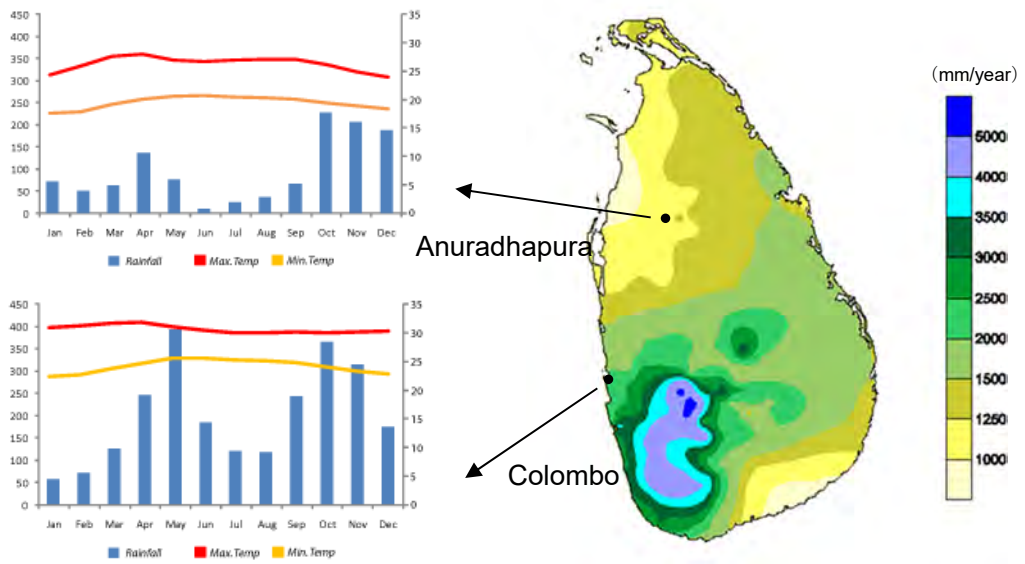


Figure2.1.2 Mean annual rainfall distribution and rainfall pattern
Source: modified after DoM HP

[2] Department of Meteorology, Government of Sri Lanka, HP
[3] Project for Improving of Meteorological Observation, Weather Forecasting and Dissemination, JICA brief note

2) Seasonal rainfall pattern

Below is the outline of seasonal rainfall pattern in Sri Lanka (Figure2.1.3).

1st inter-monsoon period (March, April)

Sea breeze is dominant, and thunderclouds are mainly generated in the afternoon and night time. The mostly seasonal rainfall in the south-western region is higher than 250mm. In the mountainous area of the south-western region, over 700mm seasonal rainfall is observed. On the other hand, the seasonal rainfall in the other region ranges from 100mm to 250mm. Notably, the seasonal rainfall at Jaffna located in the northern region is lower than 100mm.

South-west monsoon period (May-September)

Wet south-west monsoon dominates in this period. Thus, the seasonal rainfall in the mountainous area of the south-western region exceeds 3,000mm because of topographical effect. In addition, the seasonal rainfall in the south-western coastal region is more than 1,000mm. However, the northern and eastern regions located in the opposite side of the mountainous area are relatively dry. The seasonal rainfall in these regions is generally lower than 300mm.

2nd inter-monsoon period (October, November)

Convective precipitation is dominant in this period. Thunderclouds are mainly generated in the afternoon and night time. In addition, a tropical weather system (e.g. tropical depression and cyclone) in the Bay of Bengal occasionally affects the weather in Sri Lanka. In that case, wide and heavy rainfall with strong wind may occur. The seasonal rainfall exceeds 400mm all over the country. Especially, high rainfall is observed in the south-western region.

North-east monsoon period (December-February)

Heavy rainfall in the northern and eastern region is caused by north-east monsoon from the Bay of Bengal and tropical disturbance. The seasonal rainfall in the plain area is 300mm and more. In the mountainous area, the seasonal rainfall exceeds 700mm. On the other hand, the seasonal rainfall in the western and southern area is relatively low.

3) Cyclone

Most of the records on cyclone which landed or approached Sri Lanka show that cyclones occur in the 2nd inter-monsoon period and north-east monsoon period (Figure2.1.4). The cyclones generally move north along the eastern coast area. Therefore, it can be concluded that the risk of cyclone in the eastern and northern region is relatively high. In some cases, heavy rainfall in the south-western region is caused by wet atmosphere which moves through mountainous area toward cyclone on the Bay of Bengal.

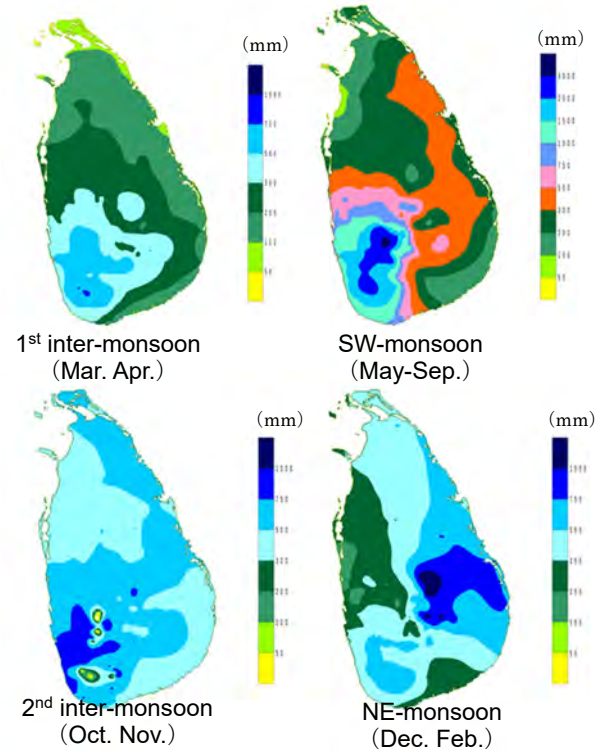


Figure2.1.3 Seasonal rainfall distribution
Source: DoM HP

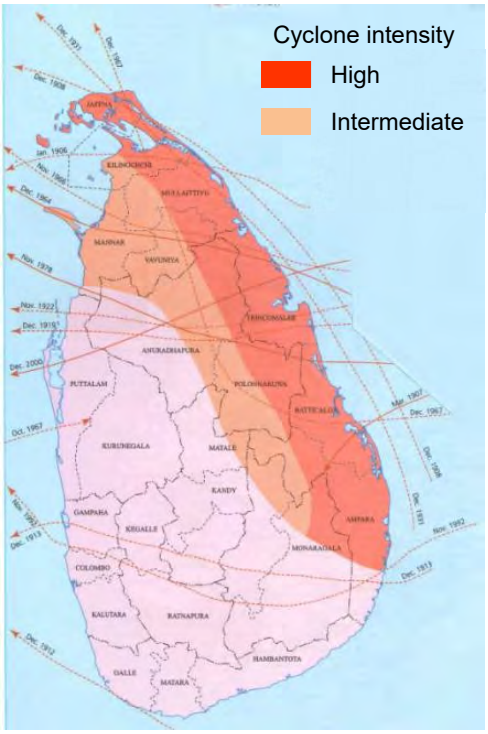


Figure2.1.4 Records of cyclone route
Source: Student ATLAS, OXFORD

(3) Record of disasters and mechanism of disaster occurrence

1) Past disaster record

The monthly total number of people affected by flood+cyclone, drought and sediment disaster is shown in Figure2.1.5 (summarized from DesInventar, period: 1974-present).

Correlating the occurrences of disasters with rainfall pattern, the highest number of people affected by flood and cyclone was recorded in the 2nd monsoon period and north-east monsoon period (November-January). It seems that north-east monsoon and tropical depression/cyclone contributed to the high occurrence of floods. In addition, many floods also occurred in the south-west monsoon period (May-June).

The trend of sediment disaster occurrence is also similar to flood, highlighting the severe sediment disaster occurrence in May. The seasonal rainfall in this period in the mountainous area caused by south-west monsoon is highest in a year. As a result, de-stabilization of soil in mountainous slopes occurs and may cause frequent sediment disasters.

Occurrence of droughts in August, the end of south-west monsoon period, is significant. The seasonal rainfall in this period in the northern and eastern region is the lowest in a year. Thus, there are many water shortage records before the rainfall increases again in October (2nd inter-monsoon period). The main water resource in the northern and eastern dry area is rainfall in the north-east monsoon period. If the rainfall in the north-east monsoon period is low, irrigation systems may face severe problem.

Figure2.1.6 shows distribution of affected people of flood + cyclone, sediment disaster and drought.

Flood affected people was mainly distributed in plain area near the coast. From the DesInventar, the numbers of affected people in the south-western region, which is a high rainfall area, and the northern and eastern region, which is in the pathway of tropical depressions / cyclones, are large. On the other hand, sediment disaster occurrences are concentrated in the central area which is a high rainfall mountainous area. The people affected by drought are distributed all over the country except in the south-west region. Attention is called on the large numbers of affected people in the north-western and eastern region, which experience low rainfall in the south-west monsoon period and the southern region, which experiences low rainfall throughout the year.

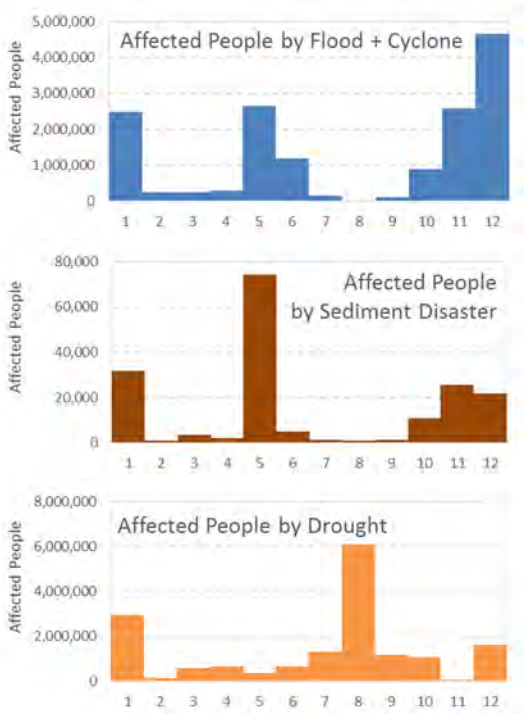


Figure2.1.5 Total number of monthly affected people

Source: Summarized from DesInventar, Period: 1974-present

In parts of the northern and eastern region, the numbers of people affected by both flood and drought are large. These regions face some problems of heavy rainfall in the rainy season and less rainfall in the dry season.

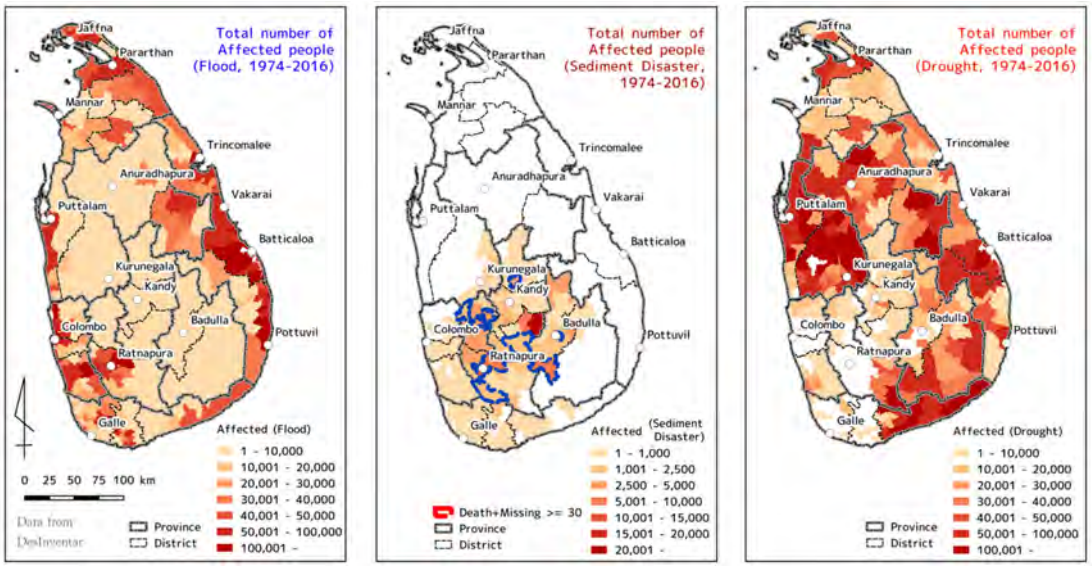


Figure2.1.6. Distribution of people affected by disaster.
(left: flood+cyclone, middle: sediment disaster, right: drought)
Source: summarized from DesInventar, period: 1974-present

Total numbers of people affected by flood, sediment disaster and drought in each district are shown in Figure2.1.7.

The numbers of people affected by floods in the eastern districts (Ampara and Batticaloa) and the south-western districts (Colombo, Gampaha and Ratnapura) are ca. 39% and 22% of the total, respectively. Large plains are located in these areas, which are affected by monsoon. Most of the people affected by sediment disaster (93% of the total) are in the central and south-west districts (Badulla, Kegalle, Nuwara Eliya and Ratnapura) located in the steep mountainous areas that experience high rainfall. The numbers of people affected by drought in the dry north-western districts (Kurunegala, Puttalam, Anuradhapura and Kandy) and the southern district (Hambantota) are 54% and 12% of the total, respectively.

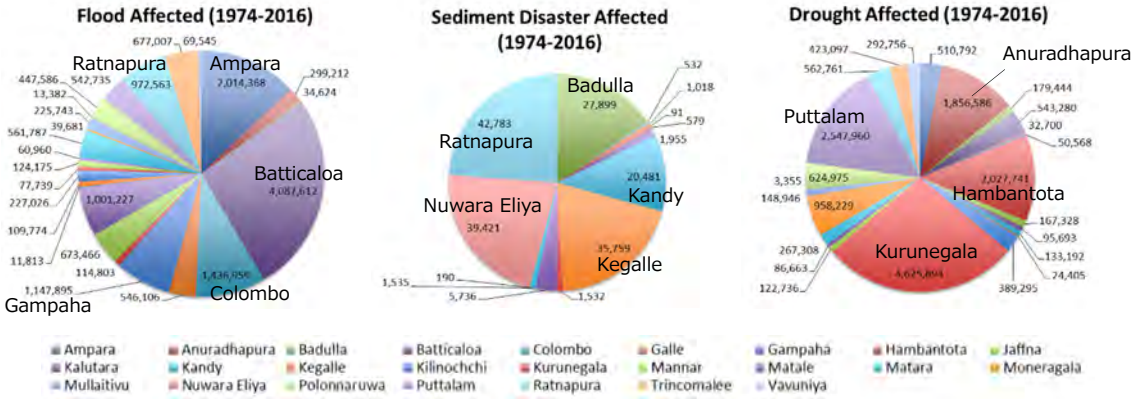
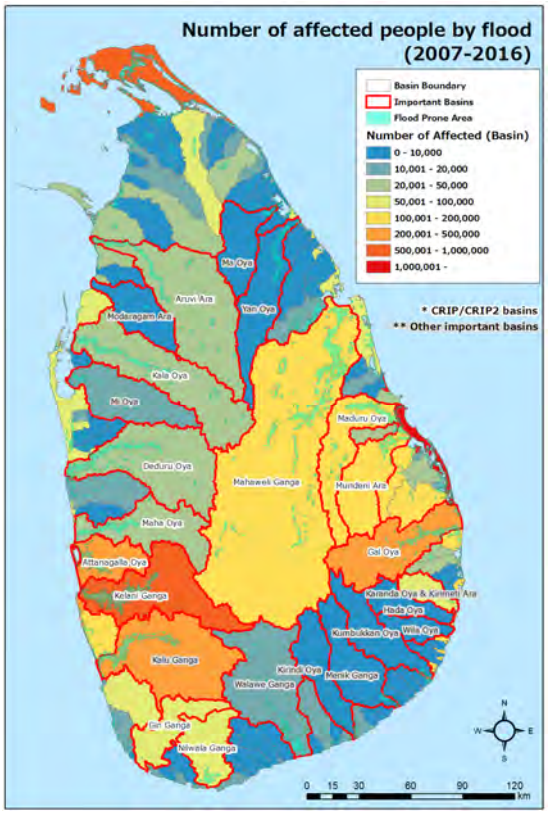


Figure2.1.7 Past total people affected by disasters in each district
(left: flood+cyclone, middle: sediment disaster, right: drought)
Source: summarized from DesInventar, period: 1974-present

Estimated total numbers of affected people, death/missing and destroyed or damaged houses by floods in main river basins in the past one decade (1997-2016) are shown in Figure2.1.8. It shows large flood damages in coastal areas near lagoons (e.g. Batticaloa and Jaffna). Especially, the flood damage in the Batticaloa Coastal Area is large because the major lagoon near Batticaloa is located downstream of some major rivers. Kelani and Kalu river basins where large floods often occurred are also important basin for flood protection. Because, those basins are located in high rainfall (south-western) area and big cities are located in the basins.



- Affected People

Rank	Basin Name	Affected
1	Batticaloa Coastal	1,476,587
2	Kelani Ganga	968,773
3	Jaffna Area	567,449
4	Kalu Ganga	450,259
5	Attanagalu Oya	339,398
6	Gal Oya	336,357
7	Colombo Coastal	231,383
8	Bolgoda Lake Basin	195,947
9	Mahaweli Ganga	166,071
10	Pottuvil Coastal	161,204

- Death & Missing

Rank	Basin Name	Death & Missing
1	Kalu Ganga	46
2	Jaffna Area	32
3	Mahaveli Ganga	24
4	Batticaloa Coastal	20
4	Kelani Ganga	20

- House Destroy & Damaged

Rank	Basin Name	Destroy&Damaged
1	Jaffna Area	65,680
2	Batticaloa Coastal	17,418
3	Mahaveli Ganga	5,812
4	Kanagarayan Aru	5,269
5	Kalu Ganga	4,738

Figure2.1.8 Estimated total numbers of affected people, death/missing and destroyed or damaged houses by floods in main river basins in the past one decade (1997-2016)
(calculated from DesInventar, LandScan population data)

2) Typical heavy rainfall records

In order to understand the basic disaster risk in Sri Lanka, damages of the past typical disasters triggered by rainfall, which occurred in the northern, western, eastern and south-western region, were studied. The information is shown in Table 2.1.1.

Table 2.1.1 Past typical rainfall disasters

Period	Main Area	Flood			Sediment Disaster		
		Affected	Death & Missing	House Destroy	Affected	Death & Missing	House Destroy
2003 May	South-western	468,040	138	6,771	19,919	231	846
2008 Nov	Northern	427,524	12	13,910	92	0	1
2014 Dec	Eastern, Northern	1,021,310	10	4,461	10,574	21	2
2016 May	Western, Northern	421,479	26	340	40,749	191	272

Five-day rainfall of the four typical disasters is shown in Figure2.1.9. Figure2.1.10 shows distribution of people affected by the past typical flood and sediment disasters.

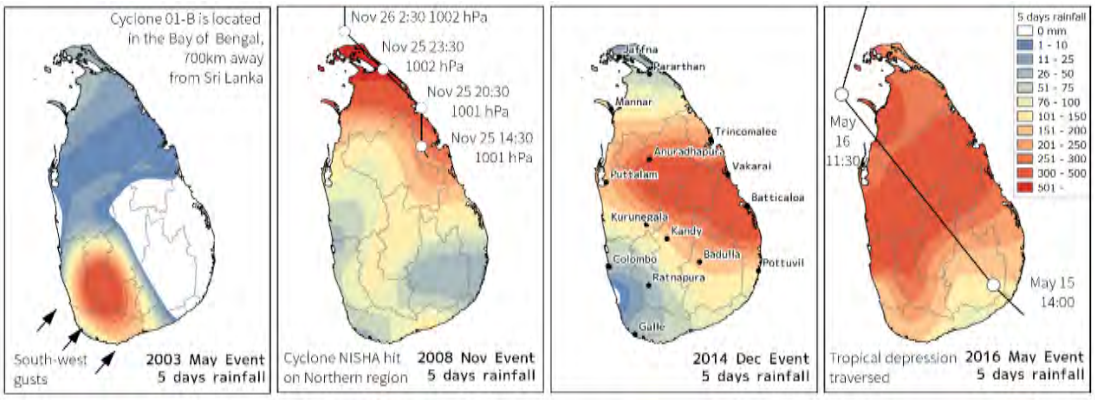


Figure2.1.9 Five-day rainfall of past typical heavy rainfall and pathway of tropical depression/cyclone

Source: observed rainfall provided by DoM and pathway data provided by IMD

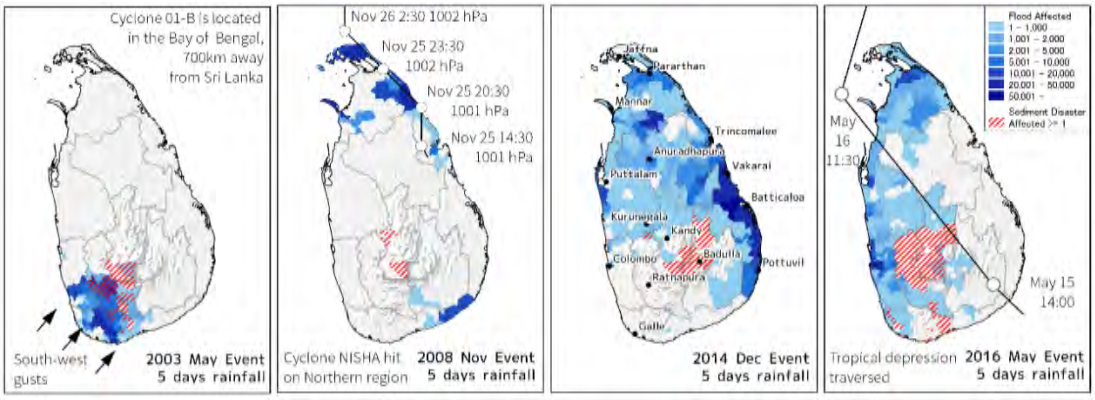


Figure2.1.10 Distribution of people affected by past typical disasters

Blue: Flood, Red hatched line: Sediment disaster, summarized from DesInventar

Heavy rainfall in May 2003[4]

Cyclone 01-B stayed in the Bay of Bengal, 700km north-east of Sri Lanka, from the 11th to the 17th of May 2003. Cyclone 01-B didn't make landfall on Sri Lanka, but the Cyclone generated wet atmosphere flux to the Cyclone. As a result, the wet atmosphere originated from south-west of Sri Lanka hit the mountainous area and caused heavy rainfall and huge disasters in the south-western mountainous area. Observed three-day and daily rainfall at Ratnapura located in the south-western mountainous area reached 446mm/3days and 345mm/day which corresponds to ca. 40 years return period probable rainfall (Figure2.1.11).

The flood caused ca. 0.5 million affected people and 138 deaths and missing people. In addition, sediment disasters in the mountainous area caused 231 deaths and missing people.

[4] Zubair, L., May 2003 Disaster in Sri Lanka and Cyclone 01-B in the Bay of Bengal, *Natural Hazards* **33**: 303–318, 2004

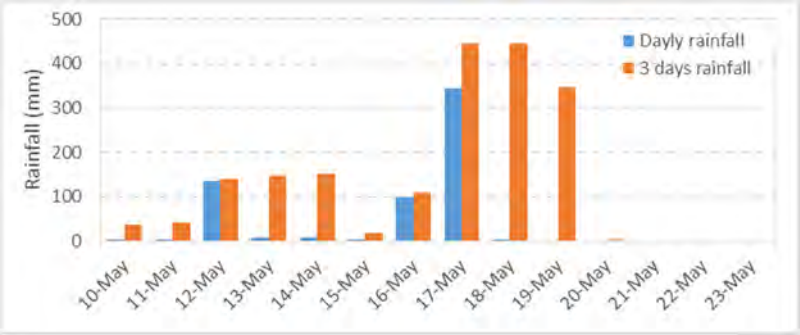


Figure2.1.11 Observed rainfall at Ratnapura during disaster in May 2003
Source; observed data provided by DoM

Heavy rainfall in November 2008

Cyclone NISHA made landfall in the northern region of Sri Lanka accompanied by heavy rain and strong wind. Observed daily rainfall at Jaffna located in the northern region reached 390mm/day which is greater than 50 years return period probable rainfall. The cyclone affected over 0.4 million people and caused huge house damage due to strong wind and flood. However, there was no significant sediment disaster because the main area of heavy rainfall was in the northern plain area.

Heavy rainfall in December 2014

The center of heavy rainfall in December 2014 was the eastern and northern region of Sri Lanka. The heavy rainfall caused floods. Over one million people were affected by the floods. In addition, over 200mm rainfall was observed in the eastern mountainous area where sediment disasters occurred. The sediment disaster caused 21 deaths and missing people. Based on the observed rainfall records at Bandarawela located in the central mountainous area, the rainfall continued for more than one week (Figure2.1.12). The maximum three-day rainfall during the disaster exceeded 200mm/3days.

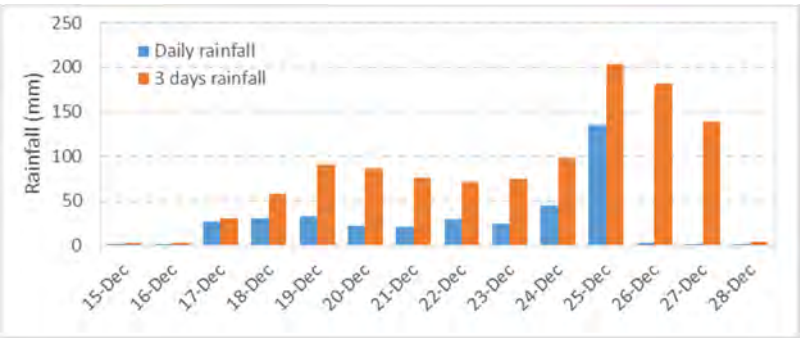


Figure2.1.12 Observed rainfall at Bandarawela during disaster in December 2014
Source; observed data provided by DoM

Heavy rainfall in May 2016

Outline of the disaster in May 2016 is described below. The detail of the disaster is mentioned in CHAPTER 3.

A tropical depression produced over 300mm rainfall widely in the northern and western region from the 15th to the 16th of May 2016. Huge disasters occurred in Sri Lanka. Especially, large floods occurred in the northern and western plain area. About 0.4 million people were

affected by the floods. In addition, severe sediment disasters occurred in the mountainous western region resulting to191 deaths and missing people.

2.1.2 Main Target Disaster

(1) Changes in Population and Damages

Increasing exposure to natural disasters caused by recent population growth and development is a big concern. To clarify the relation between population growth and disaster occurrences, population growth rate between 2001 and 2012 and disaster increasing rate between 1998-2004 and 2009-2015 were compared in Table 2.2.1.

The comparison shows that the increase in rate of people affected by sediment disaster is similar to the population growth rate. The increased rate of people affected by flood is much larger than the population growth rate. It suggests that the flood risk has increased in Sri Lanka recently. There is a possibility of flood risk increasing through rapid population growth and development in flood vulnerable area, especially in urban area. On the other hand, the number of people affected by drought decreased. It is considered that irrigation facility construction, e.g. reservoirs and canals, is effective.

Missing disaster records during the civil war and bias of meteorological factor cause uncertainties on the result, but it can be said that the impact of drought has been decreasing and that of flood and sediment disaster have been increasing against population growth.

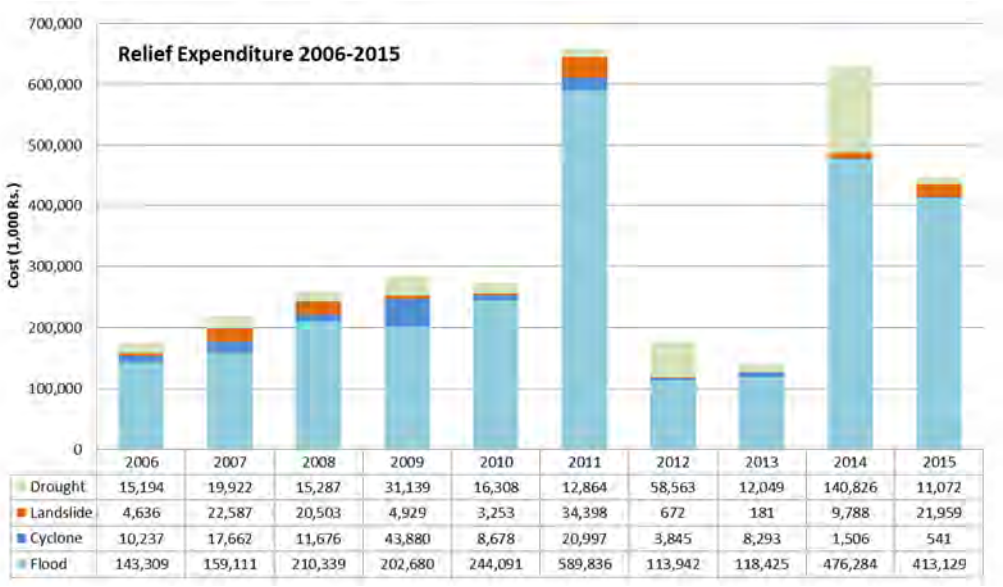
Table 2.1.2 Temporal variation of population and affected people by disasters

		1998-2004	2009-2015	Increase Rate
Population		18,797,257 (2001)	20,359,439 (2012)	8.3%
Total Number of Affected	Flood	3,030,348	4,370,001	44.2%
	Sediment Disaster	29,181	31,633	8.4%
	Drought	6,267,968	3,040,677	-51.5%
Affected Rate (Affected / Pop)	Flood	16.1%	21.5%	33.1%
	Sediment Disaster	0.2%	0.2%	0.1%
	Drought	33.3%	14.9%	-55.2%

(2) Relief Costs for Each Disaster Type

In Sri Lanka, the annual statistical data on disaster damage and rehabilitation costs are not available. However, relief cost and housing recovery cost are available from a database managed by National Disaster Relief Service Center (NDRSC). The trend of relief cost for each disaster type is shown in Figure2.1.13.

In any year, the relief cost for flood disaster accounts for approximately 80% to 90% of the annual expenditure. The Sri Lanka Comprehensive Disaster Management Programme (SLCDMP) 2014-2018 indicates that the same disaster victims who live in disaster prone area are repeatedly provided with compensation. The program also suggests the importance of relocation of people, awareness building, and legal system development by enhancement of risk governance.



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Drought	15,194	19,922	15,287	31,139	16,308	12,864	58,563	12,049	140,826	11,072
Landslide	4,636	22,587	20,503	4,929	3,253	34,398	672	181	9,788	21,959
Cyclone	10,237	17,662	11,676	43,880	8,678	20,997	3,845	8,293	1,506	541
Flood	143,309	159,111	210,339	202,680	244,091	589,836	113,942	118,425	476,284	413,129

Figure2.1.13 Trends of disaster relief costs in each disaster from 2006 to 2015
Source: Prepared by JICA Study Team based on a Database of NDRSC

(3) Priority Disaster Types in DRR Policy

The SLCDMP proposed forty-three (43) programme outputs. The disaster types targeted by each programme are indicated in Table 2.1.3. The SLCDMP prioritized flood, cyclone, landslide, strong wind and drought, in order of priority, based on the total number of programmes and activities for these disasters. It means that the government of Sri Lanka seems to consider these disaster types as investment priority.

Table 2.1.3 Proposed programmes in SLCDMP 2014-2018

Item	Programme Outputs	Flood	Cyclone	Strong Wind	Landslide	Drought	Forest Fire	Lightning	Earthquake
Outcome 1: National and sub-national level agencies are capable of assessing disaster risk and making decisions for short, medium and long-term disaster management									
1.1.A	Timely issuance of seasonal climate forecast on drought is streamlined					X	X		
1.1.B	Weather prediction capacity of DoM is enhanced	X	X	X	X	X		X	
1.1.C	Climate change scenarios for Sri Lanka 2050 and 2100 developed	X	X	X	X	X	X	X	
1.2	Timely issuance of flood early waning is streamlined	X	X						
1.3	National & community level landslide early warning systems are in place				X				
1.4	Mechanism to disseminate early warning messages are enhanced	X	X	X	X			X	X
1.5	Disaster Risk Profile are available at national level	X	X		X	X			X
1.6	Detailed risk profiles are available for high risk major urban centers	X	X		X				
1.7	Organizational capacities for management and operation of reservoirs	X				X			
1.8	Flood ordinance amended to streamline	X							
1.9	Information management and analytical capacities improved	X	X	X	X	X	X	X	X
1.10	Research and Development in DRR and CCA supported	X	X	X	X	X	X	X	X
	Sub Total	11	8	5	7	7	4	5	4

Item	Programme Outputs	Flood	Cyclone	Strong Wind	Landslide	Drought	Forest Fire	Lightning	Earthquake
Outcome 2: Key development sectors are able to incorporate Disaster Risk Management (DRM) in their respective development initiatives / processes / activities at different administrative levels.									
2.1	Legal framework improved to mainstream DRR in Local Government	X	X	X	X	X	X	X	X
2.2	Legal provisions and community capacity for GN level development plan	X	X	X	X	X	X	X	X
2.3	Legal provisions and procedure to train cadres are available	X	X	X	X	X	X	X	X
2.4	DRR concepts are mainstreamed into education sectors	X	X	X	X	X	X	X	X
2.5	Private sector disaster resilience in hazard prone areas improved	X	X	X	X	X			X
2.6	The potential impacts of flood reduced in flood prone districts	X							
2.7	Safety of small village level tanks and bunds improved	X							
2.8	Flood impact in selected urban local authorities mitigated	X							
2.9	Ensure village development programmes are resilient to multi-disasters	X	X	X	X	X	X		X
2.10	Slopes stabilized in identified high risk landslide and rock fall sites				X				
2.11	Drought risk reduction strategies developed					X			
2.12	Coastal risk reduction strategies developed		X						
2.13	Disaster resilience incorporated in the National Physical Plan and Policy	X	X	X	X	X	X	X	X
2.14	Safeguarding water resources from source pollution								
2.15	Potential impacts of lives due to human-elephant conflict reduced								
2.16	Procedure and guidelines in National Housing Policy for reducing hazard	X	X	X	X				X
2.17	Strategic Environment Assessment integrating disaster risk reduction	X	X	X	X	X	X	X	X
	Sub Total	12	10	9	10	9	7	6	9
Outcome 3: Communities, local governments and sub-national agencies have necessary capacities and mechanism to respond to and recover from disasters.									
3.1	DM Plans for national and sub-national level developed and in operation	X	X	X	X	X	X	X	X
3.2	Awareness of communities on DRR is improved	X	X	X	X	X	X	X	X
3.3.A	Human resource capacity for DRM is enhanced	X	X	X	X	X	X	X	X
3.3.B	Child and women centered DRM programmes in practice	X	X	X	X	X	X	X	X
3.4	Programmes for sustainable housing in flood prone area are available	X							
3.5	Damage, loss and needs assessment to guide post disaster recovery	X	X	X	X	X	X		X
3.6	Capacity of communities and organizations to respond to cyclone hazard		X						
3.7	Capacity of institutions and personnel for post disaster relief enhanced	X	X	X	X	X	X		X
3.8	Capacity for institutions and personnel for disaster response enhanced	X	X	X	X				X
3.9	Community awareness on pre-hospital care and patient transportation	X	X	X	X			X	X
3.10	Regulations and guidelines to empower District and Divisional Secretary	X	X	X	X	X	X	X	X
	Sub Total	10	10	9	9	7	7	6	9
Outcome 4: A system in place for obtaining advice and continuous monitoring, learning and adapting to facilitate the ongoing planning and implementation processes									
4.1	Comprehensive monitoring and evaluation system in place	X	X	X	X	X	X	X	X
4.2	Technical Advisory Committees are in operation	X	X	X	X	X	X	X	X
4.3	Effective knowledge management and integration in to global convention	X	X	X	X	X	X	X	X
	Sub Total	3	3	3	3	3	3	3	3
	Total Number of Items	36	31	26	29	26	21	20	25

Source: JICA Survey Team summarized based on SLCDMP 2014-2018

(4) Main Target Disaster and Survey Principle

According to the above-mentioned disaster characteristics, the disaster situation, damages and political priorities in Sri Lanka are summarized as follows:

- Flood is the most frequent disaster type in Sri Lanka. Landslide causes most deaths and missing people. Flood and cyclone are major disaster types that cause most houses damaged, whereas drought also accounts for high percentage of affected people following the flood.
- Affected people by flood and landslide seem to be increasing in response to population growth between 1998-2004 and 2009-2015. Especially, increasing rate of flood occurrence is very high. On the other hand, the affected people by drought seem to be decreasing.
- Regarding relief cost, flood accounts for more than 80% of the annual relief expenditure.
- The disaster types targeted by each programme in the SLCDMP are flood, cyclone, landslide, strong wind and drought in descending order. These disaster types are regarded as priority.

The Survey considers major disaster types in Sri Lanka such as flood, sediment disaster and drought for the formulation of roadmap for implementing Sendai Framework, and to confirm present situation and issues in order to propose future countermeasures.

2.2 Analysis on Current Disaster Risk Reduction

2.2.1 Legal System and Institutional Structure

(1) DRR Legal System

1) Disaster Management Act

Current Act

The massive tsunami triggered by the earthquake off Sumatra in December 2004 inflicting enormous damage on Sri Lanka highlighted the importance of disaster management activities. In 2004, there were several agencies responsible for DRR in each sector, however, there was no DRR legal framework and no overall DRR coordinating structure.

After the massive tsunami off Sumatra, Sri Lankan Government emphasized the need for a policy to strengthen national DRR systems and enacted Sri Lanka Disaster Management Act, No.13 of 2005 stipulating the comprehensive DRR framework. The Act aims to establish DRR organizational structure and to shift away from emergency response toward preparedness.

Per the Disaster Management Act, National Council for Disaster Management (NCDM) as a supreme decision-making body on DRR and Disaster Management Centre (DMC) as an implementing agency on DRR measures were established in 2005. Based on the Disaster Management Act, the National Disaster Management Plan (NDMP) was formulated in 2013 and National Emergency Operation Plan (NEOP) is under formulation as of December 2016.

Status of Amendment of the Act

The current Disaster Management Act will be amended in the near future. The amendment work is now on-going. The important points of the amendment are 1) to resolve the disagreement between the Ministry of Disaster Management (MDM) and four agencies under the umbrella of MDM and 2) to shift many authorities from NCDM to MDM. The amendment is politically touchy issue accompanied by transition of power and, accordingly, it is unclear when the amendment will be enacted.

The background of the amendment is that the positioning of NCDM has become unclear contrary to the initial spirit of the Act, since MDM was established in 2006 separately from the Act. The Minister of MDM has the authority for DRR issues, and currently, DRR policies are decided by the Cabinet through the Minister.

The four agencies under the umbrella of MDM are DMC, National Disaster Relief Services Centre (NDRSC), Department of Meteorology (DoM) and National Building Research Organization (NBRO). The outline of each agency is described in Section 2.2.2.

2) Related Laws

Other DRR related laws are NBRI Act (work on creation of the Act is on-going) (refer to Section 0 in detail), Flood Act (amendment of present Flood Ordinance of 1955) is on-going, (refer to Section 2.2.2(6) in detail) and Sri Lanka Land Reclamation and Development Corporation (SLLRDC) Act (amendment of current SLLRDC Act of 2006 is on-going) (refer to Section 2.2.2(7) in detail).

(2) DRR Policies and Plans

1) National Policy on Disaster Management

National Policy on Disaster Management was established in 2010 with the approval of NCDM. The Policy describes the principles in implementing Disaster Management Act such as multi-dimensional response, collective responsibility, equality, diversity and inclusion, transparency and accountability and best fit of best practice.

2) Draft National Action Plan

The MDM drafted the National Action Plan (NAP) 2016-2018 with the cooperation of UNISDR as a priority action plan in implementing Sendai Framework based on the Regional Action Plan (RAP) adopted at the Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR) in November 2016.

3) National Disaster Management Plan (NDMP) 2013-2017

The National Disaster Management Plan (NDMP) 2013-2017 was formulated in 2013 with the cooperation of UNDP and with the approval of NCDM as a legal document based on the Disaster Management Act. NDMP stipulates the formulation of the disaster management plans in each administrative level and each sector and the establishment of various committees. NDMP 2018-2022 will be formulated in line with the-above mentioned Draft NAP 2016-2018 based on Sendai Framework.

4) National Emergency Operation Plan (NEOP) 2015-2019

The National Emergency Operational Plan (NEOP) 2015 – 2019 is under formulation by DMC with the cooperation of UNDP as a legal document based on the Disaster Management Act. NEOP stipulates the role of agencies in-charge and the coordination mechanism of emergency response before, during and post disaster phases. NEOP is at the final draft stage in December 2016 and DMC has published the draft on the Web (http://neopsrilanka.wixsite.com/neop).

5) Sri Lanka Comprehensive Disaster Management Plan (SLCDMP) 2014-2018

The MDM has formulated the Sri Lanka Comprehensive Disaster Management Program (SLCDMP) 2014-2018 with the cooperation of UNDP. SLCDMP is the action plan of the above mentioned NDMP dealing with the issues and solutions in implementing NDMP, the agencies in charge, the budget required, the period of implementation and the evaluation indicator.

The MDM has been directly implementing the coordination and monitoring of SLCDMP through the Project Management Unit (PMU) supported by UNDP. DMC is hardly involved in SLCDMP. The detail of SLCDMP is described in Section 2.3.1.

SLCDMP will be revised in line with the revision of NDMP. According to MDM, the new NDMP will be composed of 2 sections of Strategic Section and Implementation Section. SLCDMP will be a part of the Implementation Section.

6) Disaster Management Plan in Each Administrative Level and Sector

The NDMP 2013-2017 directs each administrative level and sector to prepare disaster management plans as shown in Figure2.2.1. A common planning guideline for disaster management plans is an attachment of the NDMP.

In National Administrative Line (refer to Section (4)), 25 District Disaster Management Plan (DDMP) and approximately 200 (around 50 %) DS Division plans and GN Division plans in high risk areas were formulated. DDMP will be revised in line with the revision of NDMP considering Sendai Framework.

On the other hand, in Local Administrative Line (refer to Section (4)), no plans have been formulated in all the Provinces and Local Authorities (LA) (City, Town and Village). National Policy on Local Government established in 2009 describing the capacity enhancement of LA clearly stipulates the formulation and implementation of LA level Disaster Management Plans. However, the Policy is not fully implemented.

Almost no plans have been formulated by each ministry, semi-government organizations and private sectors.

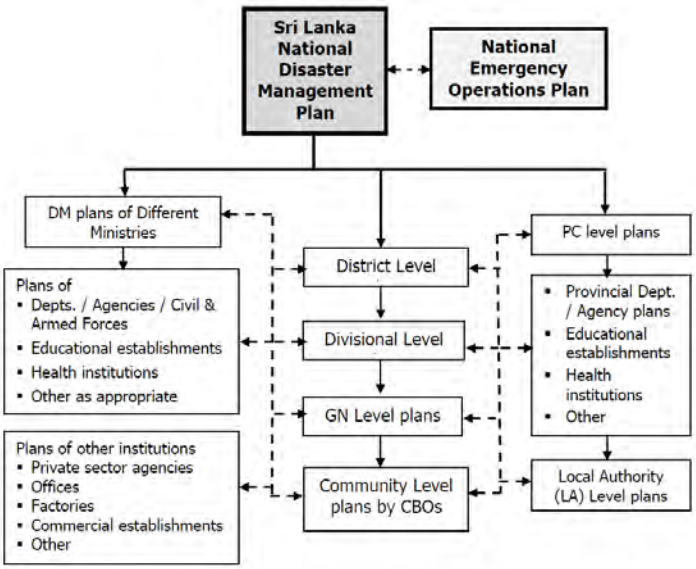


Figure2.2.1 Disaster management plan in each administrative level and sector
Source: National Disaster Management Plan (NDMP)

(3) DRR Coordinating Mechanism for Relevant Agencies

Existing coordinating mechanism of relevant agencies is described in this section. Non-existent mechanism proposed by NDMP or SLCDMP is outside the Survey objectives.

1) National Council for Disaster Management (NCDM)

The National Council for Disaster Management (NCDM) as the national highest decision-making body was created in June 2005 pursuant to the Disaster Management Act. The members include the President (chairperson), Prime Minister (vice chairperson), opposition leaders, Chief Ministers of Provinces, five opposition party members and the Ministers of relevant ministries (refer to Figure2.2.2).

Disaster Management Act stipulates the holding of NCDM quarterly meetings. However, no NCDM meeting has been held since May 11, 2012. It seems that the meaning of existence of NCDM became unclear and different from what was originally envisioned. Since the MDM was established separately from Disaster Management Act, the Minister of MDM has actual authority

on DRR while DRR policies are decided by the Cabinet through the Minister.

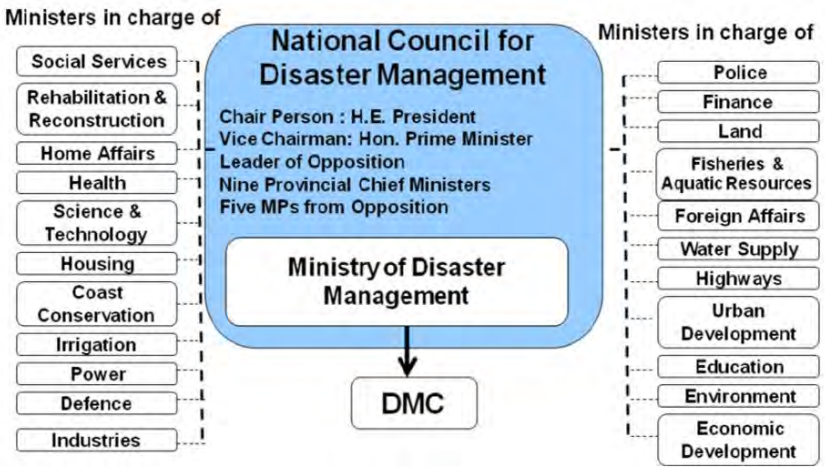


Figure2.2.2 Composition of NCDM
Source: DMC Annual Report 2014

2) Disaster Management Task Force

Instead of the NCDM, the Disaster Management Task Force as more practical platform for quick response was established after the disaster caused by torrential rainfall in May 2016. The members include the President (chairperson) and the representatives from stakeholder government agencies. The Task Force is to be held when disaster happens on temporary basis with no legal basis. The Task Force was held to discuss how to deal with the disaster in May 2016. The Task Force was also held to cope with the draught in January 2017.

3) National Disaster Management Coordination Committee (NDMCC)

The National Disaster Management Coordination Committee (NDMCC) was established in November 2007 as inter-stakeholder coordination platform. The members are the Secretary to MDM (chairperson), the Additional Secretary to MDM (vice chairperson) and the representatives from relevant government agencies, donors, UN agencies and NGOs. NDMCC virtually functions as the substitute of NCDM, since the NCDM has not met at present. 66 NDMCC meetings were held by December 2016.

4) Emergency Response Committee (ERC)

The Emergency Response Committee (ERC), chaired by the Director-General of DMC, was established for relevant stakeholders to give advices to DMC on the coordination and preparedness of the emergency response activities during disaster. ERC is scheduled to have quarterly meetings (held three times in 2016).

(4) DRR Systems in Local Level

1) Outline of Local Administration

Sri Lanka has two local administration systems in parallel. The one is “National Administration Line” since independence and the other is “Local Administration Line” introduced in 1987. Both lines basically function separately with separate personnel and budget. There is no

permanent mechanism to coordinate both lines and the lines are coordinated through temporary meetings as necessary. The outline of both lines is shown in Figure2.2.3 and Figure2.2.4 and Table 2.2.1.

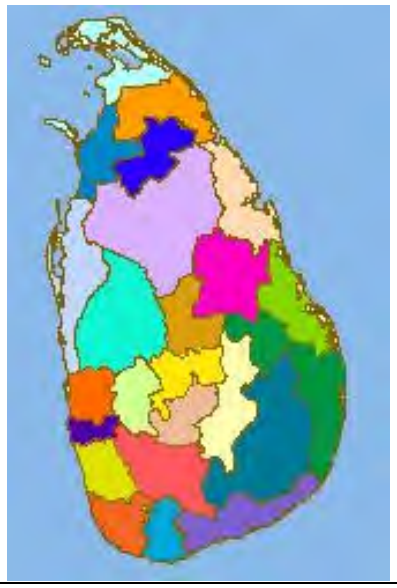
<table>
<tr><th colspan="2">National Administration Line
(District, DS Division and GN Division)</th><th colspan="2">Local Administrative Line
(Province and Local Authorities (LA))</th></tr>
<tr><td>District</td><td>25 Districts composed of .5–20 DS Divisions
  </td><td>Province</td><td>9 Provinces composed of 2-5 Districts
 
</td></tr>
<tr><td>DS Division</td><td>333 DS Divisions composed of 20-50 GN Divisions</td><td rowspan="2">LA (city, town and village)</td><td rowspan="2">335 LA composed of 14,000 Wards. The boundary of LA is almost the same with that of DS Division but not the same with that of GN Division</td></tr>
<tr><td>GN Division</td><td>14,000 GN Divisions composed of 2-4 natural villages</td></tr>
</table>

Figure2.2.3 Administrative unit and area of national and local administrative lines
Source: Prepared based on "JICA Study on Disaster Management System in Sri Lanka (2016)"

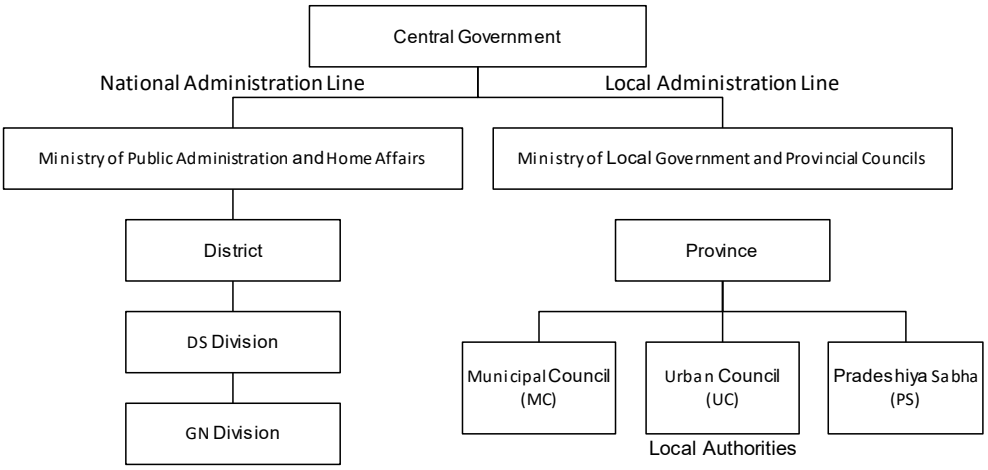


Figure2.2.4 Composition of national and local administrative lines
Source: JICA Study on Disaster Management System in Sri Lanka (2016)

Table 2.2.1 Jurisdiction of national and local administrative lines

	National Administrative Line (District, DS and GN Divisions)	Local Administrative Line (Province and Local Authority)
Competent ministry (including budget)	Ministry of Public Administration and Management	Ministry of Local Government and Provincial Councils
Background of establishment	Prototype administration exists before independence. Present administration has been established after independence	Prototype LA exist before independence. LA transferred from District to Province in 1987.
Council	Non-existence	Existence
Composition of agencies	Composed of local branch offices of central ministries	Composed of provincial own ministries and department
Scope of authority	Large scale and core infrastructures, social services and industry development spread beyond the area of Provinces	Middle and small scale local infrastructures, social services and local industry development complete within the area of Provinces

Source: Prepared based on "JICA Study on Disaster Management System in Sri Lanka (2016)"

Each Province consists of the Provincial Cabinet with one Chief Provincial Minister and four Provincial Ministers selected from Provincial Council members. Although the Central Government also dispatches Provincial Governors, the practical authorities for provincial administration are virtually belonging to the Cabinet. Figure2.2.5 presents an example of provincial administration structure.

Figure2.2.5 Example of provincial administration structure

Source: Eastern Provincial Council Website

2) DRR System in National Administration Line

Outline

DRR system of National Administration Line (District, DS Division and GN Division) is shown in Figure2.2.6.

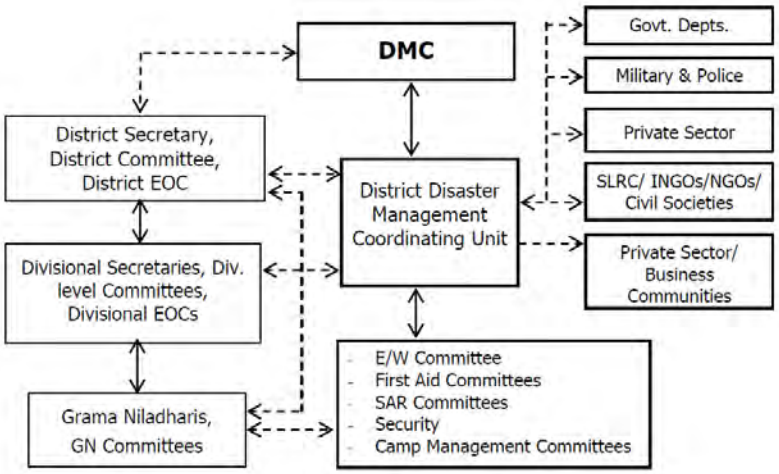


Figure2.2.6 DRR system of national administration line
Source: National Disaster Management Plan (NDMP)

District

The DMC established the District Disaster Management Coordinating Unit (DDMCU) within the District Secretariat. DDMCU has around three to seven staff and the Assistant Director dispatched from DMC works as the unit chief. The Assistant Director belongs to both DMC and District Secretary (or Government Agent). DMC has dispatched 25 Assistant Directors and 106 District Disaster Management Assistants to assist the Assistant Directors.

The DDMCU functions as the important liaison and coordination intermediary with national and local levels and the important coordination mechanism of the local level activities. However, DDMCU does not have enough staff to execute its workload. Therefore, DDMCU tends to be overloaded.

Meanwhile, NDRSC has also dispatched District Relief Coordination Officers to 25 District Secretariats separately from DDMCU, who belongs to both NDRSC and District Secretary.

In general, the Assistant Directors dispatched from DMC deal with pre- and during disaster phases and the District Relief Coordination Officers dispatched from NDRSC deal with post disaster phase. However, some duplication of activities between them can be seen, since it seems difficult for them to work as a unit because they follow different lines of command.

DS Division

Divisional Secretariat of Divisional Secretary (DS) Division does not have a DRR unit like DDMCU. DS is in-charge of DRR coordination. NDRSC has dispatched Disaster Relief Officer to DS Divisional Secretariat to accumulate field disaster information. Divisional Secretariat is the minimal administrative decision-making body and plays an important role in disaster relief activity.

GN Division

Grama Niradari (GN) Division is the smallest unit in the national administration and the contact point between local residents and administrator. GN Division is composed of GN as village officer and one to two office workers. GN Division deals with information through the community DM committee consisting of the representative of residents. Accordingly, the GN Division receives the first information from residents when disaster happens.

3) DRR System in Local Administration Line

Outline

The DRR system virtually does not exist in Local Administration Line (Province and LA) at present. There has been no progress in establishing Provincial Disaster Management Coordinating Unit (PDMCU) and Provincial EOC, which are proposed in NDMP. According to interview to the officials of MDM, MDM does not have much intention to establish them.

Province

Provincial Chief Minister is the member of NCDM and is virtually the Minister responsible for DRR. However, the response to disaster in Province has been limited only to conduct meetings to recover the facilities under the control of Provinces.

Local Authority (LA)

National Policy on Local Government established in 2009 describing the capacity enhancement of LA clearly stipulates the formulation and implementation of LA level Disaster Management Plans. However, the Policy is not fully implemented. The DRR system does not exist in LA (city, town and village). There has been no support from Province to LA because of the lack of DRR system in Local Administration Line. Instead, National Administration Line (District and DS Division) practically provides various DRR-related supports to LA.

Efforts to Strengthen DRR System

The Minister of MDM issued an instruction to the MDM to strengthen DRR System in Local Administration Line in October 2016. Under this directive, MDM is now implementing the "Study on Legal and Institutional Framework for Disaster Management in Sri Lanka and Development of a Comprehensive Strategic Plan" entrusted to a local expert to strengthen the DRR system systematically. The Study is expected to be completed in February 2017.

The MDM has a tentative plan to establish "Provincial Machinery Unit (provisional name)" in the Provincial Council of Eastern Province to begin with and to establish similar units in other Provinces. However, practical system will be strengthened based on the result of the Study described above. In any case, it is essential for MDM to discuss and coordinate with the Ministry of Local Government and Provincial Councils that control Provinces.

As a pilot effort, MDM, with the cooperation of UNDP, is now implementing the activities on Output 2.1 of SLCDMP, "Legal framework strengthened to mainstream DRR concepts in the local government sector" in several LA (city, town and village) in Uva and Central Provinces after the approval of each Provincial Council. Output 2.1 is not directly implementing DRR activity but the promotion of mainstreaming disaster risk reduction into the development projects in the LA and the preparation of Provincial Disaster Management regulation.

(5) Issues

1) Consolidating the Systems of MDM

The system stipulated by Disaster Management Act 2005 states that NCDM makes the highest decision and DMC implement it. But this has not functioned properly, since no NCDM has been held in recent years. The coordinating mechanism on the efforts of relevant agencies on

Disaster Risk Reduction (DRR) has been unclear and the progress of the efforts has not been shared at national level.

The authority to supervise the performance of DMC seems to be unclear, since NCDM is not functioning, although MDM is the authority under the current system. Consequently, the coordination, monitoring and reporting to be implemented by DMC seems not to be appropriate. In addition, the division of duties between DMC and NDRSC seems to be not clear; there are some duplication of activities in District and DS Division levels.

It is supposed that MDM allocates budget, monitors the performance of activities by four affiliated agencies, and coordinates the issues that require political response and judgement. However, in recent years, MDM not only coordinates but also deals with the implementing DRR tasks related to Mainstreaming Disaster Risk Reduction (DRR) such as SLCDMP and the Post Disaster Needs Assessment (PDNA) of May 2016 disaster, with the cooperation of international donors. DMC has not been involved in SLCDMP and PDNA. Accordingly the division of duties between DMC and MDM becomes unclear.

Now, MDM is implementing the "Study on Legal and Institutional Framework for Disaster Management in Sri Lanka and Development of a Comprehensive Strategic Plan" entrusted to a local expert to strengthen the DRR system systematically. The Study is expected to be completed in February 2017.

2) Strengthening DRR Capacity of Local Authorities

The DRR system virtually does not exist in Local Administration Line (Province and LA) at present. At the time of disaster, National Administration Line (District and DS Division) copes with disasters and the Line practically provides various DM related supports to LA.

The SLCDMP, implemented by MDM with the cooperation of UNDP, is not a regular DRR activity in LA. MDM focuses on the promotion of Mainstreaming DRR into the development projects in the LA. MDM, with UNDP under SLCDMP, is now supporting the preparation of Provincial DRR regulation as a pilot. However, the procedures and guidelines for Mainstreaming DRR have not been prepared as yet.

2.2.2 Legal Basis, Mandate, Staffing and Budget of DRR Related Agencies

(1) Ministry of Disaster Management (MDM)

The MDM is responsible for the overall DRR in Sri Lanka. The organizational chart of MDM is shown in Figure2.2.7.

The Ministry of Disaster Management and Human Rights (MDMHR) was established in February 2006 under "Extraordinary Gazette Notification dated 20th February, 2006". The Disaster Management Centre (DMC) and Department of Meteorology (DoM) became the affiliated agencies of the Ministry in February 2006. The National Building Research Organization (NBRO) became an umbrella agency of the Ministry in January 2007. In April 2010, the Ministry was renamed as MDM and the National Disaster Relief Service Centre (NDRSC) became an affiliated agency of MDM under "Gazette Notification No 1651/20 30/04/2010". The basis of the current mandate of MDM is "Gazette Notification of 1933/13 dated 21st September, 2015".

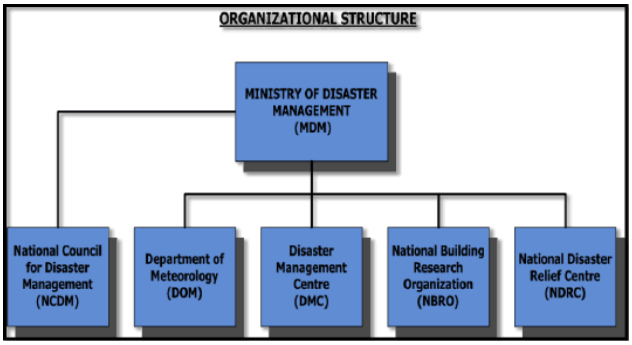


Figure2.2.7 Organizational chart of MDM
Source: MDM Website

The organizational chart of MDM main office is shown in Figure2.2.8. DMC, DoM and NBRO are the affiliated semi-governmental agencies which are led by the Director General who belongs to the Secretary of MDM. On the other hand, NDRSC is an affiliated government agency but half internal agency of MDM led by a Director and who belongs to the Additional Secretary (development and relief service) of MDM. This structure is based on the necessity of providing prompt relief service by MDM.

It is supposed that these four affiliated agencies implement practical DRR tasks while MDM allocates budget, monitors the performance of activities by these four affiliated agencies, and coordinates the issues that require political response and judgement. However, in recent years, MDM not only coordinates but also deals with the practical DRR tasks related to mainstreaming disaster risk reduction such as SLCDMP and the PDNA of May 2016 disaster with the cooperation of international donors. DMC has not been involved in SLCDMP and PDNA. Accordingly, the demarcation between DMC and MDM becomes unclear.

According to the MDM Annual Performance Report 2015, MDM main office has 92 staff (including driver) with annual budget of Rs 1,092.7 million (recurrent expenses: Rs 542.7 million, capital expenses Rs 550 million.). Capital expenses include research and planning activity budget.

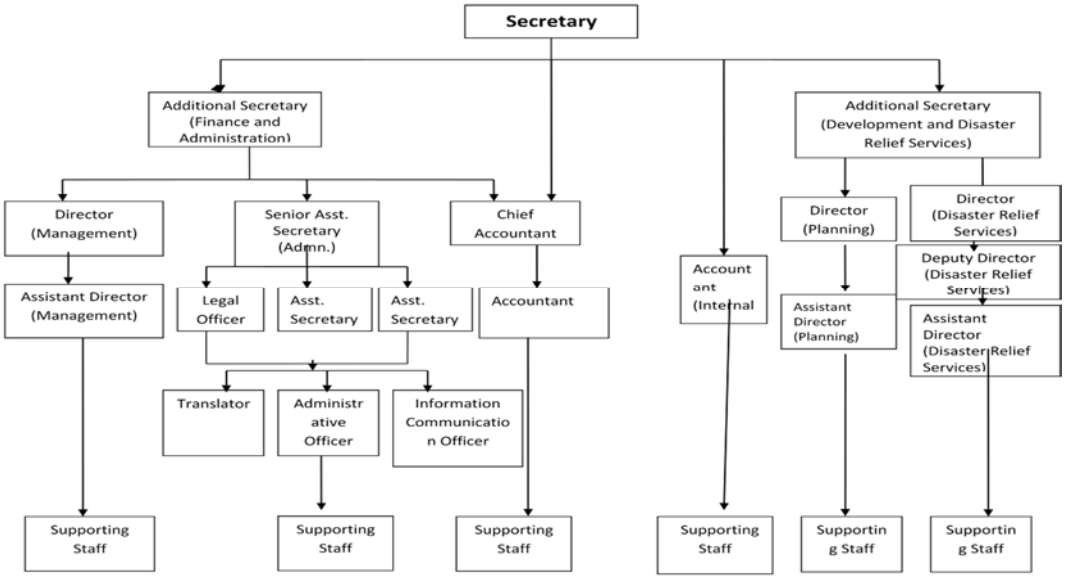


Figure2.2.8 Organizational structure of MDM main office
Source: MDM

(2) Disaster Management Centre (DMC), MDM

1) Outline

The Disaster Management Centre (DMC) was established in July 2005 under the Disaster Management Act and became an affiliated agency of MDM (MoDMHR until the rename in April 2010) in February 2006. DMC is a core semi-governmental agency responsible for overall DRR. DMC is composed of Preparedness & Planning Division to promote the Disaster Management Plan in each level, Mitigation, Research & Development Division to conduct the projects and researches on disaster risk reduction, Public Awareness Division to conduct residents' awareness-raising activity and Emergency Operation Centre (EOC) in charge of emergency response and early warning. The organizational structure of DMC is shown in Figure2.2.9. The Director-General belongs to the Secretary of MDM.

In Districts, 25 Assistant Directors and 106 Disaster Management Assistants are dispatched from DMC to District Disaster Management Coordination Unit (DDMCU) in District Secretariat.

According to the DMC Annual Report 2014, DMC has 224 staff including local level staff with the annual budget of Rs 945 million (recurrent expenses: Rs160 million, NCDM expense: Rs 14.03 million, capital expenses Rs 770.97 million).

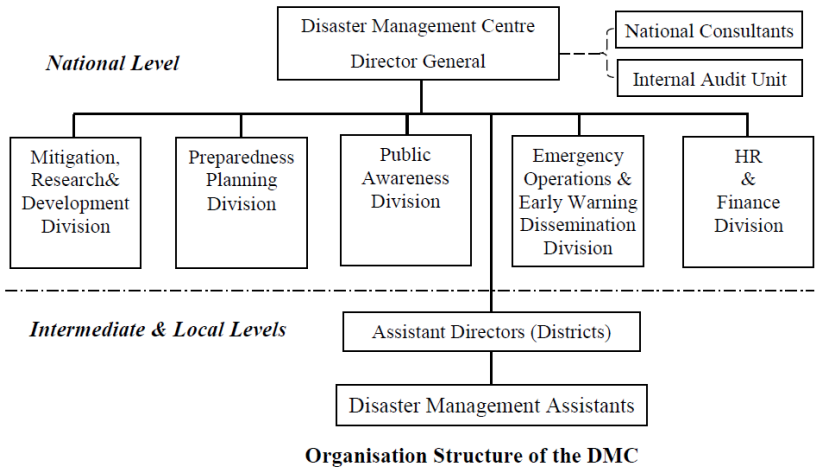


Figure2.2.9 Organizational structure of DMC
Source: DMC Annual Report 2014

2) Emergency Operation Centre (EOC), DMC

The Emergency Operation Centre (EOC) in DMC is in charge of emergency response. It has a 24/7 operation room equipped with radio and SMS facilities to communicate with relevant agencies, TV monitor screens, contact list and SOP.

The EOC disseminates the information by using various communication tools such as FAX, e-mail and SMS, and updates and upload the situation report daily during disaster. EOC conducts search and rescue, procurement of emergency goods and the coordination of rescue activity by the army for 2-3 days after disaster happens. After that, the relief activity gradually shifts from EOC to NDRSC.

(3) National Disaster Relief Services Centre (NDRSC), MDM

The NDRSC of MDM is responsible for the support of disaster affected people. National Disaster Management Centre, the predecessor of current NDRSC, was established in 1996. The Centre became the umbrella agency of the Ministry of Resettlement and Disaster Relief Services in January 2007. In April 2010, the Centre was renamed as NDRSC and became an affiliated government agency of MDM under Gazette Notification No 1651/20 30/04/2010. Not only relief, NDRSC is also responsible for the support of the resettlement from hazard risk areas as mitigation measures including the budget allocation and the monitoring the implementation.

The DMC, DoM and NBRO are led by the Director General who belongs to the Secretary of MDM. On the other hand, NDRSC is led by a Director and belongs to the Additional Secretary (development and relief service) of MDM. NDRSC is an affiliated agency of MDM but only half internal agency of MDM. According to the MDM, this structure aims to convey the field disaster information promptly to the Secretary of MDM.

The NDRSC has dispatched Disaster Relief Officers to all the District Secretariats and most of Divisional Secretariat. NDRSC is one of the agencies to be able to access the field disaster information immediately when disaster happens with the information collection and recording system established. NDRSC has a system to dispatch supporting staff from adjacent areas or NDRSC main office. The Disaster Relief Officers not only play important role in the relief activities during disasters but also evaluate disaster risk during ordinary times, since they are familiar enough with the local condition.

According to MDM Annual Performance Report 2015, NDRSC has 367 staff with an annual budget of Rs 1,484.8 million (recurrent expenses: Rs 972.8 million, capital expenses Rs 512 million).

(4) Department of Meteorology (DoM), MDM

The DoM is responsible for meteorological observation and became an affiliated semi-governmental agency of MDM (MoDMHR until the rename in April 2010) in February 2006. The meteorological observation in Sri Lanka started in 1867 while DoM was established in 1948 with no legal basis for the establishment. The organizational structure of DoM is shown in Figure2.2.10. The Director General of DoM belongs to the Secretary of MDM.

The DoM has been conducting meteorological observation at Colombo main office, 19 regional offices and three airport offices. DoM issues the early warnings on heavy rainfall and cyclone and is in charge of issuing the tsunami warning based on international meteorological information. Forecasting and Decision Support unit operates their 24/7 operation room. Katunayaka airport office functions as the backup of Colombo main office in case of the breakdown of Colombo office.

According to DoM Annual Report 2015, DoM has 370 staff with an annual budget of Rs 603.2 million (recurrent expenses: Rs 255.2 million, capital expenses Rs 348.0 million).

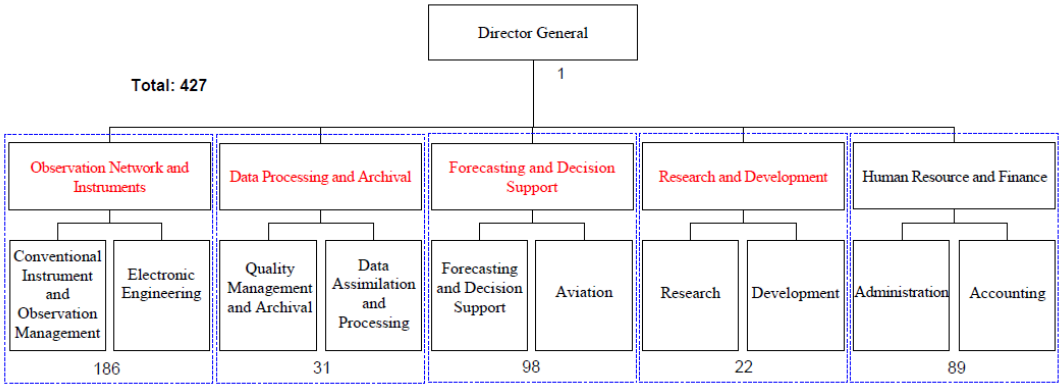


Figure2.2.10 Organizational structure of DoM

Source: Baseline Survey Report, JICA Technical Cooperation Project for Improvement of Meteorological Observation, Weather Forecasting and Dissemination (2014)

(5) National Building Research Organization (NBRO), MDM

1) Outline

The NBRO, MDM is responsible for landslide countermeasures. NBRO implements the early warning, hazard mapping and structural and non-structural measures on landslide. NBRO also deals with a wide range of engineering fields such as environmental science, human settlement planning, geo-technical engineering and construction material engineering.

NBRO was established in 1984 under the decision of Cabinet meeting without legal basis and became an affiliated semi-governmental agency of MDM (MoDMHR until the rename in April 2010) in January 2007. The organizational structure of NBRO is shown in Figure2.2.11. The Director General of NBRO belongs to the Secretary of MDM.

According to NBRO Annual Report 2015, NBRO has nine District offices and has 346 staff (permanent: 281, part-time: 65) with an annual budget of Rs 618.8 million. What is notable is that Rs 311.4 million, around half of the annual budget, is NBRO's business income by testing and consulting services.

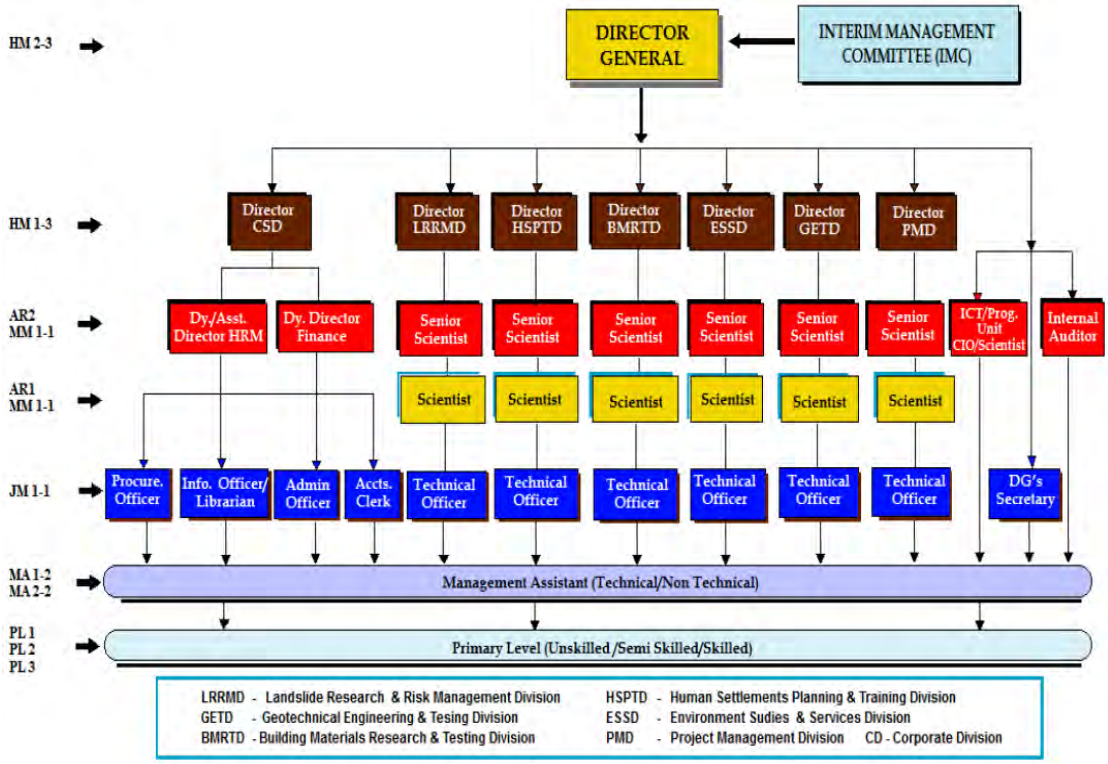


Figure2.2.11 Organizational structure of NBRO
Source: NBRO Annual Report 2015

2) Status of Legislation for NBRI Act

The legislation for NBRI Act is now underway, since NBRO, with no legal basis of establishment, faces various disadvantages in implementing activities. NBRI Act will upgrade NBRO status to NBRI (Institute) and grant legal basis and authority to NBRI. The draft law has already been sent to Parliament. However, it is not clear as of December 2016 when the legislation will be approved.

After the NBRI Act is approved, NBRI will have the authority to control the un-authorized construction activities in high disaster risk area. In addition to landslide, NBRI will have the power to conduct the investigation on constructions related to other natural disasters including flood.

(6) Irrigation Department (ID), MIWRM

1) Outline

The Irrigation Department (ID), Ministry of Irrigation and Water Resources (MOIWR) is responsible for the construction and management of rivers, reservoirs and irrigation facilities. ID, as a government agency, implements the flood control including flood early warning and structural and non-structural measures. ID was established in 1900 and the current legal basis is Flood Ordinance No. 22 of 1955.

The ID is composed of main five sub-departments, i.e. 1) Investigation, Planning and Designs Division), 2) Construction and Development, 3) System Management, 4) Administration, and 5)

Finance. ID has one Chief Resident Engineer Office and 14 Regional Offices and 48 Divisional Irrigation Engineers Offices. ID assigned a director in charge of DRR in the main office a few years ago.

Per the ID Administration Report 2015, ID has 6,000 staff (including 2,600 workers) with an annual budget of Rs 13,397 million. The budget for flood control is not counted separately in the Report, since ID has a tradition to deal with irrigation and flood control as part of regular activities and therefore reported with the overall expenses.

2) Status of Amendment of Flood Ordinance

Flood Ordinance No. 22 of 1955 has not been amended for around 60 years since 1955. ID has been authorized to plan and implement the structural measures for flood control in the Ordinance. However, the non-structural measures have not been included in the legal authority given to ID by the Ordinance. After the enactment of the Ordinance, the situation has drastically changed. For example, the various flood control related agencies, i.e., DMC, SLLRDC and UDA have been established, although the responsibility sharing among the agencies is not clear. It is necessary to amend the Ordinance to adapt to the current situation. For example, ID for river flood, SLLRDC for urban drainage and local government for local flood.

The proposal for the amendment was prepared by the related agencies through a series of discussions for one and a half years in MDM. This amendment work is also a component of SLCDMP. The status is that ID submitted the proposal to the Secretary of MOIWR as of December 2016.

The system in the Ordinance to collect the flood control cost as tax from local residents has not functioned at all. However, the system will remain even in the amended Ordinance, since the effort to delete the system will face strong opposition from stakeholders. The idea has the background that the objective of all the British legislation in Sri Lanka in 1920s was to collect tax.

The future schedule of the amendment is as follows: The legal section of MOIWR will revise the proposal in the form of a bill. MOIWR will send the bill to the Ministry of Justice to finalize the bill. The amendment will be approved after the deliberation of the bill by the Parliament. However, it is not clear when the amendment will be approved, since the amendment will be done after the on-going other amendment work of Irrigation Ordinance.

In parallel with the amendment of Flood Ordinance, ID is in the process of amending the Irrigation Ordinance. The important point of the amendment is to give authority to ID in securing the land (Irrigation Reservation) to prevent uncontrolled development along the reservoirs and rivers.

(7) Sri Lanka Land Reclamation and Development Corporation (SLLRDC), MMWD

1) Outline

The Sri Lanka Land Reclamation and Development Corporation (SLLRDC), Ministry of Megapolis & Western Development (MMWD), is responsible for urban drainage. It implements the regulations concerning the development and preservation of wetland and the planning,

designing, construction and operation & maintenance of urban drainage facilities.

The SLLRDC was established in 1968 as a semi-governmental agency under SLLRDC Act No. 15 of 1968. Current Act is amended Act No.35 of 2006 granting the authority to take legal action against unauthorized reclamation and water contamination.

The SLLRDC is composed of 10 Divisions, two of which are technical division and the rest deals with administrative matters. The two technical divisions are the Research and Design Division and the Drainage and Reclamation Division. Research and Design Division is in charge of planning while the Drainage & Reclamation Division is in charge of construction. Research & Design Division has 75 staff (including 20 engineers) and has annual budget of around Rs 7 million. In addition to the annual budget, the Division gains its own income from the consulting and designing works commissioned by the Road Development Authority (RDA) and Local Authorities. SLLRDC does not have permanent regional office but has project based tentative offices instead.

According to SLLRDC Annual Report & Accounts 2014, SLLRDC has 1,458 staff (247 technical staff including 70 engineers) with an annual budget of Rs 3,276 million. The budget for urban drainage is not counted separately in the Report.

2) Status of Amendment of SLLRDC Act

The amendment work of SLLRDC Act is now on-going. The main point of the amendment is to grant SLLRDC stronger authority to preserve wetland from un-authorized development. After the amendment, developer will have to obtain the approval of development from many agencies not only SLLRDC but Urban Development Authority (UDA) and Central Environment Authority (CEA). It is expected to work as a deterrent against un-controlled development. The draft law has been sent to the Department of Legal Draftsman, Ministry of Justice. However, it is not clear, as of December 2016, when the amendment will be approved.

(8) Urban Development Authority (UDA), MMWD

1) Outline

The Urban Development Authority (UDA), MMWD is responsible for the planning and implementation of urban planning, which was established in 1978 as a semi-governmental agency under Act No. 41 of 1978. The Act was amended in 1988 as Act No. 41 of 1988. UDA has nine Provincial offices and several District offices.

According to the UDA Annual Report 2013, UDA has 1,554 staff (of which 71% occupies under the management segment), the annual income is Rs. 2,902 million, and the administrative expenditure is Rs. 1,935 million.

2) Mainstreaming DRR into Urban Planning

The UDA started the effort to promote Mainstreaming Disaster Risk Reduction (DRR) into urban planning starting after the massive tsunami off Sumatra in 2004. UDA had no idea on Mainstreaming DRR before 2004. The Environment and Landscape Division (ELD) in UDA is in charge of promoting Mainstreaming DRR regarding DM as part of the environment. The ELD takes disaster risk into consideration in the land use zoning of the urban planning based on guidelines in collaboration with Development and Planning Division (DPD) in charge of

planning.

The UDA sets disaster risk area in urban planning with the cooperation of the specialized agencies such as ID for flood, SLLRDC for urban drainage and NBRO for landslide, since UDA has no experts on DRR. UDA, chaired by ELD, organizes the stakeholder meetings inviting those specialized agencies. UDA has close relations with MDM and DMC and, accordingly, the representatives from ELD and DPD always attend NDMCC held in MDM.

Urban plans are generally reviewed and revised once every 10 years. However, the plans are revised as needed when a big disaster happens. Therefore, the plans concerned will be revised after the May 2016 disaster. Local Authority (LA) is responsible for human resettlement after the urban plan is formulated. In Colombo District, Main Planning Committees meet bi-weekly to discuss urban planning with the attendance of the representative from UDA District Office. In this way, 280 urban development areas have been officially declared.

The UDA is responsible for the development of urban area. In rural area, National Physical Planning Department, Ministry of Urban Development and Sacred Area is responsible for the land use planning in landslide prone areas other than urban area.

(9) Road Development Authority, MHEH

The Road Development Authority (RDA), Ministry of Higher Education and Highways (MHEH), is responsible for roads. RDA was established in 1983 as a semi-governmental agency under RDA Act No. 73 of 1983. The Act was amended in 1988 as RDA (Special Provisions) Act No.5 of 1988. It implements the planning, design, construction of new national roads, and the operation & maintenance of existing national roads. The RDA is also responsible for the prevention of landslide along the roads to keep the safety of the roads. RDA conducts landslide prevention with the cooperation of the specialized agencies such as NBRO and MDM, since RDA does not have the experts on landslide measures. Amongst 19 Divisions of RDA, two Divisions are responsible for landslide, i.e., Engineering Service Division, which is in charge of planning and design, and Maintenance Management Division, which is in charge of operation & maintenance.

The RDA has 10 Provincial Director Offices (Eastern Province is managed by two offices). 25 Chief Engineer Offices in Districts are established under Provincial Director Offices. Chief Engineer Offices have five to ten engineers. RDA main office provides all the budget to Provincial and District offices.

According to the RDA Annual Report 2015, RDA has 5,673 permanent staff, 763 part-time staff and 4,213 permanent workers. The annual budget is Rs 191,214 million. (national budget: 39%, foreign budget: 61 %). Rs 38,872 million is allocated for road construction and Rs 6,000 million is allocated for operation and maintenance including landslide measures.

(10) Sri Lanka Red Cross Society (SLRCS)

The Sri Lanka Red Cross Society (SLRCS) was established in 1951 as an inter-government organization under Royal Charter of 1951. Colombo main office has 60 staff while the 25 District branch offices have two permanent staff (Branch Executive Officer and Finance Officer). Branch Executive Officer Meetings are held quarterly in the Colombo main office. SLRCS is

able to mobilize 6,500 registered members during ordinary time and 100,000 members during disasters. SLRCS has an emergency storage of relief supplies near Colombo airport.

The financial resources for activities are 1) donation (not only from individuals but also companies such as Coca Cola), 2) income by the trainings for private sector and other agencies, and 3) the support from International Federation of Red Cross and Red Crescent Societies (IFCS).

The SLRCS conducts DRR activities in coordination with DMC in central level and the Assistant Directors of DDMCU in local level. SLRCS in cooperation with DMC developed the CBDRM guidebooks for lecturer and participants in 2013 with the support of IFCS and AusAID.

The SLRCS distributes relief supplies in cooperation with NDRSC. In establishing the evacuation places in 400 communities, SLRCS has received the advice from NBRO whether the building is safe and suitable as evacuation place (Country Resilience Building). SLRCS implements Safer School Program in collaboration with the Ministry of Education.

(11) National Water Supply and Drainage Board (NWSDB), MCPWS

The NWSDB of Ministry of Urban Development and Water Supply (MUDWS) is the responsible agency for the promotion of drinking water supply and sewage as well as public hygiene in the country. The predecessor of the NWSDB was established in 1965 as a sub-department of Public Works Department under Ministry of Local Government. Based on "NWSDB Act" enforced in 1974, the NWSDB has functioned as an affiliated organization under MUDWS since January 1975 (The MUDWS was renamed as Ministry of City Planning and Water Supply (MCPWS) at present).

In accordance with the NWSDB Act, a number of major Urban Water Supply Schemes operated by Local Authorities were taken over by the NWSDB to provide more coverage and improved services. Consumer metering and billing commenced in 1982. Rural water supply & Sanitation programmes including deep well development had also been implemented by the NWSDB. However, since the Department of National Community Water Supply (DNCWS: described later) was established, the functions for the rural water supply has been transferred to the DNCWS.

Pipe borne water supply rate in Sri Lanka is currently at 47%. 324 pipe borne water supply schemes (35%) are currently managed by the NWSDB. Regarding sewerage, the NWSDB manages piped sewerage schemes in Colombo and suburbs, Hantane, Hantane, Koggala, Hikkaduwa, Kataragama and in few housing system. Sewerage scheme in the core city area of Colombo is controlled by the Municipal Council. Most of the other rural areas have no sewerage scheme.

The NWSDB has more than 10,000 employees. It has 11 Regional Support Centers (RSCs) at the provincial level for overall management, 24 regional offices for operation and maintenance of water supply schemes and 19 District Support Units (DSUs) to provide technical assistance for rural schemes.

The NWSDB has the original financial resources from water supply business. According to the financial statement report for 2015, the revenue of the NWSDB in 2015 was Rs.19,584 million, of which Rs.18,120 million (92%) is the income from metered sales of water supply.

(12) Department of National Community Water Supply (DNCWS), MCPWS

The DNCWS of MUDWS is the agency responsible for technical assistance on community level water supply. National Community Water Trust (NCWT), the predecessor of current DNCWS, was established in 2010 to improve community water supply services for 4,500 Community Based Organizations (CBOs) in the country. In September 2014, the NCWT was renamed as DNCWS under Gazette Notification, in order to enhance sustainable operation of community water supply system.

Out of 47% of the total pipe borne water supply rate in Sri Lanka, approximately 12% are managed by the CBOs. The DNCWS is responsible for designing, estimating, supervising and monitoring the community water supply facilities funded by the government and local authorities. After construction, the facilities are transferred to the CBOs. Those are operated and maintained by the CBOs.

Currently, the DNCWS has 232 staff despite the authorized number of 462. 46 staff belong to the headquarters and the others are at 25 districts offices. The budget allocation for 2016 was about Rs.100 million and the ministry allocation was Rs.156 million.

(13) Water Resources Board (WRB), MIWRM

The WRB was established in 1966 under Act No.29 (WRB Act) of 1964, as an advisory body to the minister on all matters concerning the control and utilization of water resources in Sri Lanka. At the beginning, the WRB had covered broad area on water resources. The WRB Act was amended in 1999. With the amendment, the WRB started to focus on matters pertaining to groundwater resources in Sri Lanka under the Ministry of Irrigation and Water Resources Management (MIWRM).

The mission of the WRB is to provide groundwater development services for multipurpose utilization and to accumulate scientific data such as hydrogeological and geochemical data bank of national, regional and local significances.

Recently, groundwater pollution from increasing human activities and urbanization as well as seawater intrusion and land subsidence by excessive groundwater extraction becomes serious social problem in Sri Lanka. In such situation, the Government of Sri Lanka issued a Gazette in March 2017 on groundwater management and regulation to control groundwater development. According to this Gazette, all sectors including public and private who develop groundwater have to conduct necessary investigation and environmental assessment to obtain official permit from the WRB.

The WRB is composed of several engineering divisions such as hydrogeology, engineering, drilling and operation at the headquarters in Colombo. Four (4) regional offices in Puttalam, Anuradhapura, Moneragala and Jaffna districts are under operation. The total number of staff is 255 at the moment although 331 have been approved.

2.2.3 Coordination Mechanism on Disaster Information and Early Warning

(1) Disaster Information Flow and Data Collection Structure

1) Disaster Information Flow from the Sites to the Central Agencies

As mentioned in Section 2.2.1, disaster information flow from local people to Ministry of Disaster Management (MDM) is divided into two (2) lines. One is the information flow through District Disaster Management Coordination Units (DDMCU) to Emergency Operation Center (EOC) of DMC. The other is through Assistant Directors who are dispatched to district offices from NDRSC and Relief Officers at DS Division as shown in Figure2.2.12.

The former is the information collection mechanism mainly for during disaster, and the latter is mainly for after disaster. However, there is no clear division between them. For example, in case of long duration disasters such as flood and drought, both information flows often overlap with each other.

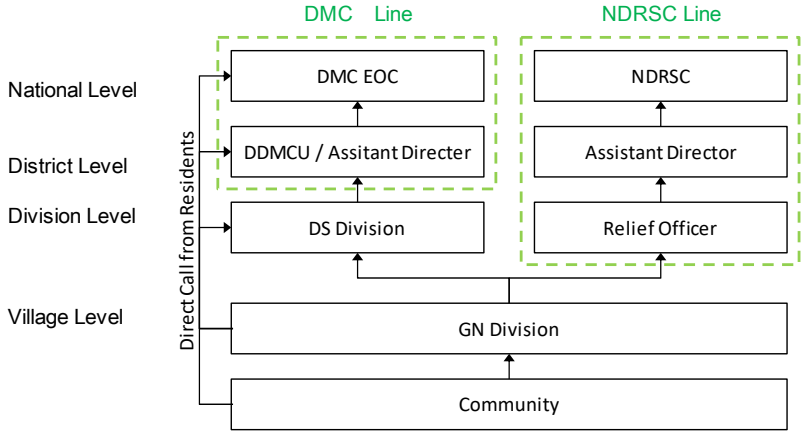


Figure2.2.12 Disaster information flow to MDM

Source: Prepared by JICA Survey Team based on interview

The collected disaster information sent to EOC through DDMCU are inputted to “DesInventar”, a disaster information database system managed by Mitigation Research and Development Division of DMC. The NDRSC also manages a disaster information database system for their purpose, but it is not open to the public to avoid confusion.

Technical Agencies such as NBRO and ID have local offices at the district level and/or division level. Disaster information is also sent to DDMCU through these local offices. Further, DMC operates a call center, dial (117), which the local people can directly call to provide disaster information.

2) Information Network in DDMCU

The DDMCU is composed of several dozens of staff including an Assistant Director (AD) dispatched by DMC. The AD belongs to DMC and is under the command of the District Secretary at the same time. They closely communicate with each other not only in emergency but also in normal condition. During disaster, the DDMCU functions as a district level EOC. In case of minor disaster, which can be controlled at the district level, the central EOC doesn’t engage in the district operation.

The scale and organization of DDMCU offices are different in each district. For example, Colombo DDMCU is composed of 23 staffs including 18 military staffs. Gampaha DDMCU is composed of 6 staffs. The ADs of 2 districts including Colombo are dispatched from the Air Force and those of 4 districts are dispatched from the Army. ADs of the other 19 districts are civilians employed by DMC.

Colombo DDMCU coordinates 13 DS divisions in the district. There are responsible staffs who are in-charge of designated DS division. During disaster, the responsible staffs stay in each DS division to cope with the disaster and share the disaster information with AD.

There are several communication tools between DDMCU and central EOC such as VHF radio, satellite phone, CDMA and land phone. DDMCU checks the proper operation of these tools at fixed time daily. Mobile phone is the only communication tool between DDMCU and DS districts. According to the AD of Colombo DDMCU, they have no experience of mobile disconnection during disaster. However, the mobiles, which were distributed to DS and GN divisions, sometimes are not functional during disaster due to insufficient phone time credit. More reliable communication tools are required.

Regarding disaster information collection, there is a unified format to record the number of disaster victims and damaged houses that are similar to the ones collected by NDRSC. However, there is no information describing detailed disaster condition, actual responses by local agencies, timing of warning and situation of evacuation that should be shared with DMC and stored, in the DMC archive, for future references.

(2) Early Warning Mechanism

1) Early Warning Procedure by Technical Agencies

Department of Meteorology (DoM)

The DoM issues weather forecasts (three times a day) and sea weather forecasts (twice a day). In addition, warnings for heavy rainfall, strong wind, cyclone and tsunami are also issued when severe weather condition is expected. Standard Operation Procedures (SOP) about issuance of the warnings have been prepared for each warning types.

When severe weather condition (e.g. heavy rainfall) is expected, officers of NMC (National Meteorological Centre), DG and directors share the information, and a warning signed by the forecaster is issued to relevant agencies and media. The warnings are disseminated to DMC, NBRO, President's Office, Cabinet Office, GA, Ministry of Fisheries and Aquatic Resources Development, forces, police, Coast Guard, regional office of DoM, media, etc. The warning is sent to the agencies from the Communication Center of DoM by using FAX. In addition, NMC sends the warnings via e-mail to some agencies. In order to disseminate the warnings to public and media, DoM uploads the warnings to the DoM website and records it on answer phone.

Irrigation Department (ID)

The ID informs the DMC the observed water level and rainfall by using FAX. Frequency of data transmission is once a day during normal times or every 3 hours during flood situation. In addition, ID issues flood warnings to relevant agencies and media. The flood warnings are issued based on the observed water level at 34 gauging stations. Rainfall, spilling from

reservoirs and dangerous area information are mentioned in the warnings as necessary.

The SOP about issuance of flood warnings is included in the NEOP. However, the actual framework and organization relating to the flood warning release is different from the SOP, because ID has not caught up with the SOP completely. ID issues the warnings according to the following procedures.

- Hydrology Division of ID collects observed water level data from local gauging station. Additionally, they collect observed rainfall data from regional offices of ID and DoM.
- When the observed water level exceeds flood warning level (4 warning levels), the warning is issued by ID. Signature of ADG is required on the first warning for large floods. After the first warning, director of hydrology can issue second warnings for large floods. The director is also authorized to issue warnings for small floods.
- The warnings are disseminated to DMC and media by using FAX.
- At district level, regional/divisional offices of ID usually disseminate the water level information to GA, DDMCU, local media, forces and police, directly. In some cases, the media contact the regional/divisional offices to ask for the river condition.

National Building Research Organization (NBRO)

As of December 2016, NBRO manages over 100 rain gauges throughout the country. Based on rainfall data collected in these rain gauges, NBRO issues "Landslide Warning" to DMC and public through the NBRO website. The Director of the Landslide Research & Risk Management Division (LRRDMD) and responsible staff in NBRO meet to discuss warning issuance.

Generally, an uniformed rainfall criteria is used for warning for entire country. In some cases, however, NBRO can issue warning before the condition reaching the criteria considering the accumulated rainfall and rainfall forecast for each district. According to the strong needs that the warning should be done at the Division level, NBRO is planning to improve the warning system. The detail is described in Section 2.3.3(1).

2) Early Warning Flow from DMC to the People

The technical agencies send warning messages to the relevant agencies. EOC of DMC is always included in the addressees as DMC has the main responsibility to transfer the messages to the local level. The warning messages are sent from EOC to DDMCU, from DDMCU to the local organizations, and then, finally, to the GN and local residents. Land phone, SMS, Media and Email are the communication tools. GN often use megaphone to disseminate the warning to the people.

As mentioned above, warning messages to DDMCU come not only from DMC but also from the other technical agencies such as ID and NBRO. In disaster situation, DDMCU works in close collaboration with such local offices of the technical agencies.

In Figure2.2.13, the central information communication line (center and right flow) basically functions well, whereas the local administration line (left flow) is not functional at the moment. Furthermore, there seems to be no regulations and processes for "decision making" on matters such as "evacuation direction" and "evacuation order" to the people by Local Authorities.

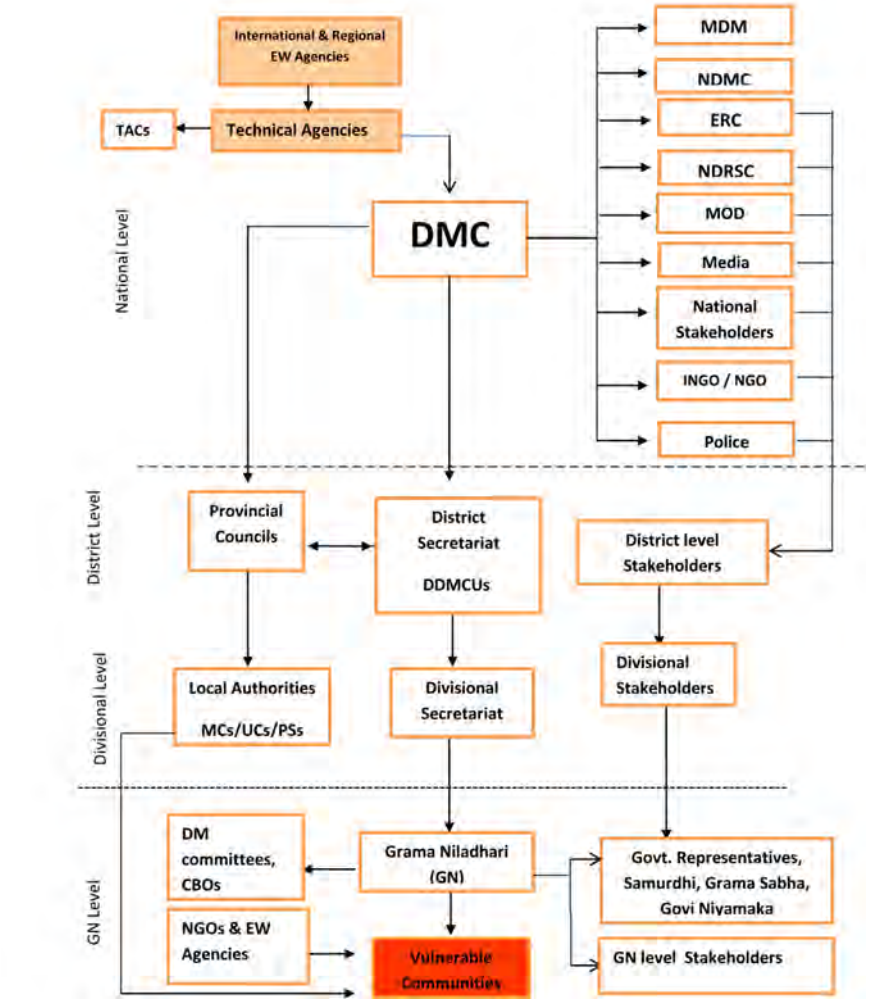


Figure2.2.13 Early warning flow and coordination between relevant agencies
Source: National Emergency Operation Plan

(3) Issues

1) Monitoring of DRR Activities and Damage Survey Reporting

Monitoring of the DRR efforts and reporting of damage survey are the mandate of DMC and DDMCU. However, the reporting includes only basic damage information such as affected population and damaged houses and does not include the progress and timeline of DRR activities. No report has been prepared on past disasters.

Both DMC and NDRSC dispatch their staff to District Secretariat. The information from disaster sites sometimes differ between DMC and NDRSC because of less coordination, since DMC dispatches the staff to DDMCU and NDRSC dispatches the staff to the District Secretary.

The DDMCU staffs are not able to collect field disaster information properly, since DDMCU, with only 5-20 staffs, are extremely busy during and post-disaster phases. No integrated format for disaster situation reporting has been prepared. As a result, the awareness raising activities by SLRCS and NGOs sometimes face difficulties.

2) Decision Making for Disaster Response

The warning messages from the relevant agencies are disseminated efficiently to the people through the districts, DS divisions, media and EOC. However, there is no clear differentiation of "Warning / Advisory" issued by the central agencies and "Evacuation Direction / Order" by the local administration. In the present mechanism, warning is only provided from upstream to downstream, but no decision-making processes by local administration.

Normally, administration services to the residents are primarily the task of Local Authority (LA). Decision-making such as people's evacuation is done by LA. Accordingly, clear evacuation procedure, necessary mobilization and proper management of evacuation shelter are efficiently executed.

2.2.4 Planning and Strategy for Global Targets of Sendai Framework

(1) Background of Sendai Framework

1) Achievement of HFA

The Hyogo Framework for Action 2005-2015 (HFA) formulated in the 2nd UN World Conference on DRR (WCDRR), set the goal of achieving substantial reduction in losses of life, as well as in losses of social, economic, and environmental assets, from disasters, and defined following five (5) Priorities for Action (PA) to be implemented over 10 years to achieve this.

- PA 1: Ensure that disaster risk reduction (DRR) is a national and a local priority with a strong institutional basis for implementation.
- PA 2: Identify, assess and monitor disaster risks and enhance early warning.
- PA 3: Use knowledge, innovation and education to build a culture of safety and resilience at all levels.
- PA 4: Reduce the underlying risk factors.
- PA 5: Strengthen disaster preparedness for effective response at all levels.

Based on the progress evaluation of HFA, disaster management organizations and systems have been established in each country based on PA 1 and disaster response systems including early warning systems have been strengthened based on PA 5. However, initiatives under PA 4, "Reduce the underlying risk factors," have fallen relatively behind. Due to recent urbanization in the disaster-prone area and increasing intensity of disasters, the disaster risks are still increasing year by year. In addition, a disaster in one country or region now affects economic activities in other countries because supply chains have grown to extend across a wider area due to globalization.

2) Achievement of the 3rd World Conference and Sendai Framework 2015-2020

According to the above circumstances on the progress of HFA, the 3rd WCDRR addressed the substantial promotion of disaster preparedness and "Build Back Better" concept. These were discussed among the participants in the viewpoint that DRR should be considered not only as humanitarian issue but also as a consideration for the sustainable development in developing countries.

Anticipated outcome of the Sendai Framework in the next 15 years is "The substantial reduction of disaster risk and losses in terms of lives, livelihoods, and health, and in terms of the economic, physical, social, cultural, and environmental assets of persons, businesses, communities, and countries". To realize this, the following four (4) new Priorities for Action (PA) were agreed as the successor of the HFA PAs.

- PA 1: Understanding disaster risk
- PA 2 Strengthening disaster risk governance to manage disaster risk
- PA 3: Investing in disaster risk reduction for resilience
- PA 4: Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction.

In addition, to promote the evaluation of progress of initiatives to accomplish these outcomes and goals, the following seven (7) Global Targets were established.

(a). Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate in the decade 2020–2030 compared to the period 2005–2015;
(b). Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 in the decade 2020–2030 compared to the period 2005–2015;9
(c). Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030;
(d). Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030;
(e). Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020;
(f). Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the present Framework by 2030;
(g). Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030.

The Sendai Framework fully reflects the following assertions that Japanese government had emphasized from negotiation stage of the framework.

- DRR Investment is the most priority for sustainable development of countries.
- It is essential to strengthen institution and finances of central DRR agencies in order to promote the investment.
- Reconstruction phase following a disaster is a precious opportunity to build more resilient communities. "Build Back Better" should be considered rather than just recovery.

(2) Efforts by Government of Sri Lanka to implement Sendai Framework

1) National Action Plan

The 7th Asian Ministerial Conference on DRR (AMCDRR) in New Delhi, India in November 2016 was the first AMCDRR after the formulation of the Sendai Framework. In the conference, the "Asia Regional Plan for Implementation of the Sendai Framework 2015-2030" was

formulated. The plan guides a long-term roadmap and a biennially Action Plan for implementation of Sendai Framework. In response to the Asia Regional Plan, the government of Sri Lanka prepared a draft National Action Plan with support of UNISDR.

The draft National Action Plan indicates the plans to be taken for each Priority for Actions in SDFRR as shown in Table 2.2.2.

Table 2.2.2 Expected efforts by government in Draft National Action Plan

Priority Actions	Expected Efforts in Draft National Action Plan
PA 1: Understanding Disaster Risk	▪ Strengthen national disaster damage and loss database - i.e. DesInventar database (covering geographically, age, gender, ability, and type of industry (SME sector) dis-aggregated data) ▪ Develop and agree on risk assessment methodologies for key hazards (i.e. Flood, Landslide, Drought, Tsunami) and develop guidelines for risk assessment ▪ Identify schools, hospitals, etc. in high risk locations (including private sector) ▪ Build capacity of the Disaster Management Centre (DMC) to conduct risk assessments and to assist other agencies to conduct risk assessments
PA 2: Strengthening Disaster Risk Governance to Manage Disaster Risk	▪ Set and agree national targets for disaster risk reduction in line with the global targets for Sendai Framework and formulate baseline for identified indicators ▪ Develop and agree on data sharing policy and mechanism for disaster and environmental data (including risk profiles) ▪ Revive National Disaster Management Coordination Committee ▪ Review the existing disaster management legal and institutional framework against the Sendai Framework ▪ Provide inputs for developing regulations and approaches to implement the National Housing Policy, Local Government Policy of Sri Lanka
PA 3: Investing in DRR for Resilience	▪ Develop and implement an insurance scheme to cover lives and properties (focusing on houses, small businesses) (i.e. through National Insurance Trust Fund) ▪ Ensure building codes available for the use in constructing schools and hospitals, etc. and incorporate disaster risk reduction into urban planning ▪ Develop risk profiles for selected hazard prone areas to streamline development planning ▪ Ensure national agencies use risk assessment in development planning and making risk informed investment decisions
PA 4: Enhancing Disaster Preparedness for Effective Response and to Build Back Better	▪ Develop a mechanism to collect disaster damage and loss data and formulate Post Disaster Needs Assessment (PDNA) based on sectoral needs ▪ Build the capacity of relevant agencies to develop international appeals for disasters beyond the in-country capacity ▪ Identify and agree on a mechanism (administrative and technical) to drive a building back (recovery)process ▪ Ensure National Emergency Operations Plan is in full operation with contingency plans for specific disasters ▪ Promote volunteerism in post disaster management with special focus on pre-hospital care on accidents

Source: Presentation material by MDM

2) Challenges and Recommendations to implement Sendai Framework

The MDM suggested issues and recommendations shown in Table 2.2.3 for implementation of the draft National Action Plan.

In order to monitor Sendai Framework and to achieve the Global Target (e), the draft National Action Plan indicates amendment of National Disaster Management Plan (NDMP) and re-development of SLCDMP. It seems the government intends to promote DRR governance further. The NDMP is going to be revised in 2018.

On the other hand, regarding implementation of PA3: "Investing in DRR for Resilience", promotion of mainstreaming of DRR seems higher priority than creation of new investments to DRR.

Table 2.2.3 Challenges and recommendations to implement Sendai Framework

Challenges	Recommendations
Translation and dissemination of key messages and essence of the Sendai Framework in national languages to increase awareness.	To Design & Develop IEC Materials, including materials for children, to disseminate widely
Preparing the Readiness Report for 2017	Revamping the existing DesInventar Database and national post disaster assessment mechanism to collect disaggregated data
Sendai Monitoring	Implement the Monitoring & Evaluation system already developed under SLCDMP to ensure data availability to Monitor Sendai Framework progress & report
Revise the national strategies for DRR in line with the Sendai target (e)	Review & re-develop the NDMP (next version) and the CDMP II in line with Sendai Framework
Implementation of the Sendai Framework in Sri Lanka	Draft National Action Plan (NAP). Revisit the NAP and make amendments in line with Global Targets
Establish multi-sectoral and multi-stakeholder national and local platforms for risk-sensitive development and innovative risk management.	Establish a new dimension to the NDMCC through a National Working Committee to be regularly monitored
Policy frameworks to reinforce risk considerations and risk reduction measures into development initiatives	Make legislative arrangements for community resilience framework to be mandatory for all development initiatives

Source: Presentation material by MDM

3) Mainstreaming of DRR

The evaluation of the HFA revealed that progress on initiatives of PA 4, "Reduce the underlying risk factors" has stalled. Disaster risks are increasing due to improper land use and urban development. Especially in developing countries, mainstreaming DRR, integrating considerations of disaster risk from the development stage and creating resilient cities and communities are necessary to mitigate existing and future disaster risks and to escape the vicious cycle of poverty.

The problem is that it is difficult to collect funds and move disaster prevention policies forward before a disaster strike compared with the amount of funds for emergency response measures after a disaster. The government of Japan has emphasized on the importance to promote the mainstreaming of DRR. There is a need for greater understanding that prior investment in DRR is much more cost effective than investment in recovery and restoration after a disaster.

The government of Sri Lanka formulated SLCDMP 2014-2018 to integrate DRR activities into relevant sectors under the initiative of MDM. This is an appreciated innovative effort to promote mainstreaming of DRR. The details on SLCDMP are described in Section 2.3.1(1).

(3) Issues

1) Promoting DRR Investment

In the draft NAP, the specific actions taken by the government for the Priority for Actions are clearly indicated. Especially for PA 4, to promote the mainstreaming of DRR into development sectors seems to be high priority. In order to promote more investment on DRR, it is necessary for the government not only to reallocate the existing resources but also to create proactive investment for DRR involving policy making agencies.

2) Basic Data for Risk Profiling

It is important to show the economic effects brought by DRR investment in accurate and numerical risk profiling. Currently the quantity and quality of basic database for the accurate risk profile are insufficient in Sri Lanka. Preparation of database such as topographical and geographical data as well as hydro-meteorological information is necessary. Besides, establishment of methodology of disaster risk assessment and the capacity development is required.

2.3 Progresses and Outcomes of Disaster Risk Reduction Activities

2.3.1 Comprehensive Disaster Management

(1) Status and Efforts on Comprehensive Disaster Management

1) Sri Lanka Comprehensive Disaster Management Programme (SLCDMP)

Outline and Mechanism of SLCDMP

Efforts on comprehensive disaster management by the government of Sri Lanka are summarized in the Sri Lanka Comprehensive Disaster Management Programme (SLCDMP) 2014-2018, which is an action plan for National Disaster Management Plan (NDMP).

The SLCDMP was formulated in 2014 as the successor of "Towards a Safer Sri Lanka Road Map for Disaster Risk Management", which was a 10 years DRR roadmap formulated in 2005. The most important target of SLCDMP is the mainstreaming of DRR. The SLCDMP plans to invest on 43 programmes implemented by 45 relevant agencies in charge. Based on the SLCDMP, each sector prepares proposals in cooperation with MDM and submits to the Department of National Planning, Ministry of National Policy and Economic Affairs. After approval by Ministry of Finance, the budgets are directly allocated to each sector, not through MDM.

Progress of SLCDMP

UNDP has a Project Management Unit (PMU) office in MDM to support MDM for coordinating and monitoring of SLCDMP under the project "Strategic Support to Comprehensive Disaster Management Programme of Sri Lanka (SS2CDMP)".

The progress of SLCDM is summarized in Table 2.3.1. As of December 2016, US$ 60 million (Rs 8.9 billion) of government budget have been allocated to the relevant sectors. Moreover, World Bank project of "Climate Resilient Improvement Project (CRIP)", which is a co-financing programme for implementation of SLCDMP, will invest US$ 110 million in total of which, approximately 50 % of the total investment has been expended.

Table 2.3.1 Progress of SLCDRM 2014-2018

No.	Outcome	Progress				
		Plan	Proposal	Approval	Budget	Remarks
Outcome 1: National and sub-national level agencies are capable of assessing disaster risk and making decisions for short, medium and long-term disaster management						
1.1.A	Timely issuance of seasonal climate forecast on drought is streamlined	16 mil.	○	○	Non	Waiting to implement with Indian financial assistance
1.1.B	Weather prediction capacity of DoM is enhanced	20 mil.	○	○	Non	Financial allocation is not available for year 2016
1.1.C	Climate change scenarios for Sri Lanka 2050 and 2100 developed	21 mil.	○	○	Non	
1.2	Timely issuance of flood early warning is streamlined	100 mil.	○	○	△	Trained the relevant officers. Also covered under the CRIP (10 river basins)
1.3	National & community level landslide early warning systems are in place	155 mil.	○	○	△	Automated rain gauge system established. Two Project proposals approved by NPD and are being implemented
1.4	Mechanism to disseminate early warning messages is enhanced	102 mil.	○	Non	Non	A project proposal submitted for NPD approval for implementation in year 2017

No.	Outcome	Progress				
		Plan	Proposal	Approval	Budget	Remarks
1.5	Disaster Risk Profiles are available at national level to capture the elements at risk and assess damage to capital assets and economic losses	708 mil.	○	○	△	Under implementation by CRIP
1.6	Detailed risk profiles are available for high risk major urban centers prone to flood and landslides	152 mil.	○	○	△	To be allocated to DMC (USD 1.5 million). Also partly implemented by CRIP
1.7	Organizational capacities for management and operation of reservoirs to minimize flood impacts are enhanced	100 mil.	○	○	△	Under implementation by CRIP and DSWRM
1.8	Flood ordinance amended to streamline institutional mandates for managing floods	0.6 mil.	○	○	△	Draft amendments are available. Cabinet paper is to be submitted
1.9	Information management and analytical capacities for disaster management improved	30 mil.	○	○	Non	To be implemented by "Data Project" by UNDP
1.10	Research and development in DRR and CCA supported	15 mil.	Non	Non	Non	
Outcome 2: Key development sectors are able to incorporate Disaster Risk Management (DRM) in their respective development initiatives / processes / activities at different administrative levels.						
2.1	Legal framework improved to mainstream DRR concept in local government	30 mil.	○	○	△	By-laws developed for the Central Province and to be developed for the Uva province
2.2	Legal provisions and community capacity for the preparation of GN level development plans incorporating DRR and CCA measures established	1.0 mil.	Non	Non	Non	Need to be done once the amended act is approved.
2.3	Legal provisions are available for mainstreaming DRR into the development process	6.0 mil.	○	○	△	Disaster Management Act amended. Waiting approval from the Attorney General Department. Capacity building needs to be done.
2.4	DRR concepts are mainstreamed into primary, secondary, tertiary education institutes, universities and national & provincial level training institutes including technical collage	49 mil.	Non	Non	Non	University of Colombo being supported to develop a Master's programme.
2.5	Private sector disaster resilience in hazard prone areas improved	5.0 mil.	Non	Non	Non	Pilot study on value chain analysis based on disaster and climate risk being conducted
2.6	The potential impacts of flood reduced in flood prone (14) districts	4,250 mil.	○	○	△	Partly under implementation by CRIP. A proposal submitted in 2017
2.7	Safety of small village level tanks and bunds improved	1,200 mil.	○	○	○	Fund has been allocated to Agrarian Department.
2.8	Flood impact in selected urban local authorities mitigated	10,000 mil.	△	△	Non	Waiting to implement with Indian financial assistance. However, the proposal will not cover the full requirement.
2.9	Ensure village development programmes are resilient to multi-disasters	28 mil.	○	○	△	Implemented for three districts by UNDP, two districts by EU. Other 20 districts are needed.
2.10	Slopes stabilized in identified high risk landslide and rock fall sites	6,000 mil.	○	○	△	Partly supported by government (1.6 billion was allocated for Buddula). NBRO receiving constant fund for mitigation.
2.11	Drought risk reduction strategies developed	320 mil.	○	Non	Non	
2.12	Coastal risk reduction strategies developed	5.0 mil.	○	○	○	Completed. Revised coastal zone management plan
2.13	Disaster resilience incorporated in the National Physical Plan and Policy-2030	6.0 mil.	Non	Non	Non	
2.14	Safeguarding water resources from industrial, agro chemicals and domestic point and non-point source pollution	10 mil.	Non	Non	Non	

No.	Outcome	Progress				
		Plan	Proposal	Approval	Budget	Remarks
2.15	Potential impacts on lives and properties due to human-elephant conflict reduced	3,517 mil.	○	○	△	Under implementation by department of wildlife. 7.5 billion Allocated.
2.16	Procedure and guidelines for the implementation of provisions in National Housing Policy for reducing impacts of hazards in housing sector are available	2.6 mil.	○	○	Non	Training programmes on resilient housing conducted in Landslide prone districts. The strategy developed
2.17	Strategic environment assessment integrating disaster risk reduction concerns are available at provincial level to facilitate sustainable and resilient development	55 mil.	Non	Non	Non	
Outcome 3: Communities, local governments and sub-national agencies have necessary capacities and mechanism to respond to and recover from disasters.						
3.1	DM Plans for national and sub-national levels sector organization in high and moderate risk area developed and in operation	20 mil.	○	○	△	Draft guide line has been prepared. DMC receiving annual fund for implementation
3.2	Awareness of communities on DRR is improved	30 mil.	○	○	△	Modules for awareness building prepared. DMC receiving annual fund (10 million / year) for implementation
3.3. A	Institutional capacity for developing human resource for DRM enhanced	1,200 mil.	○	Non	Non	A new project proposal submitted to construct a well-equipped training center
3.3.B	Child and women centered DRM programmes in practice	6.0 mil.	○	○	○	To be implemented in 2017
3.4	Programmes for sustainable housing in flood prone area and micro insurance scheme to assist small farmers & low income groups to minimize impacts of disasters are available	25.5 mil.	○	○	△	Insurance scheme for housing damages introduced with NITF
3.5	At national and district levels, ability to conduct damage, loss and needs assessments to guide post disaster recovery and cost benefit analysis of DRR investment is improved.	12.5 mil.	○	○	△	Under implementation as a part of PDNA
3.6	Capacity of communities and organizations is enhanced to respond to a potential cyclone hazard	30 mil.	○	Non	Non	
3.7	Capacity of institutions and personnel for post disaster relief is enhanced	200 mil.	○	Non	Non	
3.8	Capacity for institutions and personnel for disaster response enhanced	500 mil.	○	○	△	Partly funded to Ministry of Defense (300 million).
3.9	Community awareness on pre-hospital care and patient transportation during mass casualty incidents improved.	50 mil.	○	Non	Non	National consultative workshop conducted.
3.10	Regulations and guidelines to empower District and Divisional Secretary	3.0 mil.	Non	Non	Non	
Outcome 4: A system in place for obtaining advice and continuous monitoring, learning and adapting to facilitate the on-going planning and implementation processes						
4.1	Comprehensive monitoring and evaluation system in place	5.0 mil.	○	○	△	Under Implementation by UNDP consultant
4.2	Technical Advisory Committees are in operation	1.0 mil.	−	−	−	MDM handles
4.3	Effective knowledge management and integration in to global convention ensured	15 mil.	−	−	−	

Price is in Sri Lanka Rs. Source: A material from PMU of SS2CDMP (UNDP)

2) Local Disaster Management Plan

As mentioned in section 2.2.1 (4), Sri Lanka has two local administration systems in parallel. The one is "National Administration Line" and the other is "Local Administration Line". National Disaster Management Plan (NDMP) stipulates both lines having Disaster Management Plans respectively. As of now, all 25 Districts and 187 of 333 DS Divisions have already formulated Disaster Management Plans. However, there is no Disaster Management Plan prepared by Provinces and Local Authorities in Local Administration Line.

Previous District and DS Division Disaster Management Plans were composed of five (5) chapters as shown in Table 2.3.2. Since the plans seem to put more priority in disaster response than prevention and mitigation, a JICA project "DiMCEP 2010-2013" reviewed the previous plans and developed a template of Local Disaster Management Plans. The new template is composed of "2: Disaster Prevention and Mitigation Plan", "3: Disaster Preparedness and Response Plan" and "4: Rehabilitation and Reconstruction Plan". However most Districts and DS Division have formulated only "3: Disaster Preparedness and Response Plan" as of now.

Table 2.3.2 Components of District and DS Division Disaster Management Plan

Previous Components	DiMCEP Template
1. Introduction and Institution Arrangement	1. Introduction
2. Disaster Preparedness and Response Plan	2. Disaster Prevention and Mitigation Plan
3. Early Warning Plan	3. Disaster Preparedness and Response Plan
4. Emergency Operation Plan	4. Rehabilitation and Reconstruction Plan
5. Mitigation Plan	

3) Disaster Awareness and Training

Public Awareness Division of DMC is responsible for disaster awareness and training in central level. Trainer's Guidebook and Training Manual are being prepared for three target groups: Community Leaders, Government Officers, and Armed Forces and Police. The final drafts of those materials are already prepared in February 2017. On the other hand, School Safety Plans are to be formulated. Most of the schools at high-risk areas are preparing the plans. Some other awareness raising activities such as youth volunteers training and exhibition base activities also have been conducted in many Districts. Since these awareness activities and training courses, however, are managed by each DDMCU (District Disaster Management Coordination Unit), implementation plan and progress at each district is not understood at central level.

Table 2.3.3 Materials for disaster awareness raising and training

Target Groups	Materials
1. Community Leaders	Trainer's Guidebook Disaster Management Training Course for Community Leaders
	Training Manual Disaster Management Training Course for Community Leaders
2. Government Officers	Trainer's Guidebook Disaster Management Training Course for Government Officers
	Training Manual Disaster Management Training Course for Government Officers
3. Armed Forces and Police	Trainer's Guidebook Disaster Management Training Course for Armed Forces and Police
	Training Manual Disaster Management Training Course for Armed Forces and Police

4) Disaster Relief Service System

In keeping with National Budget Circulars no. 152 (1), (II) and (III) issued by the Ministry of Finance (MOF) giving instructions on provision of disaster relief services, NDRSC is engaged in the tasks of designing, implementing and follow up of disaster relief work.

The General Treasury (Department of National Budget of MOF) allocates budget for NDRSC to implement immediate relief services for the people affected by natural disasters. NDRSC through the budget allocation to District Secretary supplies cooked meals, dry rations, kitchen utensils, vocational tools, funeral subsidies and medical assistance. The medical assistance includes the psychological care for the people affected. At District Secretariat, Disaster Relief Officer dispatched from NDRSC to District Secretariat implement prompt relief services. In addition to the relief supplies to the people affected, NDRSC provides the material such as tents and boat to District and Divisional Secretariats. Rehabilitations of damaged houses as a result of disasters are implemented by the budget allocation from the General Treasury to each District Secretariat through NDRSC.

To enhance the capacity of NDRSC for relief services, the trainings for Disaster Relief Officers are conducted at various venues such as the Diyathalawa Sri Lanka Army Training School. One of the important parts of Relief Management activity is camp management and NDRSC provides the Training of Trainers (TOT) on the management for the local representatives (community, school and temple). The camp management sometimes lasts more than 20 months depending on the magnitude of disaster.

The urgent issues of NDRSC are the introduction of the database and manual to make the receipt and distribution of domestic and foreign supported relief supplies smooth and the GIS database for the preparation of incident report and the implementation of relief management.

5) Risk Financing

National Natural Disaster Insurance Policy Programme

The MDM has implemented the National Natural Disaster Insurance Policy Programme since the 1st of April, 2016 in collaboration with the National Insurance Trust Fund (NITF) and Ministry of Finance. Under this insurance policy scheme, every house and small & medium-scale industry damaged by natural disasters such as floods, landslides, storms and whirlwinds (excluding drought) are entitled to receive compensation for death and damages. Previously they could demand only Rs 100,000 for fully damaged house under the Relief Scheme, but now they can demand the maximum of Rs 2.5 million.

Just six weeks after the government paid US$ 2.0 million premium to NITF, the government received USD 3.6 million (Rs 535.67 million) for relief and recovery for severe disaster caused by heavy rainfall in May 2016. The government was able to carry out housing construction programme for landslides in Kegolle districts where 230 residents lost their houses. This insurance policy can offer maximum of Rs10 billion.

Emergency Stand-by Loan by International Donors

The government of Sri Lanka signed an emergency stand-by loan of “Development Policy Loan with a Catastrophe Deferred Drawdown Option Program (CAT-DDO)” with World Bank in April

2014. CAT- DDO can mobilize contingency fund of maximum US$ 102 million as development policy loan. For the disaster in May 2016, the government received USD 101.47 on the 30th of August, 2016.

Additionally, Asia Development Bank is also discussing with the government the application of an emergency stand-by loan after 2017.

(2) Support by JICA

The government of Japan has implemented several DRR related projects after the tsunami attack of the Sumatra Earthquake in 2004. Table 2.3.4 shows the projects related to comprehensive disaster management.

Table 2.3.4 Projects relating to Comprehensive DRR field supported by JICA

Project Name	Scheme	From	To
Comprehensive Study on Disaster Management in Sri Lanka	Development Study	2006	2009
Disaster Management Capacity Enhancement Project Adaptable to Climate Change (DiMCEP)	Technical Cooperation	2010	2013

1) Comprehensive Study on Disaster Management in Sri Lanka (2006-2009)

The goal of this study is to develop plans to mitigate the damages caused by natural disasters in Sri Lanka by strengthening the capacity of concerned organizations and communities. To achieve this goal, the study implemented four (4) components targeting four (4) river basins in the south-western region and the tsunami-affected area, to wit:

- To formulate integrated flood management plans for selected river basins in the south-western region of Sri Lanka
- To support the establishment of early warning and evacuation (EWE) systems
- To support community-based disaster management (CBDM) activities
- To strengthen capacity of concerned organizations

The formulated integrated flood management plans recommended structural measures for minor floods. For major floods, conservation of wet-lands as retarding basins, non-structural measure such as CBDRM and strengthening hydro-meteorological network to respond to climate change were proposed. In addition, the study provided necessary data and information to conduct Feasibility Study for Kalu Ganga river basin as a priority project.

Early warning and evacuation systems were developed in Kelani Ganga and Kalu Ganga river basins as pilot projects. Inter-Governmental Network (IGN) was also developed to share disaster-related information among the relevant agencies. IGN is still functioning at EOC in DMC. However, Fax and mobile phones are preferred for reliable information sharing today.

The community-based activities were implemented in 15 pilot communities. Through the participatory workshops, DS officers and community leaders were trained. They were involved in the implementation of small-scale countermeasures, search and rescue trainings and evacuation drills. Guidebooks named “Fliptation” were developed to educate community people as well as DS officers.

At the conclusion of the above activities, the study proposed further capacity enhancement on

DRR in Sri Lanka. It was applied to the following JICA technical cooperation project.

2) Disaster Management Capacity Enhancement Project Adaptable to Climate Change: DiMCEP (2010-2013)

This technical cooperation project aimed to strengthen the capacity of DMC and other technical agencies on each component supported by the "Comprehensive Study on Disaster Management (2006-2009)". The project objective is to develop a model for complete communication network in disaster observation, forecasting and community level activities including evacuation in the pilot area. The project team was composed of a long-term expert and short-term experts dispatched intermittently.

- Output 1: Leadership and coordination capacity of DMC is strengthened.
- Output 2: Analysis and monitoring capacity of DoM is enhanced.
- Output 3: Analysis and monitoring capacity of NBRO is enhanced.
- Output 4: Disaster management information is regularly transferred.
- Output 5: Disaster management capacities of districts, divisions and communities in pilot areas are improved.

In the activities for Output 1, a mechanism for Disaster Impact Assessment (DIA) for development sector, especially for road development sector, was introduced. The DIA was well recognized in Sri Lankan government after the project activity. It seems this is one of the most important contributions of the project according to DMC. Furthermore, the project supported to prepare a template of District Disaster Management Plan (DDMP).

Regarding Output 2 and 3, the project supported capacity enhancement for DoM and NBRO respectively. Based on the recommendation by the project, the "Project for Improving of Meteorological Observation, Weather Forecasting and Dissemination (2014-2017)" and the "Technical Cooperation for Landslide Mitigation Project (2014-2018)" are being implemented.

Output 4 and 5 aimed on the dissemination of the efforts supported by the previous project of "Comprehensive Study on Disaster Management in Sri Lanka". Especially in the pilot districts, the project conducted activities considering up-scaling of the inputs through the District Disaster Management Coordination Committees.

(3) Support by Other Donors

UNDP has been supporting MDM and DMC on comprehensive disaster management fields. Table 2.3.5 shows on-going and planned project by UNDP.

Table 2.3.5 Projects relating to comprehensive DRR field supported by other donors

Project Name	Donor	From	To
Strategic Support to Comprehensive Disaster Management Programme of Sri Lanka	UNDP	2014	2018
Climate Change Adaptation Project	UNDP	2014	2017
Data Management Project	UNDP	2016	2018
Climate Resilient Integrated Water Management Project※	UNDP	2017	2024

※Ministry of Mahaweli Development and Environment is the main C/P. MDM take part in a component

(4) Issues

1) Promotion of SLCDMP

The government of Sri Lanka expended approximately 50% of estimated budget of SLCDMP 2014-2018. The progress at the moment is appreciated as mid-point of implementation period. However, Rs 7.5 billion out of implemented Rs 8.9 billion is allocated for output 2.15: "Potential impacts of lives and properties due to human-elephant conflict reduced". It means the number of implemented programmes is not very high. There are many programmes that have not yet been approved or the budgets have not been allocated. It is recommended that the government promote the mainstreaming of DRR further.

It is important to share the progress of SLCDMP among relevant agencies in order to promote international support and investment to SLCDMP. Output 4.1: "Comprehensive monitoring and evaluation system in place" has not been realized at the moment. The system should be operated as soon as possible.

2) Promotion of Local Disaster Management Plan

Due to the administration structure in Sri Lanka, it seems difficult to formulate Local Disaster Management Plan in Provinces and Local Authorities in a short period. Meanwhile, it is realistic approach to accelerate to strengthen DRR structure along National Administration Line, then, District and DS Division support DRR activities by Local Administration.

To strengthen local DRR strategy, concrete plan for DRR investment should be developed in District and DS Division Disaster Management Plans. However, "Prevention and Mitigation Plan" has not been formulated in most District and DS Division, because they tend to lack disaster risk assessment necessary for the plan. The risk assessment should be done in highest priority.

3) Disaster Awareness and Training

Materials for disaster awareness raising activities are prepared and training courses for government officers and community leaders are conducted in each district by many organizations such as Sri Lanka Red Cross and NGOs. However, the progress of entire activities is not understood at central level and implementation plan of national level is not yet formulated. Though DMC has intention to formulate national level implementation plan based on results of risk assessment, methodology of the risk assessment at each region is not established. Thus, it is impossible to assess risk at each region and formulate the implementation plan at national level.

On the other hand, though material for general DDR training courses for government officers are being prepared, detailed disaster management training program for staff of MDM and DMC is not yet prepared. Approaches to develop capacity of those staff are still limited so far.

4) Involvement of DMC in SLCDMP

In the SLCDMP implementation, each sector submits proposal and directly receives the necessary budget on approval. This is an innovative system to promote the mainstreaming of DRR under the initiative of the central government.

Each proposal is prepared by the sectors in collaboration with MDM and UNDP consultants. However, there are comments that DMC, a coordination agency in the National Council for

Disaster Management (NCDM), has not been involved in this process. As mentioned in Section 2.2.1(5), it is required to clarify the roles and responsibilities of DMC as an implementing agency under MDM.

5) Strengthening Disaster Relief Service System

There are difficulties in implementing immediate relief services and resettlement and the management of domestic and foreign relief supplies, since the database, manual, SOP, guideline and plan on Relief Management are not available at the moment.

2.3.2 Flood Risk Reduction

(1) Status and Efforts on Flood Risk Reduction

1) Flood Risk

According to the National Adaptation Plan for Climate Change in Sri Lanka (2016) prepared by Ministry of Mahaweli Development and Environment (MMDE), increasing trend of air temperature as well as change in intensity and spatio-temporal pattern of rainfall have been observed in the past meteorological data. It is also observed that mean sea level has been rising with 1-3mm/year in average in Asian countries. The results of GCM and RCM indicate that the volume of rainfall can increase in wet zone and decrease in dry zone of the country by 2050. Such trends in climate change may increase frequency and intensity of flood and drought events in future. It is therefore important to continue advertent monitoring of climate condition and to predict flood and drought hazards affected by climate change.

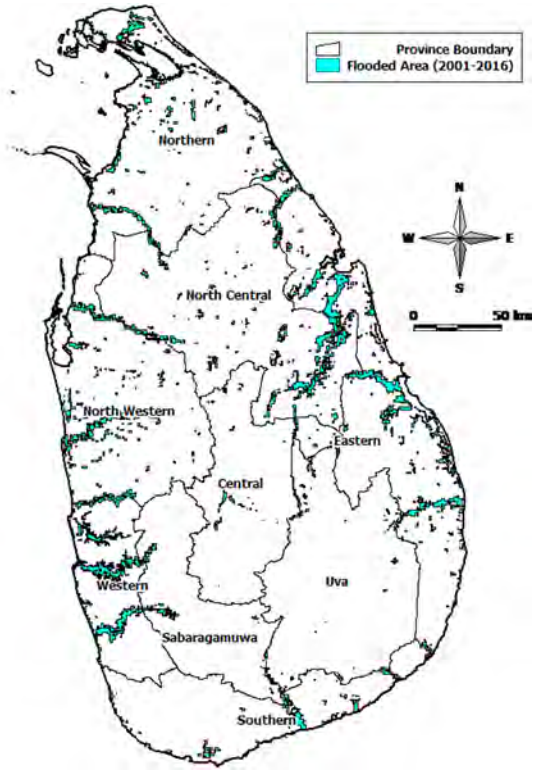


Figure2.3.1 Identified flooded area (2001-2016)
Source: Prepared by JICA Survey Team based on Data provided by IWMI and Survey Department

On the other hand, it is also necessary to pay attention to trend of exposure against flood hazard, considering increasing population and economic activities. The International Water Management Institute (IWMI) has identified recurrent flood areas with 500 mesh in South Asian countries based on past satellite images, which is exhibited in the web-site of IWMI. Figure2.3.1 shows the flooded area identified from satellite images during 2001 to 2015 by IWMI as well as the flooded area during flood disaster in May 2016. To check the trend of exposure in the flooded areas shown in Figure2.3.1, overlay analysis with population data with grid basis in 2000 and 2015 (Land Scan Data. grid size = about 1km. Refer to Figure2.3.2) was performed.

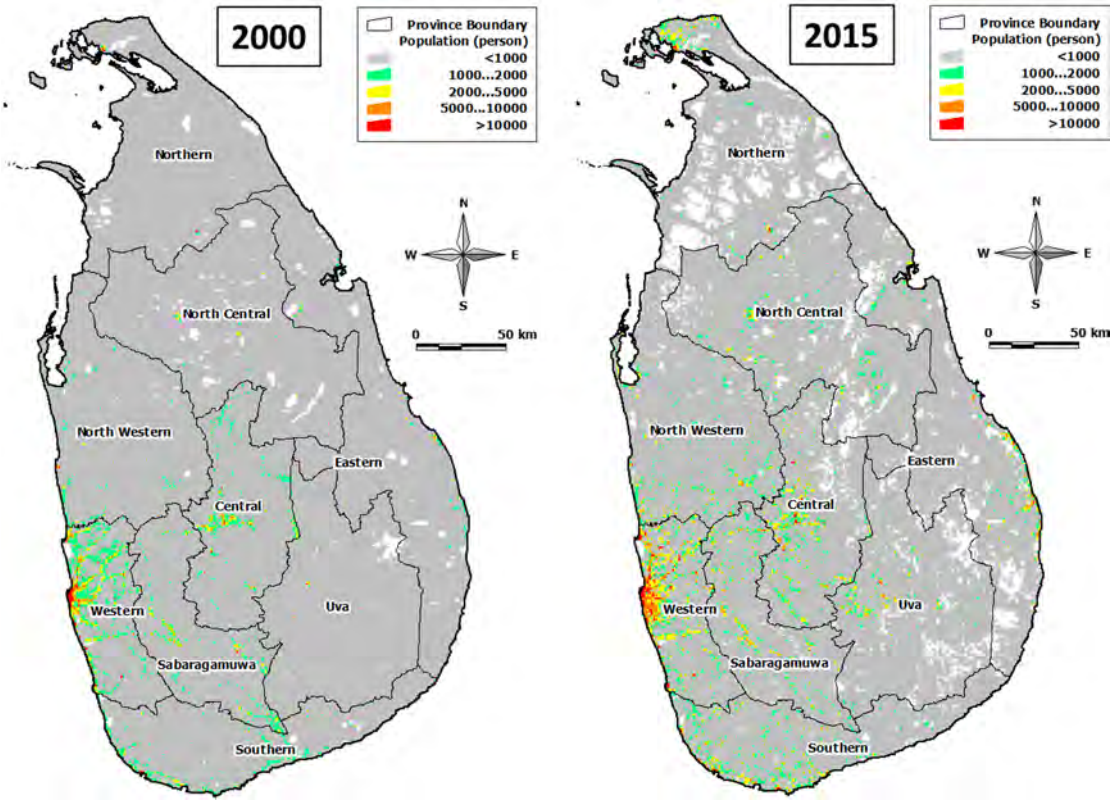


Figure2.3.2 Change in population distribution based on Land Scan data

Remarks: The original Land Scan data in 2000 was modified so as to keep consistency with the data in 2015.

Source: Prepared by JICA Survey Team based on Land Scan Data

Figure2.3.3 shows the change in population from 2000 to 2015 in the flooded areas, which demonstrates that the population increased in the Western and Eastern Provinces.

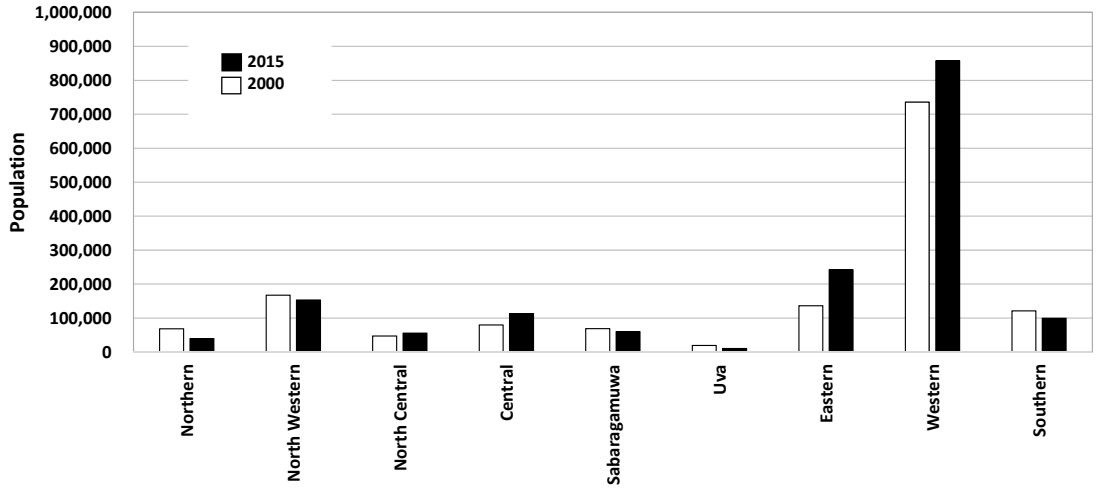


Figure2.3.3 Change in population in flooded area

Source: JICA Survey Team

Table 2.3.6 shows the population in flood area in 2015 by river basin.

Table 2.3.6 Population in Flood Area in 2015 by River Basin

River Basin	Population in flood area (thousand) (2015)	Share (%)
Kelani Ganga	395	24.2
Attanagalu Oya	183	11.2
Mahaweli Ganga	172	10.5
Kalu Ganga	123	7.5
Deduru Oya	84	5.1
Maha Oya	76	4.7
Bolgoga	64	3.9
Gal Oya	46	2.8
Other 95 river basins and coastal area	492	30.0
Total	1,635	100.0

Source: JICA Survey Team

Figure2.3.4 shows a concept of future national development by National Physical Planning Policy and Plan (2030). There is a plan to develop five metro regions in the country. Since there are risks of flooding, in the planned metro regions, countermeasures not to increase flood risk by new development are required.

As for drought, the increasing population and economic activities would bring about growing water demand in future, which may increase the risk of drought.

With the increasing trends of flood and drought risk, recognition of the flood and drought risk in detail as fundamental information for disaster risk reduction will become more important.

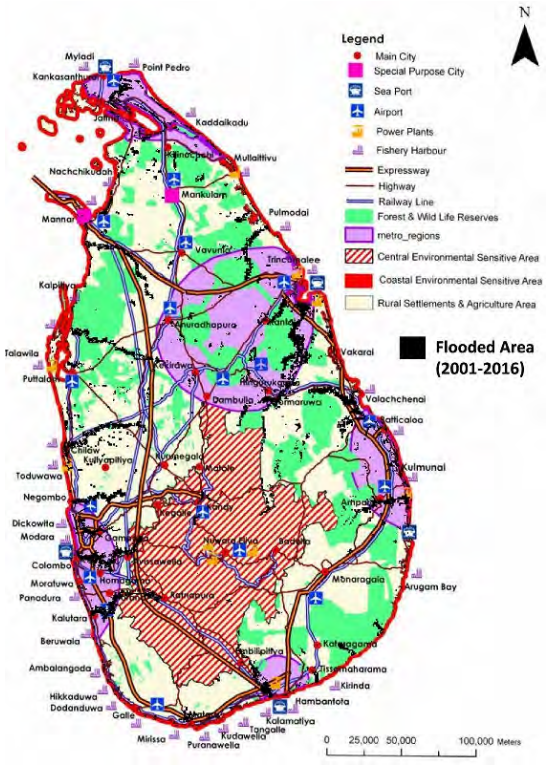


Figure2.3.4 Spatial development plan by National Physical Planning Policy and Plan (2030)

Source: Based on National Physical Planning Department, flooded area is added

At present, there are almost no flood hazard and risk maps in detail except for simulated flood area by drainage master plan for Metropolitan Colombo area and flood hazard maps prepared by ID and DMC for the south-eastern river basins. The evaluation of drought risk in terms of water balance between water supply capacity of existing water resources facilities and water demand has been conducted in limited river basins. The following activities for preparation of flood hazard and risk maps and evaluation of drought risk are on going:

- Twenty-four (24) river basins among 103 river basins in the entire country are recognized as important river basins by ID. In component 1 of CRIP supported by World Bank, detailed

flood hazard and risk map and assessment of drought risk in 10 river basins will be prepared during the preparation of basin investment plan. Flood Risk Modelling and Pre-Feasibility Studies for Flood Risk Management in Mundeni Aru Basin, which is also supported by World Bank, will prepare detailed flood hazard and risk map for eastern river basins.

- The ToR for flood hazard and risk mapping for five (5) river basins and 28 urban areas are under preparation by DMC.

Figure2.3.5 shows the river basins and urban areas where the detailed flood hazard and risk map assessment of drought risk will be prepared.

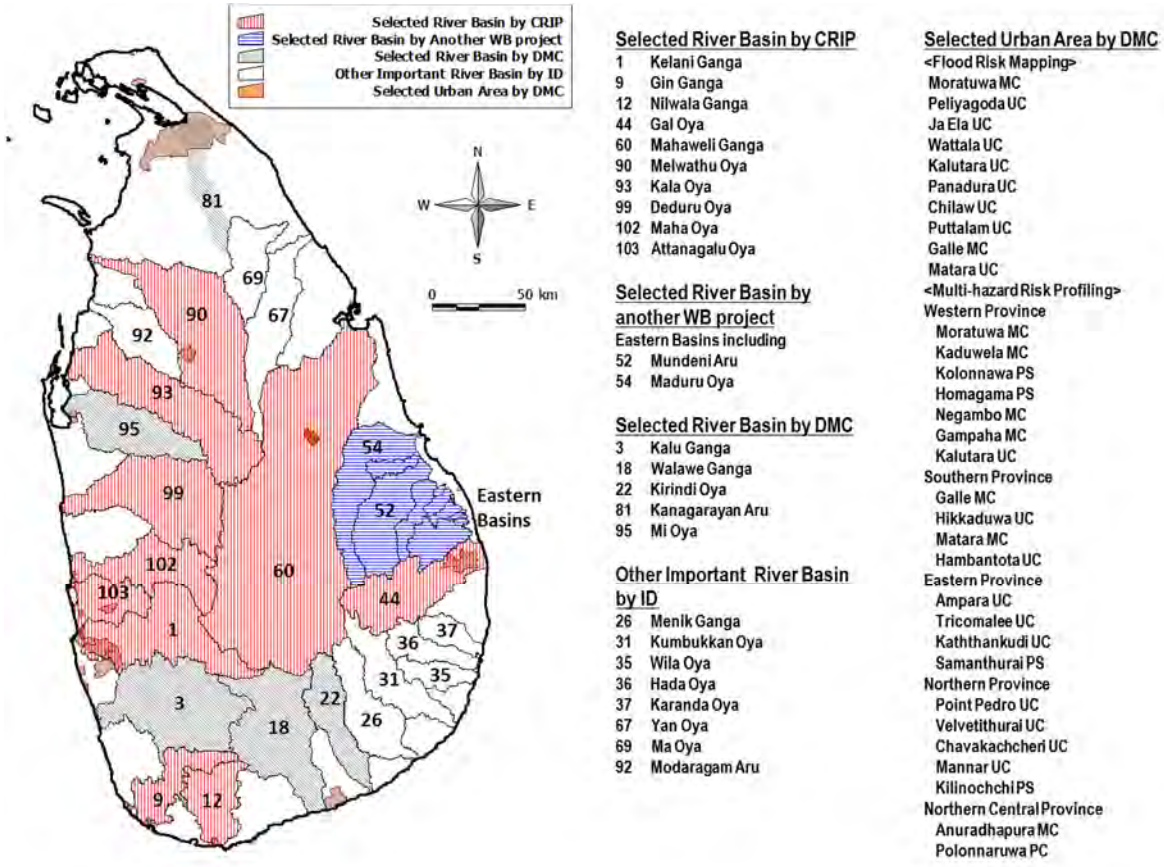


Figure2.3.5 River basins and urban areas
where detailed flood hazard and risk map will be prepared
Source: Prepared by JICA Survey Team based on information by ID, DMC

2) Institution

As described in Section 2.2.2(6), the legal basis for flood management in Sri Lanka is Flood Ordinance No. 22 of 1955. However, sharing of roles and responsibilities on flood management among relevant agencies is not clearly described in the ordinance. According to the ordinance, ID is responsible for structural measures on flood. However, it has no authority for non-structural measures. In order to improve the institutional situation, a working group with members from among the relevant agencies has been organized for revision of the ordinance, and as a result, a proposal has been prepared. In the proposal, flood phenomena are defined as shown in Table 2.3.7.

Table 2.3.7 Definition of Flood Phenomena in Proposal for Revision of Flood Ordinance

Flood Phenomena	Definition
Floods	A temporary condition of partial or complete inundation of normally dry land areas from overflow of inland or tidal waters from or unusual accumulation of surface waters from any source shall be defined as floods.
Local Flood	Local Flood shall be defined as the inundation of land or property caused by rainfall in isolated areas due to insufficient drainage system or unavailability of a connection to a drainage system.
Urban Flood	Urban flood shall be defined as the inundation of land or property, in areas declared under Urban Development Authority Act, caused by rainfall overwhelming the drainage capacity of the area.
Coastal Flood	Coastal flood shall be defined as the inundation of land property caused by overflowing sea due to natural or human intervention.
Riverine Floods	Riverine floods are the floods that occur when rainfall causes relatively high water levels in rivers or creeks to overtop the banks
Reservoir induced floods	Reservoir Induced Floods shall be defined as the Inundation of land and property in an area downstream of a Reservoir due to spillage water of that Reservoir or due to a dam break in an extreme event.

Source: ID

In the proposal, the Director General of ID is responsible for overall flood management. Under the guidance of Director General of ID, respective local authority, respective urban authority and Director General of Coast Conservation Department are responsible for local flood, urban flood and coastal flood, respectively.

For urban flood, it is proposed that DMC would support the urban authority for the preparation of related database. Technical agencies such as SLLRDC and UDA would certify the flood management plan that is prepared by the urban authority.

The related organizations on flood and water resources management are presented in Table 2.3.8.

Table 2.3.8 Related organizations on flood risk reduction

Related Organization	Main Responsibility
Ministry of Irrigation and Water Resources Management (MIWRM)	Overall water resources management
Irrigation Department (ID)	Irrigation, drainage and food control in the river basin which encompasses more than two districts
Sri Lanka Land Reclamation and Development Corporation (SLLRDC)	Flood control for urban flood
Urban Development Authority (UDA)	Urban development considering flood risk
Disaster Management Center (DMC)	Overall disaster management
National Building Research Organization (NBRO)	Monitoring of buildings in disaster risk area
National Water Supply and Drainage Board (NWSDB)	Water supply and sewerage
Central Electric Board (CEB)	Hydropower
Central Environmental Authority (CEA)	Water environment
Mahaweli Authority of Sri Lanka (MASL)	Water resources development and management in Mahaweli river basin
Northern Provincial Council (NPC)	Irrigation, drainage and food control in Northern province
Department of Agriculture (DOA)	Medium and small scale irrigation
Department of Agrarian Development (DAD)	Small scale irrigation

Source: Prepared by JICA Survey Team based on Interviews to Relevant Organizations

3) Flood Risk Reduction as Part of Water Resources Management

In Sri Lanka, flood management has been implemented as part of water resources development

and management especially for irrigation water use. The irrigation area managed by ID encompasses 288,000ha, in which ID manages water from reservoir to farming field. Flood and drought management are inextricably linked through reservoir operation.

The current basis of water resources development and management in Sri Lanka is the Water Resources Master Plan developed in 1959. The Mahaweli basin development was also initiated from the master plan. The master plan has been gradually updated from time to time. The latest update of the master plan was conducted during the project implementation of Dam Safety and Water Resources Planning Project (DSWRPP) supported by World Bank. In this update, non-feasible projects in terms of social situation have been struck out from the project list. Table 2.3.9 shows the list of priority projects under planning.

Table 2.3.9 List of priority projects under planning by ID

Project Name	River Basin	Outline
Lower Malawathu Oya Reservoir Project	Malawathu Oya	Multi-purpose dam project with irrigation, municipal water supply and mini hydropower Construction of new dam (storage capacity =209MCM), Project cost = US$78million
Heda Oya Reservoir Project	Heda Oya	Multi-purpose dam project with irrigation, municipal water supply Construction of new dam (storage capacity =147MCM), Project cost = US$66million
Mundeni Aru Basin Development Project	Mundeni Aru	Multi-purpose dam project with irrigation, municipal water supply and mini hydropower Construction of new dam (storage capacity =80MCM), Enhancement of existing dam (storage capacity =73MCM), Project cost = US$118million *Support from AFD is expected.*
Kumbukkan Oya Reservoir Project	Kumbukkan Oya	Multi-purpose trans-basin project with irrigation, municipal water supply and mini hydropower Construction of new dam (storage capacity =19MCM), Construction of conveyance (4.75km), Project cost = US$184million
Gin-Nilwala Diversion Project	Gin Ganga Nilwala Ganga	Multi-purpose trans-basin project with irrigation, municipal water supply and mini hydropower Construction of conveyance (13.8km), Project cost = more than US$300million *Support from China is expected.*

Source: ID

Water resources development and management projects by ID are multi-purpose development projects with irrigation, municipal water supply and mini hydropower components. Large scale hydropower project is handled by Ceylon Electricity Board (CEB). There is no budget allocation even in the multi-purpose project. At present, there are no existing and planned dam projects that consider storage volume for flood control. However, ID would like to consider flood control function in the dam projects by setting operation rule such as seasonal limited water level in flood season. The optimum operation considering both flood and drought is sought.

In DSWRPP that started in 2008, rehabilitation and review of rule curve of 32 dam reservoirs have been implemented. Additional 25 dam reservoirs will be rehabilitated and their rule curves will be reviewed by 2018.

During the flood disaster in May 2016, there were severe flood damages in Kelani Ganga,

Attanagalu Oya, Ma Oya, Deduru Oya, Mi Oya, Kala Oya and Malwathu Oya. In these river basins, reservoir operations of dams managed by ID during the flood have been reviewed.

The reservoirs managed by ID are operated by Range Office (RO) of ID. When there are more than two ROs in the same river basin, the operation is not always coordinated well among the ROs. In order to improve the operation, it is necessary to establish a river basin management body so that better decision-making considering the entire river basin will be possible.

MIWRM is preparing establishment of Riverine Management Division for improving water resources management at basin level. This is based on the recommendation that Irrigation Department play central role on riverine management under National policy on the protection and conservation of water sources, their catchments and reservations in Sri Lanka, which was adopted in 2014. There is a plan to establish and strengthen Riverine Management Division by 2019 and gradually establish basin management mechanism for important river basins after 2020. It is also targeted to enact new water resource law by 2020.

In 2014, CRIP started. The duration of project is five (5) years and the total project cost is US$110million. There are 4 components in the project as shown in Table 2.3.10

Table 2.3.10 Components of CRIP

Component		Objective	Project Cost
1	Development of Basin Investment Plans	To improve the understanding of the climate risk & develop both flood and drought mitigation interventions	US$13mil.
2	Increasing Climate Resilience of Infrastructure	To implement urgent climate risk mitigation investments Flood & Drought Mitigation US$47mil. Transport Continuity US$36mil. School Protection US$7mil.	US$90 mil.
3	Project Implementation		US$5 mil.
4	Contingent Emergency Response		US$2 mil.

Source: ID

MIWRM is the implementing body of CRIP. The project manager who manages the entire component of the project has been solely assigned. Under the project manager, deputy project managers for each component have been put in. The deputy manages for component 1 and 2 are assigned from the directors of ID.

As for the component 1, Atkins - Greentech Consultants JV has been selected as a consultant for the project. According to the inception report submitted by the JV, the consultant team consists of 19 experts including team leader. Totally 30 C/P members including fifteen full-time C/P members have been assigned.

As an example of work in CRIP, the case in downstream part of Mahaweli Ganga basin is described below.

- The upstream portion of Mahaweli Ganga basin is managed by Ministry of Mahaweli Development and Environment, whereas the downstream portion is managed by ID. The downstream part of the basin is a recurrent flood area, and rehabilitation work for the damaged irrigation facilities by past floods are being implemented in component 2 of CRIP.
- Due to peak operation of hydropower dam upstream of the basin, it is difficult to abstract

irrigation water stably at head works in the downstream portion of the basin. ADB is supporting to improve the head works so that stable abstraction will be available. However, the farmers in further downstream reach (Mawil irrigation scheme) worry about possible decrease of water volume to reach their irrigation scheme. It is necessary to consider some countermeasures. In the Mawil irrigation scheme, a temporary structure to abstract water is constructed in dry season every year by the farmers themselves, because the structure is destroyed every flood season. It is desirable to construct a permanent structure that cannot be damaged by flood. In component 1 of CRIP, this will also be considered in the formulation of basin investment plan.

In component 1, the basin investment plan for 10 river basins will be prepared. The basin investment plan will consider both flood and drought mitigation. The high impact projects will be selected as priority projects, and 3-4 projects for each basin will be further studied at Pre-F/S level.

In the 10 river basins, the priority and method to prepare the plan are different, as shown in Table 2.3.11. It is noted that Flood Risk Modelling and Pre-Feasibility Studies for Flood Risk Management in Mundeni Aru Basin in Sri Lanka supported by World Bank is also presented in the table.

For the high priority basins, the priority projects will be implemented in CRIP2 from 2017.

Table 2.3.11 Priority and method of preparation of basin investment plan

River Basin		Priority	Method of Preparation of Basin Investment Plan
1	Kelani Ganga	High priority: In CRIP2, priority projects will be implemented.	Prepared by Consultant Target completion: June 2017
9	Gin Ganga	Priority	Prepared by Consultant
12	Nilwala Ganga	Priority	Prepared by Consultant
44	Gal Oya		Prepared by staff of ID with support from consultant
60	Mahaweli Ganga	High priority: In CRIP2, priority projects will be implemented.	Prepared by Consultant Target completion: 2017
90	Melwathu Oya	Priority	Prepared by Consultant
93	Kala Oya		Prepared by staff of ID with support from consultant
99	Deduru Oya		Prepared by staff of ID with support from consultant
102	Maha Oya		Prepared by staff of ID with support from consultant
103	Attanagalu Oya	High priority: In CRIP2, priority projects will be implemented.	Prepared by Consultant Target completion: 2017
52 54	Eastern Basins incl. Mundeni Aru Maduru Oya	High priority: In CRIP2, priority projects in Mundeni Aru will be implemented.	Prepared by Consultant Target completion: June 2017 (Flood Risk Modelling and Pre-Feasibility Studies for Flood Risk Management in Mundeni Aru Basin in Sri Lanka)

Source: ID

In CRIP2, it has been planned to implement priority projects identified by the basin investment plan prepared by the component 1 of CRIP and to conduct technical support for integrated use of meteo-hydrological information. It could start from 2017 before completing CRIP. Therefore CRI and CRIP2 would be implemented in parallel.

In Mundeni Aru basin, new water resources development project is considered to be implemented under support of AFD. F/S will be started from July 2017. The F/S will refer to the result of the ongoing World Bank supported project. It might be possible to consider adding flood control storage in the proposed dam reservoir. Establishment of a river basin management body will also be considered.

There are 17 river basins with more than 1,000km^2 in catchment area. ID considers that the river basins with planned water resources development projects are also important river basins. In addition to 10 river basins selected by CRIP and the eastern basins supported by World Bank project, it is recognized that 12 river basins shown in Table 2.3.12 may need basin study and its implementation.

Table 2.3.12 Other river basins with priority for basin plan and its implementation

River Basin		Points to be considered for Basin Planning
3	Kalu Ganga	- There are already existing plans. Implementation of the existing plan is higher priority than basin planning.
18	Walawe Ganga	- In Walawa Ganga basin, the upstream part is managed by Ministry of Mahaweli Development and Environment, and the downstream part is managed by ID. The hydropower dams are managed by CEB. The institutional set-up for basin management is very complex. - Since there is a plan for inter-basin transfer from Gin Ganga and Nilwara Ganga, it is necessary to consider entire water management among related river basins. It is expected that water demand for industrial area around Hambantota will increase. The inter-basin transfer project will be implemented with support of China.
22	Kirindi Oya	
26	Menik Ganga	- These areas are vulnerable to drought. The optimum water resources management including inter-basin transfer is required.
31	Kumbukkan Oya	
35	Wila Oya	
36	Heda Oya	
37	Karanda Oya	
67	Yan Oya	- Since there is an inter-basin transfer between two basins, it is necessary to consider entire water management between two basins.
69	Ma Oya	
92	Modaragam Aru	
95	Mi Oya	- There is a dam constructed with support of JICA. Since there is an inter-basin transfer from Deduru Oya, it is necessary to consider entire water management with Deduru Oya.

Source: ID

When the basin plan is formulated, it is necessary to prepare detailed topographic information as a fundamental requirement for the planning. The first priority of planning may be optimization of operation of existing facilities considering both flood and drought. Second step may be new water resources development and its optimization. In some river basins there are inter-basin transfers. In such cases, it is necessary to consider entire water management and basin management organization covering related basins.

4) Urban Flood Risk Reduction

As for urban flood management, SLLRDC has been implementing urban drainage improvement projects in Colombo Metropolitan area.

Improvement of Urban Drainage in Colombo Metropolitan Area by Yen Loan Projects

The Yen loan projects shown in Figure2.3.6 and Table 2.3.13 have been implemented.

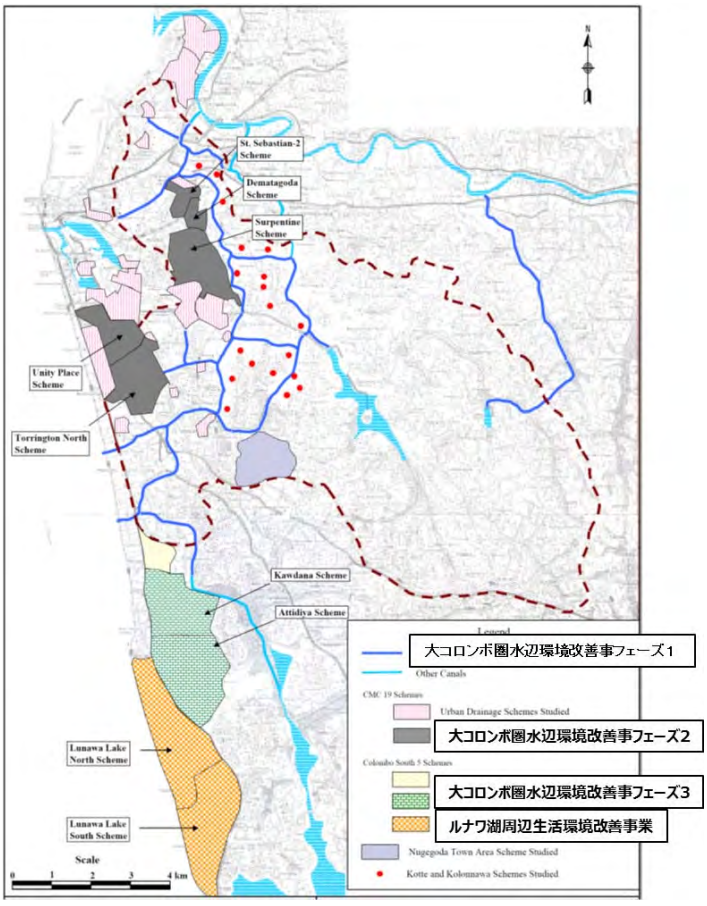


Figure2.3.6 Improvement of urban drainage in Colombo Metropolitan Area by Yen loan projects
Source: The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region (2003)

Table 2.3.13 Urban drainage improvement projects in Colombo Metropolitan Area by Yen loan

Project Name	Duration	Project Cost	Objective	Project Outline
Greater Colombo Flood Control and Environment Improvement Project Phase 1	1992-1999	10.4 billion yen	Mitigation of recurrent flood in Greater Colombo by improvement of drainage system such as channel and retarding basin, and environmental improvement of living condition around drainage channel.	1) Drainage improvement (widening of channel, dredging, diversion channel and retarding basin) 2) Resettlement and environmental improvement around drainage channel 3) Procurement of equipment for maintenance (dredging machine etc.) 4) Consulting service

Project Name	Duration	Project Cost	Objective	Project Outline
Greater Colombo Flood Control and Environment Improvement Project Phase 2, 3	1994-2005	9.4 billion yen	Setting up of drainage system and improvement of living environment in five areas where flood damage is severe and two areas in Dehiwala-Mount Lavinia.	1) Installation of drainage channel (open and closed conduit) 2) Program for improvement of water quality and environment 3) Program for improvement of living environment 4) Procurement of equipment for maintenance (dredging machine etc.) 5) Consulting service
Lunawa Environment Improvement and Community Development	2001-2010	6.3 billion yen	Mitigation of flood damage in area around Lunawa lake by setting up drainage system, and improvement of environmental and sanitary condition in the area	1) Drainage channel 2) Procurement of equipment 3) Development of resettlement site 4) Resettlement 5) Program for improvement of living condition of poverty group 6) Capacity enhancement for implementation 7) Consulting service

Source: MOFA (Japan) and JICA web-page

The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region (SWDPCMR) (2003)

The study started in 2001 and was completed in 2003 with master plan on drainage system in Colombo Metropolitan area. The target areas of the master plan are Greater Colombo basin, Kalu Oya basin, Bolgoda basin and Ja Ela basin (Attanagalu Oya Basin) (see Figure2.3.7). The flood control measures on Kelani Ganga are not included in the master plan.

The total project cost of the master plan is US$103million. The master plan consists of the following components:

- Structural measures for each basin,
- Non-structural measures,
- Institutional development plan,
- Operation and maintenance plan, and
- Human resources development plan.

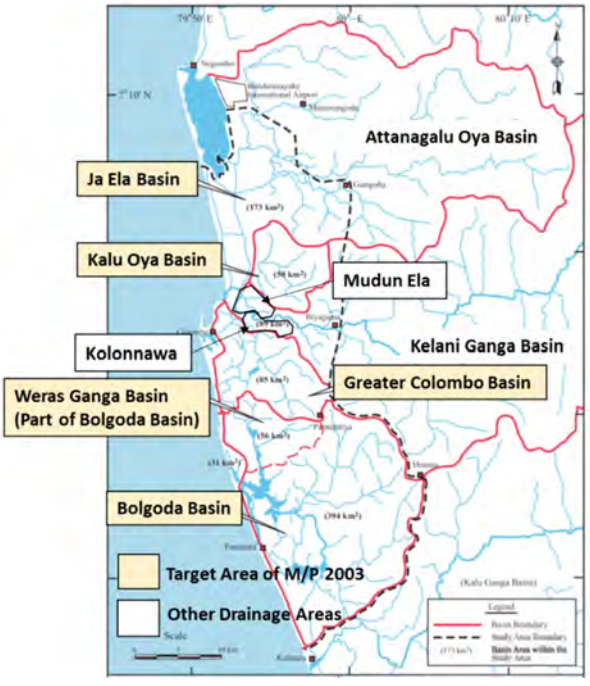


Figure2.3.7 Target area of SWDPCMA

Source: The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region (2003)

The target safety level of structural measures was set at 1/50. The recommended structural measures for each basin are shown in Table 2.3.14

Table 2.3.14 Recommended structural measures in SWDPCMA

Basin	Recommended Structural Measures
Greater Colombo	・Madiwela South Diversion Canal (length 8.8 km, width 32 m) ・Existing Mutwal Tunnel Restoration (length 554 m, diameter1.8 m) ・New Mutwal Tunnel (length 740 m, diameter 4 m) ・Storm Water Retention Area (Kolonnawa Marsh, Kotte Marsh, Heen Marsh and Parliament Lake Area 380 ha in total)
Kalu Oya	・Kalu Oya Channel Improvement (length 5 km, width 25-50 m) ・Old Negombo Canal Improvement (length 4.5 km, width 40 m) ・Storm Water Retention Area (lower area 360 ha, upper area 89 ha)
Bolgoda	・Weras Ganga Scheme (length 5.5 km) ・Nugegoda-Rattanapitiya Scheme (length 5.47 km) ・Bolgoda Canal Scheme (length 2.4 km) ・Boralesgamuwa North Scheme (length 3.09 km) ・Boralesgamuwa South Scheme (length 0.98 km) ・Maha Ela Scheme (length 4.46 km) ・Ratmalana-Moratuwa Scheme (length 11.12 km) ・Storm Water Retention Area (retention area in Weras Ganga basin 295 ha, lowlands surrounding North and South Bolgoda Lakes 4,739 ha)
Ja Ela	・Ja Ela Channel Improvement (length 7 km, width 60 m) ・Dandungam Oya Channel Improvement (length 9.9 km, width 70-80 m) ・Storm Water Retention Area (lower area 500 ha, upper area 376 ha)

Source: The Study on Storm Water Drainage Plan for the Colombo Metropolitan Region (2003)

In the study, Weras basin that is northern part of Bolgoda basin has been selected as the priority basin and F/S for the Weras basin has been conducted.

Progress after SWDPCMA

According to SLLRDC, the progress after SWDPCMA is as shown in Table 2.3.15.

Table 2.3.15 Progress after SWDPCMA

Basin	Progress
Greater Colombo	Being implemented by Metro Colombo Urban Development Project (MCUDP) supported by World Bank. Madiwela South Diversion is not included in MCUDP.
Kalu Oya	Not yet implemented. F/S is on-going by government fund.
Bolgoda	Being implemented by government fund for Wares basin.
Ja Ela	Not yet implemented. Master plan will be formulated by CRIP supported by World Bank, and priority projects will be implemented in CRIP2.
Mudun Ela	Basic study for pump station has been completed by government fund.
Kolonnawa	Basic survey for drainage channel is on-going by government fund.

Source: SLLRDC

After the devastating flood disasters in Metropolitan Colombo area in 2010, Metro Colombo Urban Development Project (MCUDP) supported by World Bank has been implemented in Greater Colombo basin.

When MCUDP started, SWDPCMA was first reviewed considering heavy rainfall events in 2010. The review concluded that it is necessary to implement more measures than the ones recommended by SWDPCMA.

Madiwela South Diversion was recognized as the highest priority project in the review. However, its implementation had been planned in Weras basin project at that time, and thus Madiwela South Diversion was not included in MCUDP. Afterwards, the Madiwela South Diversion was not implemented in Weras basin project. Currently there is no clear implementation plan for Madiwela South Diversion.

Figure2.3.8 shows the measures implemented by MCUDP and progress. The implementation period of MCUDP was originally 2012-2017. However, it would be extended for another two years. According to SLLRDC, Kolonnawa Canal diversion could be implemented after 2017.

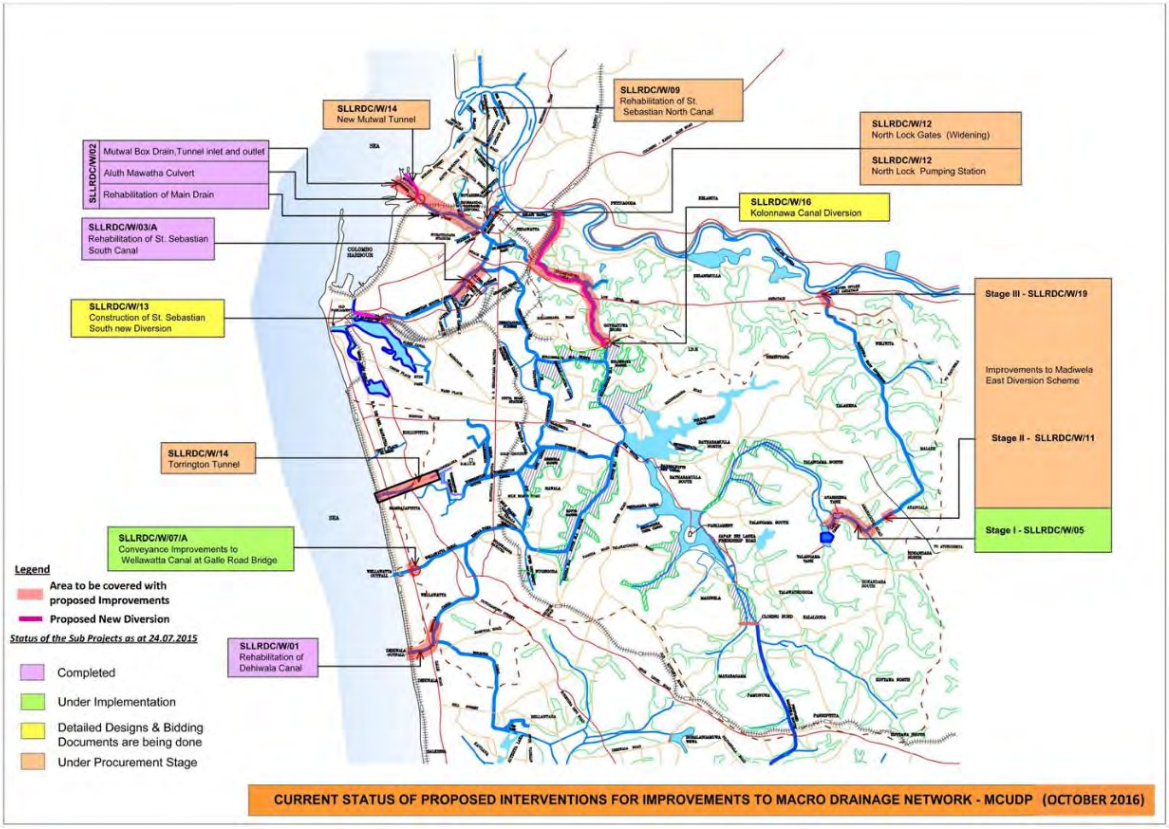


Figure2.3.8 Measures implemented by MCUDP and progress
Source: SLLRDC

Other Efforts by SLLRDC

The SLLRDC is implementing urban flood mitigation projects by government fund as shown in Table 2.3.16. The total project cost for 2014 is US$10million.

Table 2.3.16 Urban flood mitigation project implemented by SLLRDC with government fund

Project Name
Drainage Improvements and Landscaping work in and around Bloemendhal, Mattakuliya, Crow Island area and its surroundings
Drainage Developments, Flood Control & Urban Landscaping Improvements in and around Mudun Ela, Peliyagoda, Oliyamulla, Kelaniya and Kiribathgoda area and its surroundings
Flood Mitigation Works and Improvement of Landscaping Works along Kittampahuwa Canal, Kolonnawa, Meethotamulla, Mulleriyawa and Angoda area and its surroundings
Flood Mitigation Works and Improvement of Landscaping Works in and around Bolgoda Canal and its surroundings
Flood Control, Environment Improvement, Landscaping Works in Parliament Upper Catchment and its surroundings
Drainage Improvements and Urban Development along Heen Ela marshy area, Pagoda area and its surroundings including Kirulapone – Heen Ela bifurcation
Dredging and Rehabilitation Works to Beira Lake and Inlets & Outlets around the whole area of the lake
Drainage Improvements in and around Maligawatta, Applewatta area and its surroundings
Dredging and Rehabilitation of Lunawa Canal Network. Lunawa Lake and its surroundings
Protection and Improvements of Water retention area in order to facilitate retention capacity by creating lakes, ponds and dredging of peripheral canals
Flood Mitigation & Storm Water Drainage Projects outside Colombo District

Source: SLLRDC

Furthermore, SLLRDC is contracted with clients on the projects shown in Table 2.3.17.

Table 2.3.17 Contracted projects by SLLRDC

Project Name	Client
Drainage Improvement at Modarawila Integrated Urban Development Project at Panadura – Stage 2	District Secretary, Kalutara
Construction of Retarding Wall & Linear Park at Kirama Oya, Tangalle	DMC
Proposed Drainage System & Improvement of Play Ground at Padukka	UDA
Town Center Development at Ehaliyagoda	UDA
Development of Land for the Office of the Public Service Commission at Battaramulla	Public Service Commission
Redevelopment of Existing Canals at Heenpandela, Galle	District Secretary, Galle
Proposed Land Improvement Work for Makumbura New Township Development Project – Stage 1	UDA

Source: SLLRDC

Land Use Plan and Regulation in Urban Area

As one of the activities related to mainstreaming of DRR, UDA considers disaster risk into zonation when urban development plan is formulated.

UN-Habitat is implementing Disaster Resilient City Development Strategy for Sri Lankan Cities with UDA and DMC as partners, utilizing fund from Australia. In the project, preparation of land use plan that considers disaster risk is supported for selected pilot cities. The project cost for phase 1 is US$1million. Phase 1 was implemented from 2012 to 2013. Four cities (Batticaloa UC, Ratnapura MC, Kalmunai MC, Balangoda MC) were selected in Phase 1. In Phase 2, Akkaraipattu MC, Mannar UC, Vavuniya UC and Mullaitivu Pradeshiya Sabha are targeted.

For land use regulation, the revision of SLLRDC law is under preparation, in order to strengthen authority to protect wetland areas from unauthorized development. It is expected that the

revised law would contribute to prevent unregulated development of wetland where flood risk is high.

The government of Sri Lanka aims to strengthen regulation of development in disaster risk area, by returning authority of permission for development and building to UDA in February 2017 after devastating flood and sediment disaster in May 2016. However, its authority is still limited to large scale development and building (development with land area of more than 1,000m2 and building with floor area of more than 371 m2).

NBRO is currently preparing database and monitoring for buildings in sediment disaster risk area. NBRO is interested in doing similar for flood risk area in future.

(2) Support by JICA

Figure2.3.9 shows history of support of JICA for flood mitigation project.

JICA has been continuously supporting flood mitigation projects in Metropolitan Colombo area from the 1990s. Four Yen loan projects had been completed by 2010. The outlines of these projects are described in Table 2.3.13. Furthermore, the Study on Storm Water Drainage Plan for the Colombo Metropolitan Region (SWDPCMR) was implemented from 2001 to 2003, and drainage master plan for Metropolitan Colombo area was formulated.

The Comprehensive Study on Disaster Management in Sri Lanka was implemented from 2007 to 2009. The project included studies on flood mitigation plan in south eastern river basins (Kelani Ganga, Kalu Ganga, Gin Ganga and Nilwala Ganga). F/S on the priority projects identified in the flood mitigation plan was conducted under Preparatory Study for Flood Risk Management and Climate Change Adaptation from 2010 to 2011. However, the project has been suspended since the mutual agreement among relevant stakeholders was not obtained.

During December 2011 and February 2012, severe flood disasters that damaged roads and irrigation facilities occurred in central, north central and eastern provinces due to heavy rainfall. Emergency Natural Disaster Rehabilitation Project was implemented from 2011 to 2015 to recover the damaged infrastructure.

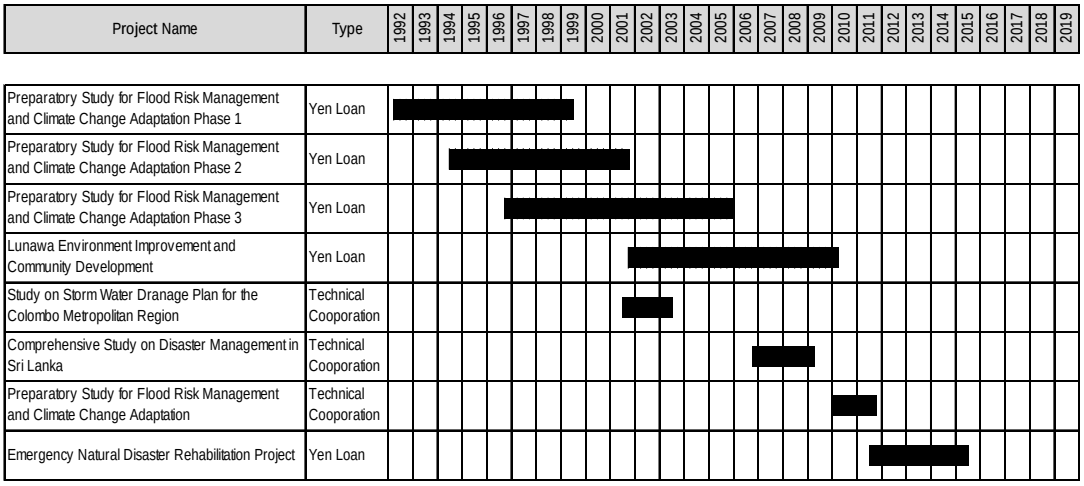


Figure2.3.9 History of support of JICA for flood mitigation project
Source: MOFA (Japan) and JICA web-page

(3) Support by Other Donors

Support by other donors for flood mitigation projects is described in Section (1). Table 2.3.18 summarizes the support by other donors.

Table 2.3.18 Support by other donors for flood mitigation project

Donor	Project Name	Duration	Project Cost	Remarks
World Bank	Dam Safety and Water Resources Planning Project (DSWRPP)	2008-2018	US$70mil.	
	Dam Safety and Water Resources Planning-Additional Financing	2014-2018	US$83mil.	
	Metro Colombo Urban Development Project (MCUDP)	2012-2017	US$321mil.	It is expected to be extended by 2 years.
	Climate Resilience Improvement Project for Sri Lanka (CRIP)	2014-2019	US$110mil.	CRIP2 will start from 2017.
	Climate Resilience Improvement Project-Additional Financing	2014-2019	US$42mil.	
	Flood Risk Modelling and Pre-Feasibility Studies for Flood Risk Management in Mundeni Aru Basin in Sri Lanka	2016-2017	n.a.	
UN-Habitat (AusAid)	Disaster resilient City Development Strategy for Sri Lankan Cities	2012-2013 (phase1) 2014- (phase 2)	US$1mil. (phase 1)	

Source: Web-page of donors and hearing from relevant agencies

(4) Issues

1) Increasing Trend of Flood and Drought Risk and Recognition of Flood and Drought Risk in Detail

It is expected that flood hazard may increase in the future due to climate change. The overlay analysis between the flooded area based on information on past floods and change in population distribution in the last 15 years showed that the exposures in the flooded area are increasing.

With the increasing trends of flood and drought risk due to change in climate and social conditions, the recognition of flood and drought risk in details using the latest natural and social data will become more important.

2) Improvement of Legal and Institutional Aspect on Flood Mitigation

Sharing of roles and responsibilities on flood management among relevant agencies are not clearly described in the existing flood ordinance. No authority for non-structural measures are included. Flood mitigation at basin level and urban flood mitigation are not always coordinated well. The existing SLLRDC law is not enough to prevent unregulated development of wetland where flood risk is high. In order to improve this situation, it is necessary to revise the existing laws and promote well-coordinated flood mitigation measures among relevant agencies.

3) Promotion of Investment Plan with IWRM Concept

It is expected that the basin investment plan which will be prepared under CRIP will be the plan with Integrated Water Resource Management (IWRM) concept considering both flood and drought mitigation. In CRIP, US$13 million has been allocated to prepare the basin investment

plan. The basin plan for eastern basins will also be prepared with support of World Bank. In four high priority basins, priority projects will be identified by the middle of 2017 and will be implemented in CRIP2.

Although the investment plans to mitigate flood and drought have been developed in some basins, there are still no plans for other basins. ID recognizes other 12 important basins in addition to the basins selected by CRIP and another World Bank project. It is necessary to prepare basin plans for these basins, in order to promote further investment.

4) Renewal of Urban Drainage Master Plan, Considering Change in Natural, Socio-economic Conditions and Urban Development Scenario

The MCUDP supported by World Bank allocated US$115 million to flood mitigation measures in Greater Colombo basin. However, many proposed projects in drainage master plan for Metropolitan Colombo area in 2003 have not yet been implemented except for Greater Colombo basin and Weras basin (part of Bolgoda basin). Meanwhile, the natural conditions such as rainfall and socio-economic situation and urban development scenario have already changed. It is, therefore, necessary to review and renew the master plan to reflect such changes. It is also important to coordinate with the flood mitigation measures which will be proposed in the basin investment plan for Kelani Ganga.

5) Landuse Plan Considering Flood Risk

There are cases that existing land use plan does not coincide with planned protected area from flood. The information on buildings in flood risk are is not enough. It is necessary to update the land use plan considering the detail information on flood risk area and to enhance monitoring of buildings in flood risk area.

6) Enhancement of Flood Operation and Establishment of Monitoring and Flood Warning System at Basin Level

As shown in Section 2.3.5(1), ID launched a flood operation room to execute integrated flood operation including hydrological information and release from reservoirs, which urgently requires enhancement of its capacity. Based on the enhanced hydrological monitoring systems so far, it is necessary to establish monitoring and flood warning system at basin level.

2.3.3 Sediment Disaster Risk Reduction

(1) Status and Efforts on Sediment Disaster Risk Reduction

The NBRO has been the responsible agency to establish standards and laws related to building, material testing and research in construction field. Presently, NBRO is positioned as the main organization for sediment disaster risk reduction in the NDMP and NEOP. Besides, NBRO is also the responsible agency in the environmental fields for the Initial Environmental Examination (IEE) and the Environmental Impact Assessment (EIA) implemented by the Central Environmental Authority (CEA) especially in sediment disasters and natural condition such as geology and hydrology. Thus, NBRO conducts the necessary technical investigations and assessments as well as provide advices to various government agencies and private sectors for the development activity. The roles and responsibilities of each agency regarding sediment disaster are summarized as Table 2.3.19.

Table 2.3.19 Roles and responsibilities of relevant agencies in sediment disaster

Organization	Role and Responsibility
MDM	・ Coordination of relevant agencies in disaster response
DMC	・ Data collection of disaster ・ Information sharing with local authorities and residents
NBRO	・ Pre/post disaster survey and mitigation planning ・ Preparation of landslide hazard zonation map ・ Awareness raising and relocation for residents living in high risk areas ・ Issuing Landslide Warning based on real-time rainfall observation ・ Landslide monitoring and implementation of countermeasures ・ Technical advice and assessment of development activity in the central mountain area
DoM	・ Observation and forecasting of rainfall
RDA	・ Construction and maintenance of slope countermeasures and recovery for the main national road
UDA	・ Regulation of land use plan in housing development in urban area ・ Housing regulation in hazardous area based on the hazard map ・ Coordination of relocation for residents in urban area
District Secretary	・ Disaster response based on information and advice from technical agencies

Source: JICA Survey Team based on interview result

1) Role and Activity of NBRO

Recently, landslides have frequently occurred in the central highland area in Sri Lanka. Those are triggered by several factors such as changing rainfall pattern, extreme heavy rainfall due to climate change and geological and topographical conditions. Residential development in the mountain and highland area due to population growth is also a cause of recent increasing landslides. Accordingly, landslides damage not only human life but also infrastructures such as main national roads. In addition, such risk is recently increasing because of unregulated or unlicensed land use and unplanned land (slope) modification without proper countermeasures.

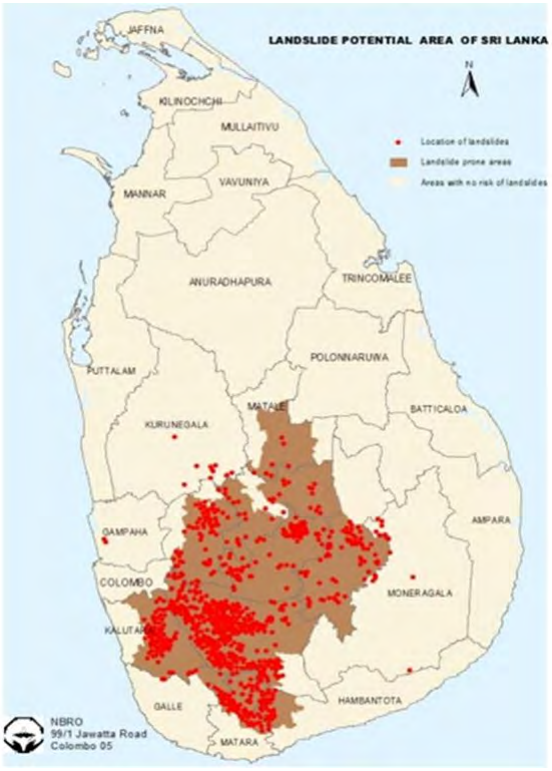


Figure2.3.10 Distribution of landslides (1947-2007) and NBRO district offices

Source: LRRMD, NBRO

The NBRO is designated as the National Focal Point for landslide risk management including implementation of structural and non-structural countermeasures. To deal with this task, NBRO has 9 district offices for 10 landslide prone districts of Badulla, Nuwara Eliya, Ratnapura, Kegalle, Kandy, Matale, Kalutara, Galle, Matara, Hambantota Galle, Matara and Hambantota (Hanbantota is under responsible of Matara office). Figure2.3.10 shows the distribution of recent landslides and location of NBRO district offices.

Recently, NBRO selected priority projects in four districts (Badulla, Kandy, Matale and Nuwara Eliya) as "Integrated Landslide Mitigation Project (2012)". Each project has been implemented by using governmental budgets and support from international donors. NBRO is currently preparing "Landslide Risk Management Plan (2017-2021)" to strengthen internal institutional structure.

Investigation, Monitoring and Observation

Development sectors in Sri Lanka generally consult with NBRO on investigation, designing of countermeasures and assessment on sediment disasters on their businesses. Since there are limited engineers with expertise in sediment disaster in each sector, NBRO is providing necessary technical services to such development projects.

Under the "Technical Cooperation for Landslide Mitigation Project (TCLMP)" and "Landslide Disaster Prevention Project (LDPP)" supported by JICA, NBRO and RDA are collaborating in implementing the investigation, countermeasure designing and monitoring by use of equipment provided by the projects (refer to Figure2.3.11 and Figure2.3.12).

Following what NBRO did at TCLMP, the same level of investigation and countermeasure for the entire landslide hazardous area is difficult due to financial restriction. Therefore, automatic monitoring systems and structural countermeasures should be implemented at only priority sections of important infrastructure (national roads and railway) and public facilities (schools, hospitals and etc.) and highly populated area. For the other minor landslides, development of low cost early warning system using simple equipment is practical measures for risk reduction.

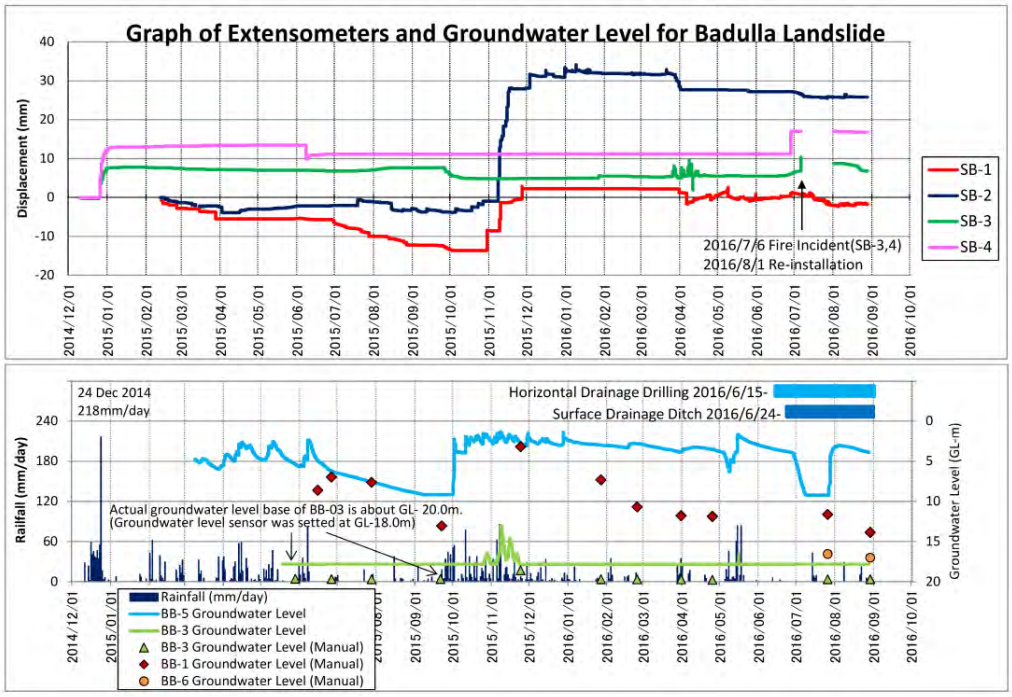


Figure2.3.11 Visualization of extensometer and groundwater level
Source: JICA Technical Cooperation for Landslide Mitigation Project

Simple Rain Gauge installed at Southern Highway

Automatic Rain Gauge (NBRO and ITI)

Observation Equipment installed by LDPP (Extensometer and Groundwater Gauge)

Figure2.3.12 Example of observation equipment installed by NBRO

Source: Presentation from NBRO

Development of Landslide Hazard Zonation Map

The NBRO is preparing 1:50,000 and 1:10,000 scales landslide hazard zonation maps based on existing disaster record, geological and topographical information. 1:50,000 scale maps are almost completed in the landslide prone area. Detailed survey for 1:10,000 scale maps is on-going. The progress of prepared landslide hazard zonation maps and the landslide prone area are shown in Figure2.3.13 and Figure2.3.14 respectively. The landslide hazard zonation maps are utilized for land use planning and development activities in relevant agencies. It is important to expand the mapping area and to improve the accuracy.

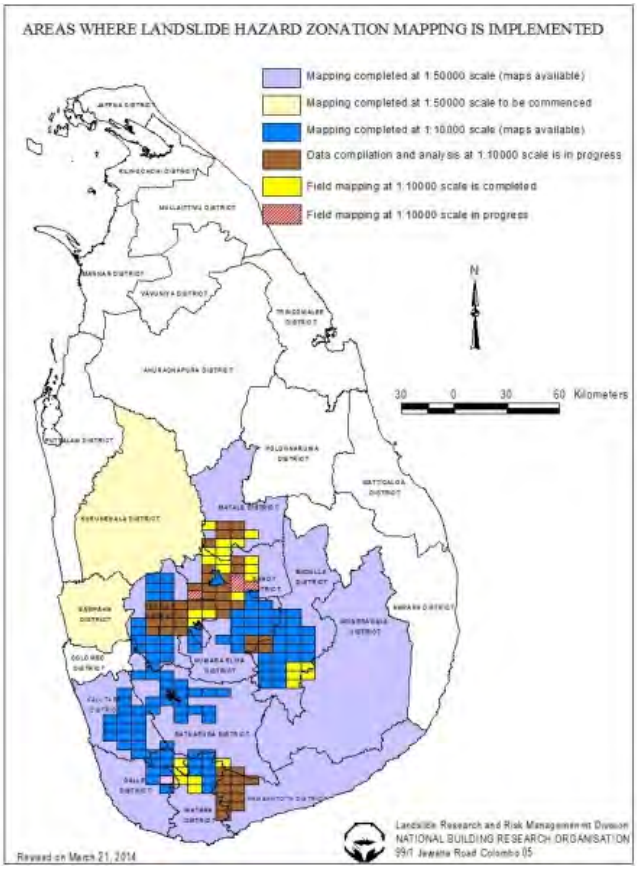


Figure2.3.13 Area where landslide hazard zonation mapping is Implemented

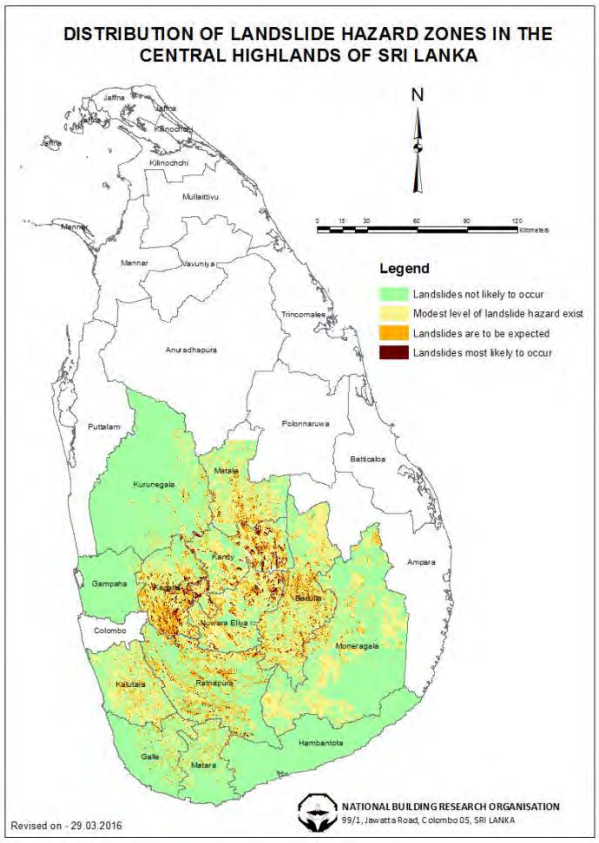


Figure2.3.14 Distribution of landslide hazard zones in the Central Highlands

Source: LRRMD, NBRO

Landslide Early Warning

The NBRO has developed an independent automatic rain observation system for landslide early warning since 2005. As of December 2016, 109 stations have already been installed. Other 51 stations are under operation checking. The operation will start on May 2017 (refer to Table 2.3.20). Distribution of rain gauges is shown in Figure2.3.15.

Table 2.3.20 Installation of rain gauge in each district

District	UNDP1	NGI	UNDP2	LDPP	GFDR	UNDP	GOSL	Total
Badulla			7	9			13	29
Nuwara Eliya		1	9	11			8	29
Kandy		1	7	7			10	25
Matale		2	3				4	9
Kegalle			7	1			7	15
Ratnapura	5			2	14			21
Kurunegala			2				1	3
Kalutara						5	2	7
Galle						5	2	7
Matara						5	4	9
Hambantota						3		3
Monaragala						2		3
Total	5	4	35	30	15	20	*51	160

*51 stations which are supported by GOSL budget aren't completed Source: Presentation from NBR

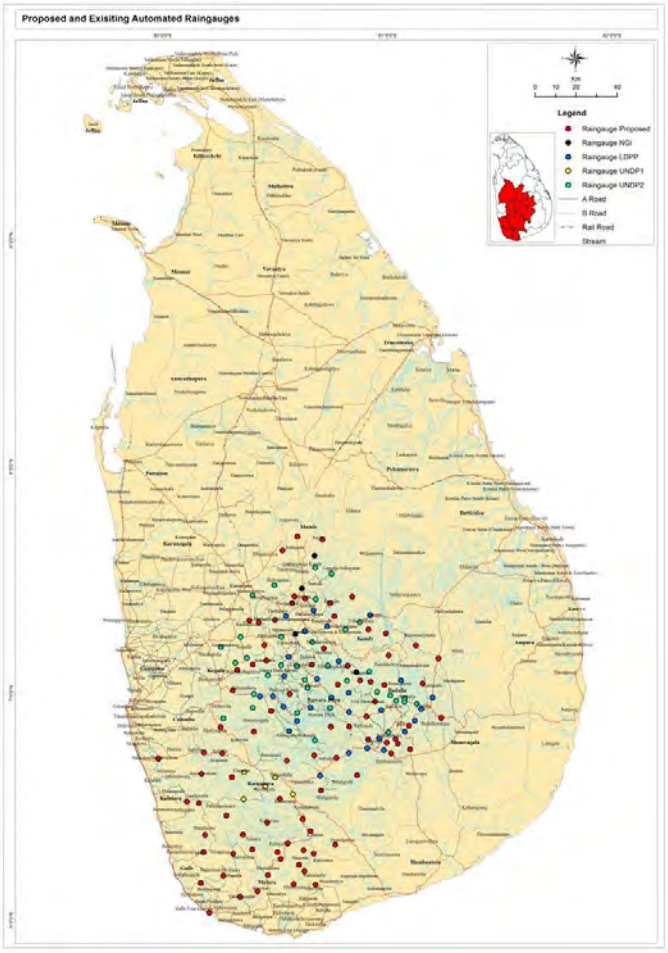


Figure2.3.15 Location of automatic rain gauge operated by NBRO
Source: LRRMD, NBRO

The real-time observed rainfall data is transmitted to NBRO's server by using GSM network. Hourly and daily rainfall data are available at NBRO website. Authorized DRR related agencies also are able to access rainfall information at the website. NBRO issues district level landslide early warning based on the observed rainfall information. The threshold of early warning is shown in Table 2.3.21.

Warning messages are sent to DMC by FAX, and published at NBRO's website at the same time. DMC is the responsible agency to issue the warnings to the residents, but NBRO also shares the warning information with the media such as TV, radio, etc.

Table 2.3.21 Threshold of landslide early warning

Warning Level	Rainfall
Alert	75 mm / day
Warning	100 mm / day
Evacuation, Off-limit	150 mm / day or 75 mm / hr

Source: LRRMD, NBRO

Resettlement for Landslide Risk Area

Awareness raising activities in landslide prone area, recommendation of resettlement, land selection for resettlement, designing of resettlement land (resilient housing, retaining wall, drainage works, etc.) and land modification works are also the responsibility of NBRO.

According to NBRO, there are 5,000 families living in landslide prone areas. NBRO promotes resettlement for the area identified as "High" risk area. As for the communities identified as "Middle" and "Low" risk area, mitigation measures and early warning and evacuation training shall be done.

Presently, NBRO has no legal authority on resettlement and housing approval. Hence, it is difficult to enforce resettlement of people living in landslide prone area. Especially in case of tea plantation area, the resettlement procedure is complicated due to negotiation with plantation estates. The final policy decision on housing and construction of infrastructures resides with the District Secretary. In addition, there are some cases of housing developments without sufficient evaluation and countermeasures.

For this situation, NBRO has submitted NBRI (National Building Research Institute) Act to the cabinet in 2014 for strengthening the institutional capacity and authorities of NBRO. On the other hand, Urban Development Authority (UDA) took over a part of authority on land development and construction from Local Authorities under Decision No.21/2016. Based on the Decision, all development and construction having over four floors and 4,000 square ft must be approved by UDA.

The NBRO has been managing only small-scale resettlement projects until now. In recent disasters, however, the project scale became larger, similar to that in the national level. The government agencies, including NBRO, don't have enough experience dealing with such large scale resettlement.

In case of Koslanda landslide in Meeriyabedda that occurred in October 2014, 75 families were resettled in cooperation with UDA, Army, MDM, NBRO and relevant agencies. In this case, NBRO was responsible for land selection and land modification for relocation area. Since this landslide occurred inside a tea plantation, the plantation managing authorities were also involved in the process of resettlement. The key stakeholders for resettlement of Koslanda are shown in Figure2.3.16.

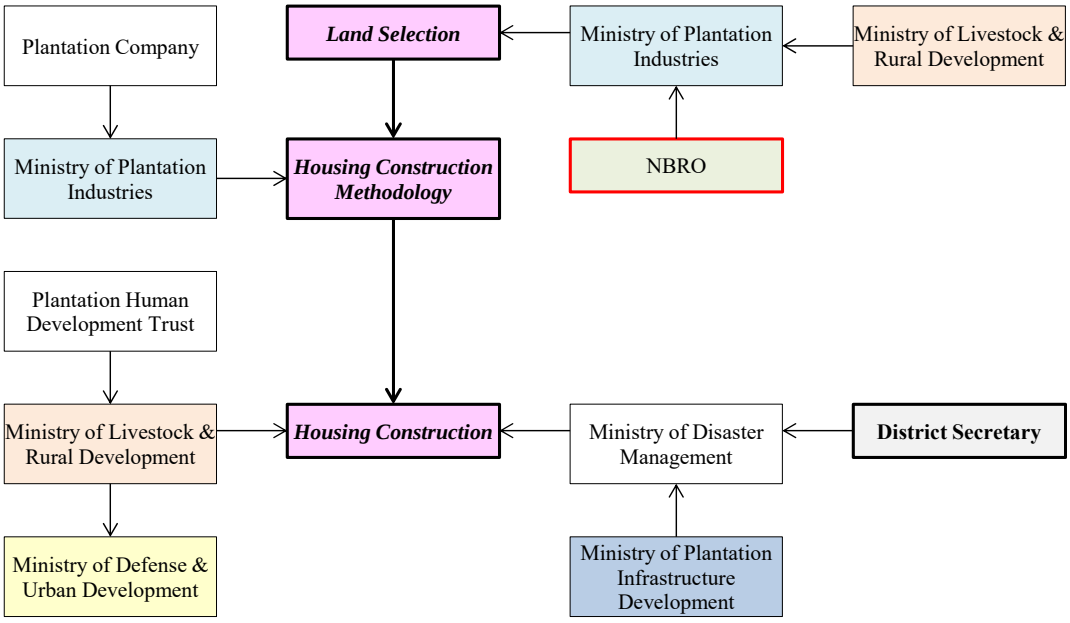


Figure2.3.16 Stakeholders for resettlement of Koslanda
Source: Human Settlements Planning & Training Division, NBRO

The following issues were revealed in response to Koslanda landslide:

- At the beginning, there was no responsible agency to coordinate the entire response activities. Each agency made efforts for their specific fields respectively.
- There was no agency to implement countermeasures to ensure safety at the resettlement area.
- The resettlement area was developed without appropriate infrastructure.

Finally, the MDM was designated as the responsible organization to conduct monitoring and coordination. Resettlement project has been completed in about two years.

The landslide in Koslanda was an important opportunity to reconsider the resettlement procedure and to re-establish warning system to the local people. Generally, GN has responsibility to warn people to evacuate. However, there was different understanding on the responsibility in case such disaster occurs inside a plantation area. NBRO is promoting to clarify the role and responsibility as well as information sharing between agencies.

2) Landslide Mitigation for the National Roads

Road Network

Road network in Sri Lanka is divided into five (5) classes as shown in Figure2.3.17 and Table 2.3.22. RDA is responsible for Class A and B roads.

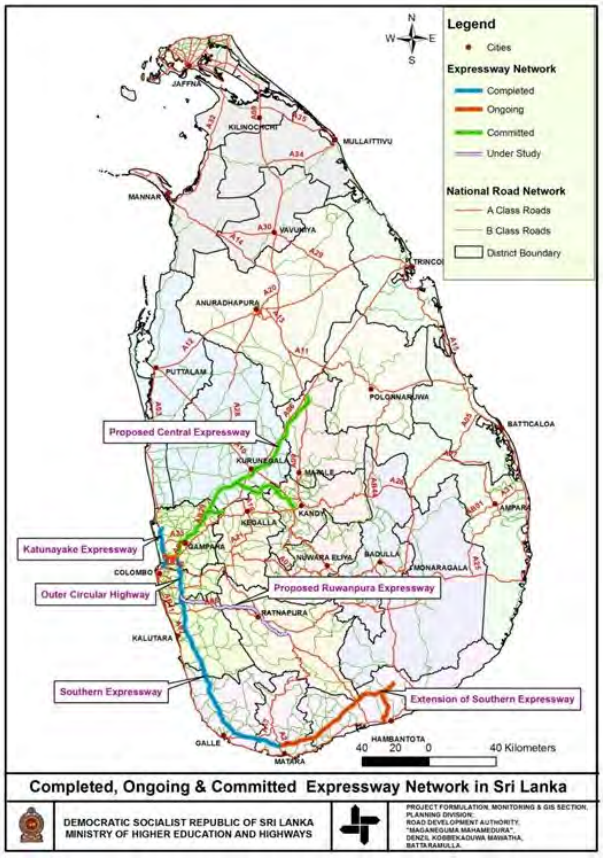


Figure2.3.17 Road Network in Sri Lanka
Source: Planning Deapartment, RDA

According to the Economic and Social Statistics 2016 published by the Central Bank of Sri Lanka, the total length of Class A, B, C and D roads (excluding the expressway) is 31,110 km as of 2015 (12,210 km for Class A and B). The total length of the roads located in the 10 districts of mountain area is 14,422 km (5,589 km for Class A and B) as shown in Table 2.3.23. The road in mountain area is about 46% of the road extension of entire country.

Table 2.3.22 Road classification in Sri Lanka

Class	Description
Class A	Main roads connecting Colombo Metropolitan and provincial capitals. The surfaces are paved. The lane width is 24 ft. to 36 ft. (total width is 36 ft. to 56 fit.)
Class B	Main roads connecting other important towns. The surfaces are mostly paved (some sections are not).
Class C	Rural and local roads. The lane width is about 12ft (total width is 22ft). The surfaces are mostly paved (some sections are not).
Class D	Unpaved road. The width is 8ft. to 10ft. Generally motorable during dry weather only.
Expressway	Southern Expressway, Katunayake Expressway, Outer Circular Highway

Source: JICA Data Collection Survey for Road Disaster Management in Disaster Vulnerable Area in Sri Lanka

Table 2.3.23 Road kilometrage in mountain area

District	Class A	Class B	Class C	Class D	Total
Badulla	267	432	1,109	406	2,214
Nuwara Eliya	120	492	433	49	1094
Kandy	184	563	934	352	2033
Matale	105	283	299	177	864
Kegalle	144	365	559	714	1782
Ratnapura	272	440	688	830	2230
Kalutara	80	341	417	247	1085
Galle	97	393	387	272	1149
Matara	135	257	288	243	923
Hambantota	115	504	240	200	1059
計	1519	4070	5,354	3490	14,433

Source: Central Bank of Sri Lanka, Economic and Social Statistics of Sri Lanka 2016

Slope Management for National Road

The national road in the central mountain area is important infrastructure for transportation, life of local residents, economic development, tourist business and others. Once landslide occurs along the roads, it takes time to restore the roads compared to flood and strong wind damages. RDA is expanding new road construction and widening of the mountain roads responding to increasing traffics. However, consideration of slope protection and stabilization is not sufficient. There are many steep cutting slopes without any countermeasures. Small-scale slope protection measures such as gabion wall are partly implemented, but no major structural measures for landslide prevention have been applied as yet.

The LDDP project has been implemented by RDA with support from Japanese loan. Slope stabilization and landslide prevention works will be done using Japanese technology and experience for 16 sites along the Class-A national road. NBRO has also participated in the project as consultants conducting technical investigation and monitoring. Target sites and proposed countermeasures by LDPP are shown in Figure2.3.18 and Table 2.3.24.

Table 2.3.24 Proposed countermeasure of LDPP

Disaster Type	Control Works	Prevention Works
Landslide Slope Failure	・Lightweight Embankment ・Earth Removal ・Gabion Wall ・Hydroseeding ・Horizontal Boring ・Surface Drainage	・Crib Works ・Groundanchor ・Drainage Well with Horizontal Boring
Rockfall	・Anti Rockfall Net ・Shotcrete ・Rockbolt Work	・Rock Fence ・Rope Net ・Concrete Guard Wall

Source: LDPP Project Office, RDA

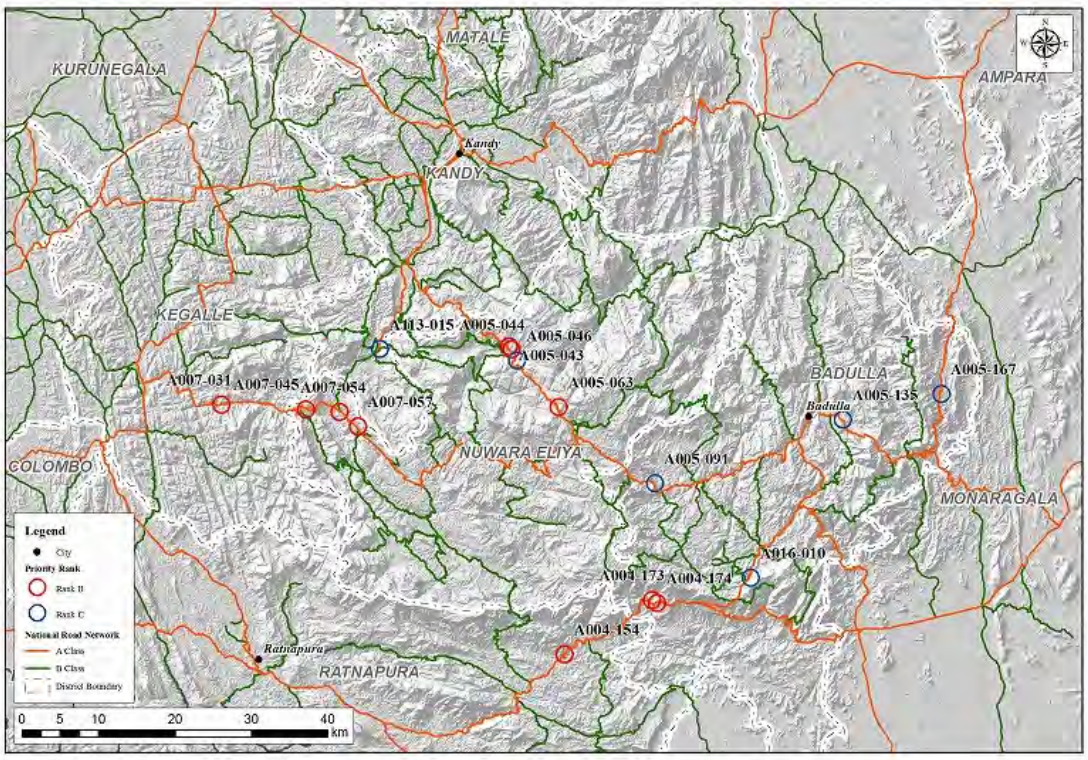


Figure2.3.18 Location map of LDPP

Source: LDPP project office, RDA

(2) Support by JICA

Since 2010, JICA continuously supports the Government of Sri Lanka on sediment disaster risk reduction sector. Especially for NBRO, technical cooperation for capacity development on landslide investigation, monitoring, risk assessment and mitigation measures have been carried out. For RDA, LDPP is under implementation by Yen loan to stabilize important national roads utilizing Japanese knowledges and technologies.

The previous and ongoing projects are shown in Table 2.3.25.

Table 2.3.25 Project for sediment risk reduction supported by JICA

Project Name	Type	Duration
The Disaster Management Capacity Enhancement Project Adaptable to Climate Change	Technical Cooperation	2010-2013
Data Collection Survey for Road Disaster Management in Disaster Vulnerable Area in Sri Lanka	Data Collection Survey	2012
Data Collection Survey on Disaster Management Program in Sri Lanka	Data Collection	2013
Landslide Disaster Prevention Project for the National Roads	Yen Loan	2013-2017
Technical Cooperation for Landslide Mitigation Project	Technical Cooperation	2014-2018
Capacity Development Project for Creating Digital Elevation Model Enabling Disaster Resilience	Technical Cooperation	2014-2016

On the other hand, "Capacity Development Project for Creating Digital Elevation Model Enabling Disaster Resilience" was implemented with Survey Department as counterpart agency. This project developed detailed topographic data by LiDAR survey. The output of the projects can be utilized for not only sediment disaster but also for the other sectors such as irrigation and land use planning. According to Survey Department, the data processing at the Colombo and Ganpaha Area have almost been completed. The data processing of the mountain area may be completed by June 2017. Target area of the survey is shown in Figure2.3.19.

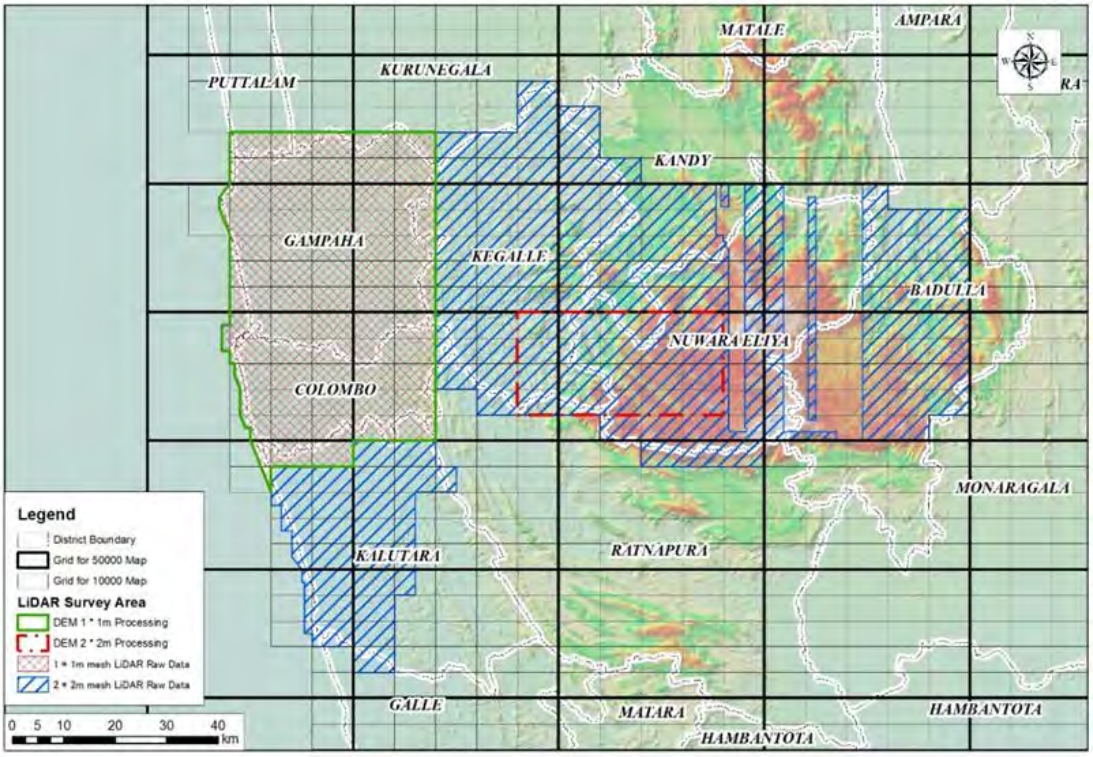


Figure2.3.19 Target area of aerial photo and LiDAR Survey
Source: Capacity Development Project for Creating Digital Elevation Model Enabling Disaster Resilience

(3) Support by Other Donors

In the following WB projects, several landslide mitigation works have been implemented.

Table 2.3.26 Project for sediment disaster risk reduction supported by other donors

Project Name	Donor	Duration
Climate Resilience Improvement Project （CRIP）	WB	2014-2019
Climate Resilience Improvement Project Additional Financing（CRIP A/F）	WB	2017
Dam safety and Water Resources Planning	WB	2008-2018

In CRIP project, school protection and drainage improvement for the selected 18 schools in Kandy district have been implemented. NBRO has already completed investigations and designing for all the sites. The selected schools are listed in Table 2.3.27.

Table 2.3.27 List of target schools in Kandy District by CRIP

No	School Name	Division	Grama Niladhari
1	St. Joseph Girls College	Gampola	Keerapane
2	Haloluwa Navodya Maha Vidyalaya	Harispattuwa	Halolwa
3	Wattegama Central College	Patha Dumbar	Wattegama -North
4	Kurukuthala Maha Vidyalaya	Udunuwara Ihala	Kurukuthala
5	Jinaraja Girls' College	Udapalatha	Aregoda
6	Galkanda Maha Vidyalaya	Poojapitiya	Glakanda
7	Bothota Maha Vidyalaya	Harispattuwa	Bothota
8	Vidyartha Vidyalaya	Kandy	Mahaiyawa
9	Kasawatta Muslim Vidyalaya	Kandy	Kasawatta
10	Molagoda Maha Vidyalaya	Poojapitiya	Haranthota
11	Sri Piyarathana Maha Vidyalaya	Harispattuwa	Gonigoda
12	Gampola Buddhist College	Udapalatha	Kendakaduwa
13	Hillwood College	Gangawata Korale	Malwatta
14	Gothami Girls' College	Gangawata Korale	Malwatta
15	Mahamaya Girls' College	Gangawata Korale	Ampitiya - South
16	Dharmaraja College	Gangawata Korale	Boowelikada
17	Mediwake Kanishta Vidyalaya	Ududumbara	Mediwaka
18	Sirimalwatta Maha Vidyalaya	Kundasalaya	Sirimalwatta

Source: JICA Survey Team prepared based on interview with NBRO

Under CRIP, slope stabilization works for several road sections were also conducted by RDA. It is going to be extended by using additional finance of CRIP as well. The target road sections are as follows:

- Kandy - Mahiyangana Road (18 locations),
- Awissawella - Hatton Road (2 locations), and
- Beragala - Wellawaya Road (2 locations)

(4) Issues

1) Legal Arrangement for Sediment Disaster Risk Reduction

Considering the increasing large scale sediment disasters in recent years, the roles and responsibilities of NBRO are getting more important than before. However, NBRO has no authority to enforce regulations for inappropriate housing constructions and development activities due to unclear legal background.

Such sediment disaster risk reduction activities are basically conducted by the "Landslide Research and Risk Management Division (LRRMD)" in NBRO. The human resources and institution of LRRMD are not sufficient at the moment according to the draft "Landslide Risk Management Plan (2017-2020)" under preparation by NBRO. Once the NBRI Act is enforced, the authority and responsibilities of NBRO will increase. The Act, once approved, is expected to strengthen organizational structure of NBRO to deal with increasing future activities.

2) Improvement of Landslide Hazard Zonation Map

The current landslide hazard zonation maps show in-situ slope stability. It doesn't indicate the affected area when debris flows down to the foothill area (such as Koslanda in 2014 and Aranayake landslides in 2016). Therefore, the maps are not sufficient to evaluate safe evacuation places and to utilize for land use planning. NBRO examines application of a simulation software "Rapid Mass Movements: RAMMS" developed by Switzerland. NBRO is also considering application of Japanese methodology for debris flow warning zone setting, so called "Yellow zone" under TCLMP project.

It is also necessary for improvement of hazard zonation maps to update topographic information. LiDAR-DEM supported by JICA can contribute to the accuracy of the maps.

3) Improvement of Threshold of Landslide Early Warning

The NBRO will complete the installation of 160 automatic rain gauges by the end of May 2017. In the present landslide early warning, an uniformed rainfall criteria has been used for the entire country based on past study and experience. Rainfall characteristics in each district or division are not considered for the threshold. Therefore, even if NBRO develops high resolution rainfall monitoring system, it is difficult to issue warnings at division level.

It is necessary to analyze the relationship between rainfall and landslide disaster occurrence, and develop warning criteria using accumulated rainfall and working rainfall that are well employed in Japan.

4) Unified Format for Disaster Records

The NBRO has accumulated sediment disaster records over the years regardless of the scale. Most of the records are only stored in hard copy at NBRO district offices. The record format varies depending on each surveyor. They are not compiled as uniform data.

The disaster records are precious source of information not only for evaluation of the relationship between rainfall and landslide but also for other research activities. Some records are processed to be converted to digital data by NBRO. The efforts should be continued so that the data can be inputted into a database system.

5) Prioritization and Investment in Important facility and transportation system

Due to financial limitation, core structural measures should be concentrated to protect public facilities (e.g. school, hospital) and important infrastructure (e.g. road, railway system). Such investment should be prioritized based on proper hazard assessment and importance of facilities.

The government of Sri Lanka has allocated Rs 200 million (US$ 13 million) to NBRO as regular budget for small-scale landslide mitigation works since 2014. In 2015, 12 structural measures were implemented by using the budget. It seems the budget will continue to be allocated in future, but more human resources are required in NBRO for the proper project management.

The TCLMP project is implementing slope stabilization works investing Rs 82 million for three pilot sites (approximately Rs 15 million for 1 site / year). The same scale slope stabilization works can be replicated in other sites by using the regular budget. Furthermore, it is expected that NBRO will strengthen the project management capacity and risk assessment methodology to maximize the investment impact.

On the other hand, there is no mechanism and division for comprehensive road slope management in RDA. Stability assessment and prioritization of the road stabilization are depending on NBRO's technical advisory. From viewpoint of comprehensive road management on planning, construction, maintenance and rehabilitation, RDA should establish a road database system on slope stability and disaster records as well as secure maintenance budget for slope stabilization facilities.

2.3.4 Drought Risk Reduction

(1) Status and Efforts on Drought Risk Reduction

In Sri Lanka, a national strategy which clearly describes the way to go for drought risk reduction and necessary coordination mechanism has not yet been formulated. In common understanding, drought risk reduction is addressed under water resources management. However, while many water related organization exist, any coordination mechanism among these organizations is not mentioned in existing documents.

Considering these conditions, MDM has focused on drinking water supply to deal with drought risk reduction. The MDM, Local Government and water related agencies are conducting only small scale projects for drought risk reduction as emergency measures. Therefore, it is pointed out that national level drought risk reduction plan in line with national level strategy is also needed, in order to effectively carry out necessary actions.

In this section, drought risk reduction carried out by relevant agencies and issues for drought risk reduction are described.

1) MDM

The drought is categorized into Meteorological drought, Agriculture drought and Social drought. MDM is in charge of drinking water supply as a part of social drought, and has a role of coordinating water related agencies. At district level, Assistant Director dispatched by DMC to DDMCU has the responsibility of coordinating water related agencies under District Secretary for drought disaster risk reduction.

Drought risk reduction taken by MDM is mainly emergency water supply by bowsers and distribution of plastic tanks in areas where damage caused by drought is more severe.

With support from World Food Programme (WFP), MDM has established Disaster Impact Management System, which is an integrated disaster information system, by using satellite imagery and other data sources. This system is being established in collaboration with relevant agencies, in order for them to smoothly access the system. In the 1st Phase, the project focuses on drought, followed by the 2nd Phase with flood perspective and the 3rd Phase focusing on update and improvement of the system.

In the meeting held on 29th June 2017 in Anuradhapura District with the participation of the

Minister of MDM, active discussion on risk reduction of severe drought took place considering the worsening conditions. As a result, countermeasures to be taken in long-term perspective are listed as follows; i) Increase of forestation coverage, ii) Control of development of hilly areas, iii) Rehabilitation of tanks and canals by removing siltation, iv) Promotion of rainwater harvesting.

2) NWSDB

Drought risk reduction is incorporated in the regular work of NWSDB. The target areas to be covered by NWSDB during drought period are mainly 324 water supply areas managed by NWSDB. The main water sources for these water supply schemes are surface water, which flow rate decreases during the drought. Therefore, during drought period they control water distribution. In addition, since hydraulic pressure of distribution line is decreased during drought period, water cannot be distributed to higher elevation areas. They supply water by a combination of systems consisting of installation of temporal plastic tanks and bowsers for these higher elevation areas.

In drought period, NWSDB also supply water to places outside of NWSDB's coverage area. They pumped up water from their own production well which are used only under drought conditions and supply water to these areas. In District level, staffs of provincial offices take necessary actions for water supply as drought risk reduction under initiative of District Secretary.

During the drought period, water supply has been affected by seawater intrusion. Seawater intrusion occurred in Kelani Ganga in Colombo, Kalu Ganga in Kaltala, Matala, Galle and Ratmarana. Especially in Kaltala, water supply becomes not operational due to sea water intrusion into Kalu Ganga. NWSDB plans to install a gate to prevent seawater intrusion in Kalu Ganga.

3) DNCWS

Though a strategy or policy related to drought risk reduction has not yet prepared in DNCWS, they are promoting improvement of water supply conditions in communities according to the following prioritization of Provinces in terms of scarcity of water resources.

1st: Northcentral, 2nd: Northern, 3rd: Northwestern, 4^{th} : Uva, 5th: Eastern

Around 80% of water sources for community water supply schemes are groundwater. In the Chronic Kidney Diseases (CKD) prone areas and water quality problem distributed areas such as Anuradhapura, Vavunia, Jaffna, Kurunegala, Puttalam and Mannar Districts, DNCWS plans to install Reverse Osmosis (R.O.) Plant to purify water for drinking purpose.

4) WRB

The roles of WRB are i) Management of groundwater resources, and ii) Groundwater studies such as geophysical investigation, pumping test and advisory for development and water source uses. During drought period, upon request by DMC, WRB conducts hydrogeological investigation, well drilling, pumping test and installation of pumps.

As one of the activities for drought risk reduction, WRB has commenced establishment of catchment based groundwater monitoring network in Polonnaruwa, Anuradhapura and Monaragala Districts, under financial support from Netherland. The project areas were selected in consideration of CKD prone areas. In the project, water level and water quality data logger is scheduled to be installed in 400 wells, and data management and operation center will

be established.

The Government of Sri Lanka has enforced the Gazette Extraordinary about regulation of groundwater development on 16th March, 2017. By this Gazette, any organization, institutions and individuals are required to obtain permission to exploit groundwater for the commercial purposes of agriculture and industry activities. For water drinking purposes, water quality test must be conducted and submitted to WRB every 6 months.

By this regulation, it is expected that over exploitation of groundwater will be properly controlled and present condition of water supply will be improved.

5) Irrigation Department

In Sri Lanka, Irrigation Department (ID) is responsible for water resources management. Since 2012, ID has conducted drought risk reduction such as i) removing siltation in tanks, ii) heightening of spill way, iii) update of capacity data of tanks, iv) lining of canal, as part of water resources management.

As described in Section 2.3.2, MIWRM will formulate basin investment plan for 10 river basins in CRIP with support of WB. The plan will consider both flood and drought risk reduction. Prioritized projects in CRIP are scheduled to be implemented in CLIP2 from 2017.

6) Ministry of Mahaweli Development and Environment (MMDE)

Under Mahaweli Development project, following three (3) projects are now under implementation.

- Diversion to Northern area: This project was commenced in the 1980s. Drinking water supply was not taken into consideration when the plan was formulated, since drinking water was sufficiently supplied.
- Diversion to Eastern area: Construction of reservoirs aiming to supply water to irrigation and hydropower generation (Moragahakanda Project)
- Diversion to Southern area: This project is suspended due to drying up of wells near the constructed tunnel and crack occurred on the building caused by ground deformation.

The MMDE has commenced updating of the National Climate Change Adaption Strategy for Sri Lanka, 2011 to 2016, with support from ADB. The project was commenced in 2017 and will be completed in 2018. The vulnerable areas of drinking water and irrigation in Northern and Eastern part of Sri Lanka were not described in the current version. Entire country will be covered by this project.

7) Ministry of Power and Renewable Energy (MPRE)

In Sri Lanka, 30% of power supply is covered by hydropower generation, 70% is covered by thermal power generation. When the amount of water for hydropower generation decreases due to drought, the deficit amount of demand for electric power is covered by thermal power generation. Therefore, there is no impact on power generation in terms of electric power supply. However, from the economic point of view, as the use of fuel increases and economic load of the Government is also increased.

In the electric power supply sector, public awareness activities for energy saving has been conducted as a part of normal operation.

(2) Drought Situation in 2016 - 2017

Since the middle of 2016, severe drought has occurred throughout the country of Sri Lanka. In May 2016, extremely heavy rainfall was observed especially in the southwestern area. However the total rainfall in 2016 was still lower than the average. Despite gradually increased rainfall in January and February 2017 and heavy rainfall in May 2017, the drought situation has not improved and has more severe.

1) Rainfall Characteristics

Rainfall Pattern in Dry Zone

Figure 2.3.20 shows monthly distribution of average rainfall (50 years: 1967-2016) and observed rainfall from June 2016 to May 2017.

In the dry zone of Sri Lanka, especially in Northcentral and Northwestern Provinces, there are two rainy seasons in October to December (Rainy Season 1, called "Maha") and in March to May (Rainy Season 2). Table 2.3.28 shows comparison of rainfalls between average and 2016-2017 focusing on these two rainy seasons.

In the dry zone of the northern region (Jaffna, Anuradhapura, Puttalam), the eastern region (Trincomalle, Batticaloa) and the southern region (Hambantota), the average annual rainfall are from 1,000mm to 1,700mm. Generally, rainfalls in a year concentrate in the period of Rainy Season 1. It accounts to 50-70% of total annual rainfall. Therefore, the rainfall during Rainy Season 1 is the main water source for surface and groundwater in the dry zone.

As shown in Table 2.3.28, rainfall during the Rainy Season 1 in 2016-2017 is extremely low. It is about 34 - 64% of normal year. Although the rainfall during Rainy Season 2 was normal or higher, excepting Puttalam, the contribution to the annual rainfall is still limited. Consequently, the broad area, where the rainfall of Rainy Season 1 was not sufficient, has suffered from severe water shortage.

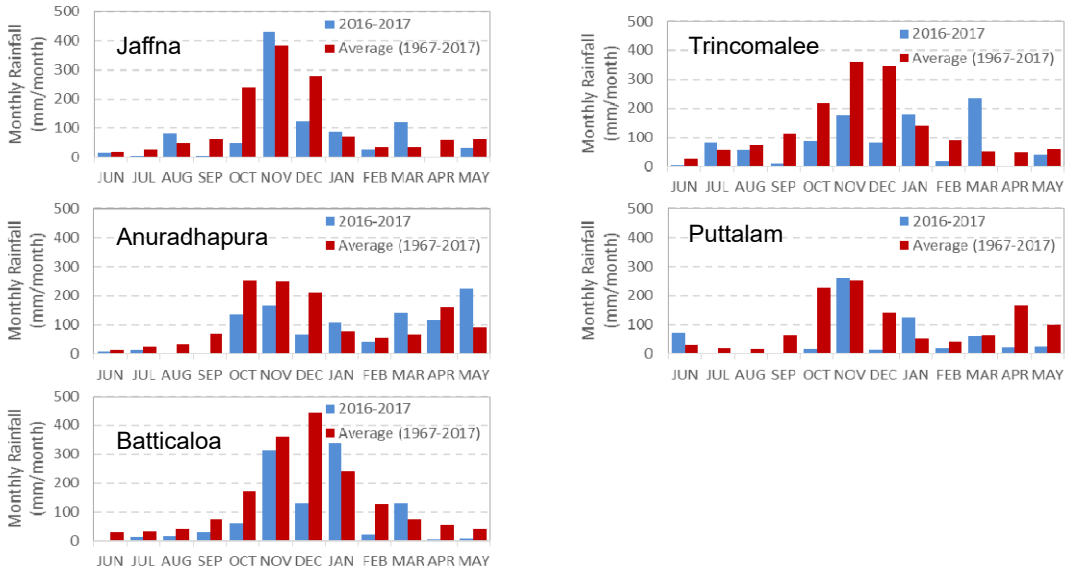


Figure 2.3.20 Comparison between 50-years average monthly rainfall (red) and rainfall during June 2016 - May 2017 (blue) at representative stations

Source: Prepared by JICA Survey Team based on data of DOM

Table 2.3.28 Comparison between average rainfalls and rainfalls in rainy seasons in 2016-2017

Data source: DOM

Province	Station	Annual	Rainy Season1 (OCT-DEC)				Rainy Season2 (MAR-MAY)			
		Ave.* (mm)	Ave.* (mm)	OCT2016-DEC2016 (mm)	Anomaly (%)	Historical Rank (1967-2017)**	Ave.* (mm)	MAR2017-MAY2017 (mm)	Anomaly (%)	Historical Rank (1967-2017)**
Northern	Jaffna	**1291**	904	**601**	**-34%**	**3**	157	149	-5%	21
North Central	Anuradhapura	**1316**	719	**367**	**-49%**	**2**	321	482	50%	46
North Western	Puttalam	**1182**	621	**289**	**-53%**	**2**	332	**109**	**-67%**	**3**
Eastern	Trincomalee	**1561**	934	**344**	**-63%**	**1**	164	275	67%	42
Eastern	Batticaloa	**1677**	990	**506**	**-49%**	**4**	171	144	-15%	21
Western	Colombo	2327	844	944	12%	35	698	558	-20%	19
Central	Nuwara Eliya	1877	649	**234**	**-64%**	**1**	377	443	18%	38
Southern	Galle	2259	789	766	-3%	25	597	611	2%	26
Southern	Hambantota	**1018**	469	**307**	**-34%**	11	231	312	35%	43

* Averaged from 1967 to 2016, hydrological year

** Rank of seasonal rainfall amount, counted from lesser rainfall records

Source: Prepared by JICA Survey Team based on data from DOM

Historical Rainfall Trends

Figure 2.3.21 shows historical rainfall trends (1967-2017) at Anuradaphura District in Northcentral Province and Batticaloa District in Eastern Province.

In both Districts, annual rainfall and rainfall during October to December are not decreasing. In fact, those seem to be slightly increasing. However the rainfalls of each year tend to vary in recent years. Though the reason for this variation is uncertain, this trend indicates possibility of drought in the future.

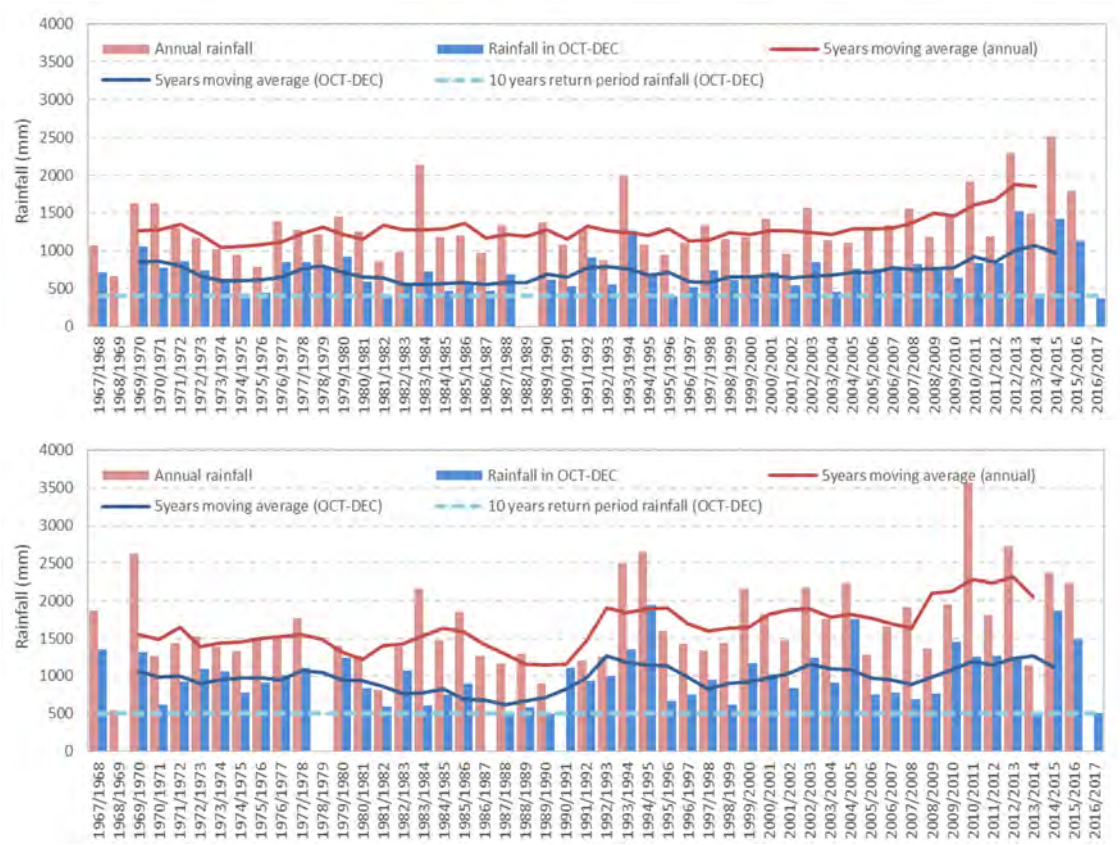


Figure 2.3.21 Rainfall trend at Anuradaphura (upper) and Batticaloa (lower) in annual rainfall and rainfall during Oct-Dec

Source: Prepared by JICA Survey Team based on data from DOM

2) Drought Damages in the Country

The number of affected people by drought in 2016-2017 is shown in Figure 2.3.22.

As shown in Table 2.3.28, rainfalls during rainy season in October to December (Maha period) are 34% to 63% lower than the average rainfall. Due to this rainfall shortage, the northern part of the country has been severely affected by drought. The probability of rainfall in October to December in 2016 is estimated 10-15 years based on 50 years records.

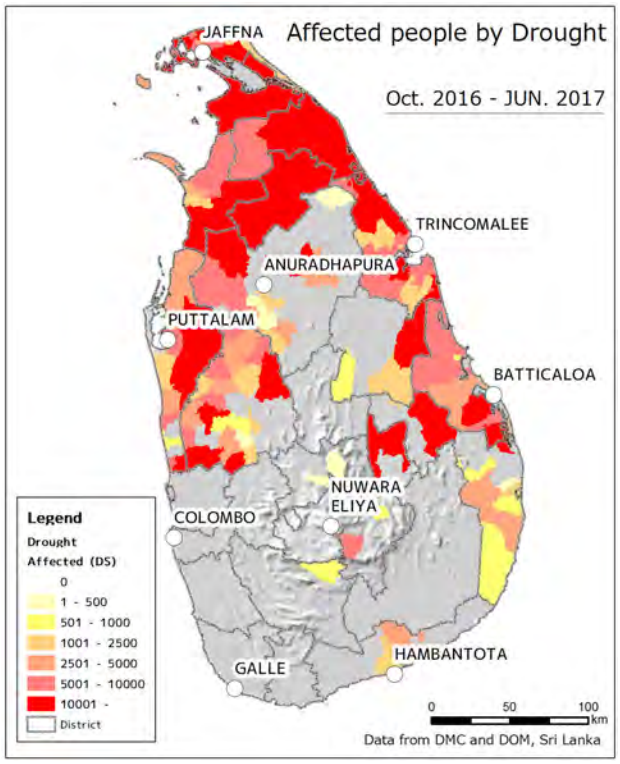


Figure 2.3.22 Affected people by drought in 2016-2017
Source: Prepared by JICA Survey Team based on DesInventer

Shortage of Drinking Water

Under drought situation, the MDM is monitoring the number of people and families who cannot access to drinking water as well as the number of affected DS Divisions. Based on such drought information, the MDM is providing water supply to the affected area as an emergency operation. The number of families who received emergency water supply is shown in Table 2.3.29.

The affected Districts use the central funds allocated by NDRSC for hiring water bowser, driver, fuel, etc. As of July 18, 2017, the total relief expenditure for emergency water supply reached to Rs.35,870,000.

On the other hand, NWSDB owned productive wells only for emergency purpose when water intake from river water is insufficient. Under this drought situation, NWSDB is providing water from productive wells to maintain water supply as emergency operation.

Table 2.3.29 The number of families who cannot access drinking water and who received emergency water supply as of July 2017

No.	District	Affected			Water Distributed		
		No. of DS Division	No. of Families	No. of Family Members	No. of Families	No. of DS Division	% of Families Distributed
1	Anuradhapura	7	7,781	25,160	7,781	7	100%
2	Gampaha	2	5,488	21,715	5,488	2	100%
3	Jaffna	15	34,195	124,568	12,233	6	36%
4	Killinochchi	4	23,206	80,973	2,405	4	10%
5	Kurunegala	19	39,836	131,731	38,652	19	97%
6	Mannar	5	13,499	47,710	7,675	5	57%
7	Mullativu	6	35,730	115,308	2,383	5	7%
8	Puttalam	13	36,394	129,969	35,655	13	98%
9	Trincomalee	7	4,163	12,807	225	7	5%
10	Vavunia	4	24,507	85,771	667	3	3%
11	Batticaloa	9	19,271	63,999	0	0	0%
12	Ampara	8	10,527	36,899	10,527	8	100%
13	Polonnaruwa	2	3,155	11,329	3,155	2	100%
	Total	**101**	**257,752**	**887,939**	**126,846**	**81**	**49%**

Source: NDRSC

Shortage of Water Storage of Major Tanks

WFP summarized the water storage situation of major tanks in the county. Figure 2.3.23 shows capacity and water storage situation of the major tanks in December 22, 2016 and January 27, 2017.

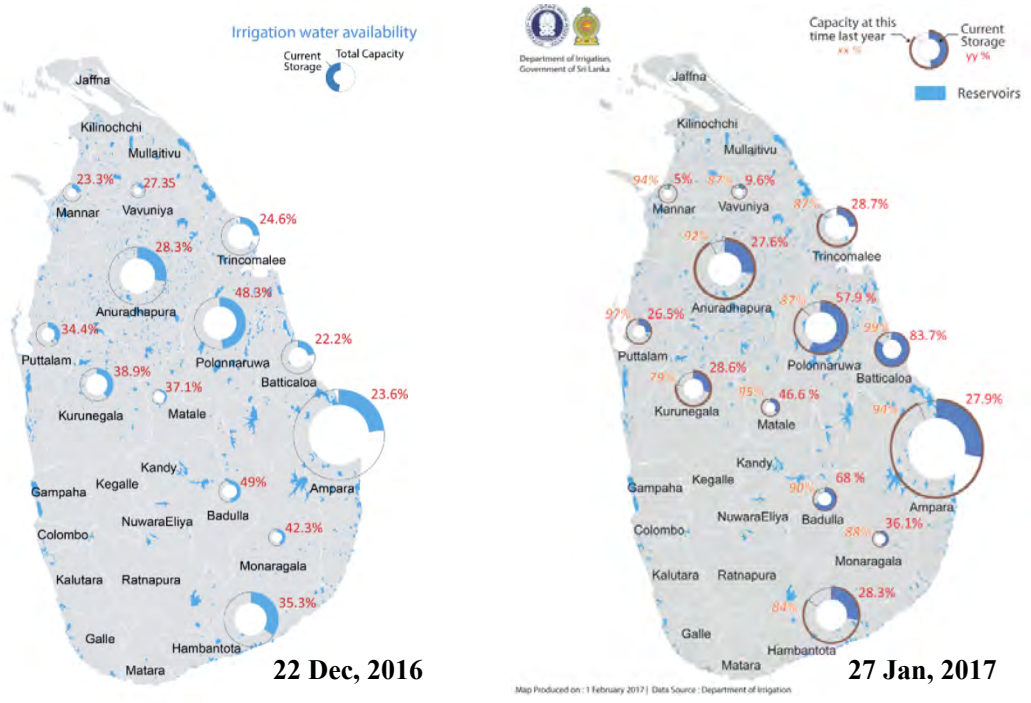


Figure 2.3.23 Capacity and water storage situation of major tanks
Source: Initial Rapid Assessment on Drought 2016/17:by WFP

According to "Initial Rapid Assessment on Drought 2016/17" prepared by WFP, the total water storage of all 73 major tanks in December 2016 is only 29% of total capacity of 3,593 MCM. Generally, at least 2,220 MCM water must be stored during rainy season of October to December (Maha period) to secure water supply for irrigation. Current water storage is about 50% of required amount. In medium-class tanks, it is only 30% of required amount. Many small to medium class tanks have dried up.

Dried-up middle-class tank in Anuradhapura District

By January 2017, the water storage amounts are slightly increasing in Polonnarwa and Batticaloa in the east. However, it is obviously decreasing in most other areas.

3) Drought Situation in Anuradhapura District

To understand actual drought situation and emergency water supply mechanism in local level, the Survey Team visited Anuradhapura District during July 5-8, 2017. The Team interviewed staff and officials at the District Secretary office, DS Divisions, Provincial Irrigation Department (PID), NWSDB district office, DNCWS district office and communities. The team also visited several water related utilities and Cascade System Tanks which are the pilot sites under JICA support project.

Drought Damages

According to the Assistant Director of DDMCU, Anuradhapura District, the following situations have been reported.

- By July 5, 2017, 17,681 families have received water supply by bowser. However, due to continuous drought situation, additional 44,000 families are expected to be affected by water shortage in the District.
- There is no major issue on water supply in urban area where NWSDB is providing pipe borne water supply. However, the northern area where the water supply is depending on groundwater and the western remote area have not received sufficient water.
- Problem of Chronic Kidney Disease (CKD) is widely recognized. For fear of CKD, people don't want to use the groundwater even if there is available water remaining. The DNCWS installed R.O. system to deal with CKD problem.
- Total water storage of 12 major tanks in the District is 21.5% of the capacity. Within the 21.5% storage, only 17.5% is available for actual use.
- Although 35% of cultivated land was planted, farming was abandoned in 17% of the land area due to severe water shortage. Only 21% of the famed area was harvested finally.

Dried dug well in a remote community. This community is far from populated area. People are not able to get water even from water seller.

R.O. facility installed by the navy in November 2016. 9 hours operation in a day produces 3,000 liters of water. It is maintained by the navy.

A schematic diagram of drinking water supply in Anuradhapura District is shown in Figure 2.3.24. The water supply system is basically categorized into 3 types such as 1) Pipe-borne Water Supply, 2) Drought Emergency Water Supply and 3) Reverse Osmosis Water Supply.

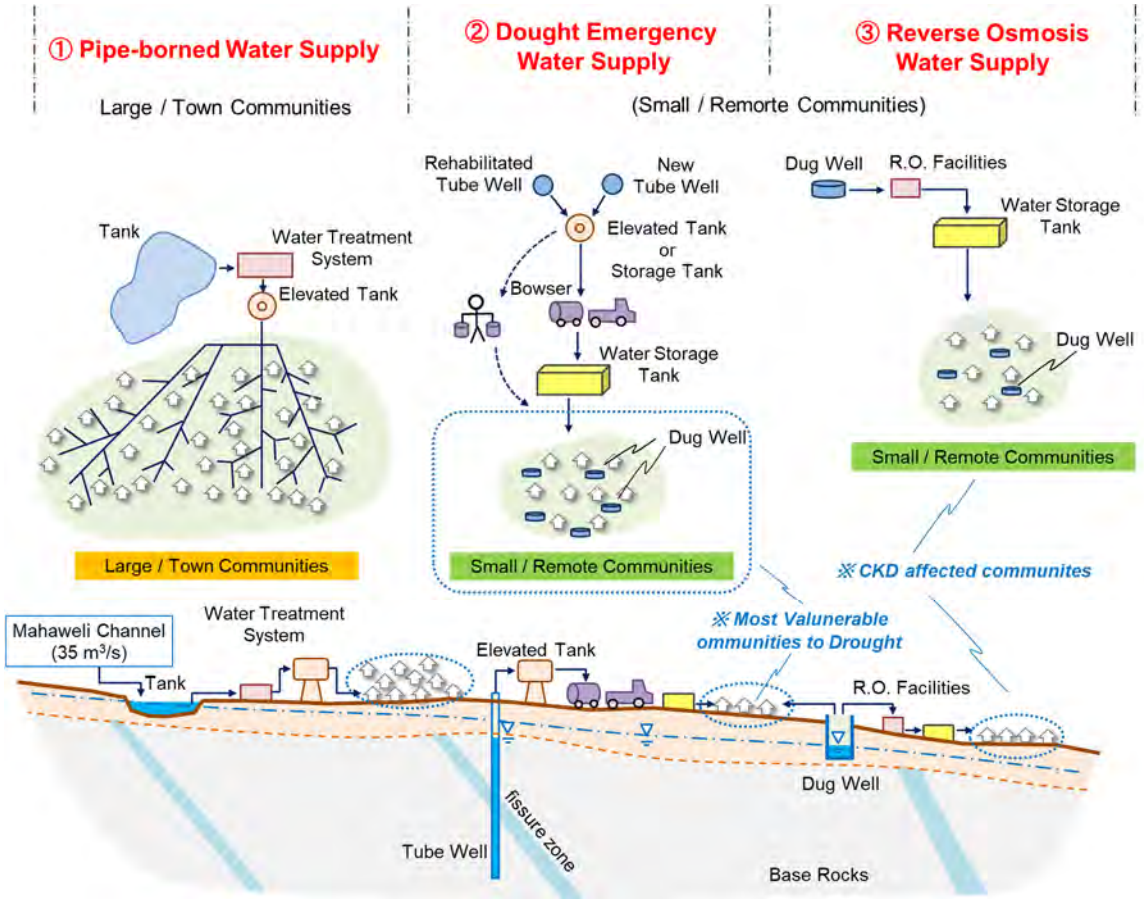


Figure 2.3.24 Schematic diagram of drinking water supply for drought emergency
Source: Prepared by JICA Survey Team

Emergency Operation by District

The District established a District Disaster Management Committee (DDMC) to deal with the drought situation under the initiative of the District Secretary. The DDMCU is the coordinating unit for the DDMC. NWSDB, DNCWS, PID, WRB are the member of the committee. There is no direct operation by Provincial Government. The Provincial Government is also involved in the DDMC.

Emergency operations by District are as follows:

- Water supply from NWSDB pipe-borne water by water bowser
- Water supply using 2 bowsers owned by DDMCU
- Building new wells in the northern area of the District

Issues for Drought Risk Reduction in District

In Anuradhapura District, CKD problem is widely recognized. Fluorine, fertilizers and insecticides are suspected as the causes. However the relationship between the disease and water quality has not been clarified at the moment.

According to DDMCU, following efforts should be done.

- To rehabilitate existing unused wells (1,373 within 2,468 wells need to be rehabilitated).
- To develop enough deep wells to secure safe drinking water
- To check water quality of existing wells.

(3) Supports by JICA

Drought issues are multi-sectoral, which are related to broad area such as water supply, public sanitation, agriculture, food security and power. Recently there has been no specific JICA project specifically focusing on drought risk reduction.

"The Study on Comprehensive Groundwater Resources Development for Hambantota and Monaragala Districts" was implemented in 2001-2003 to formulate a comprehensive groundwater development plan in order to ensure stable water resources development and sustainable local economic development in the target Districts.

In term of agricultural and irrigation purposes, which are closely related to the drought risk reduction, JICA has supported a number of projects of development study, yen loan assistance and technical cooperation mainly targeting on the North and Northcentral Provinces. "The Project for Formulating Cascade System Development Plan under North Central Province Canal" is currently under implementation. The objective of the project is to support formulation of development plans for irrigation, agriculture and livestock sectors utilizing water transferred by main and branch canals constructed by ADB fund, and plan of operation and maintenance of tanks and canals to maximize water resources utilization in the dry area of Anuradapura District in Northcentral Province and Vavunia District in Northern Province by enhancing capacity on rehabilitation, maintenance and management of the cascade tank systems.

Table 2.3.30 Projects related to drought risk reduction supported by JICA

Project Name	Target Area	Type	Duration
The Study on Comprehensive Groundwater Resources Development for Hambantota and Monaragala Districts	Southern / Uva Provinces	Development Study	2001-2003
Pro-poor Economic Advancement and Community Enhancement Project (PEACE)	Northwestern / Northcentral / Central / Northern / Eastern Provinces	Yen Loan	2003-2013
The Study on Increasing Integrated Management Capacity on Irrigation Sector	Northcentral Province	Development Study	2005-2006
Increasing the Capacity of Integrated Management in Irrigated Agriculture in Dry zone	Northcentral / Northern Provinces	Technical Cooperation	2007-2011
The Project for Formulating Cascade System Development Plan under North Central Province Canal	Northcentral / Northern Provinces	Development Study	2016-2018

(4) Supports by other Donors

Supports by relevant international agencies on drought risk reduction are summarized in Table 2.3.31. In most case, drought related projects are implemented as a part of climate change adaptation programme, in which drought mitigation is involved as a proactive approach under risk reduction concept.

Table 2.3.31 Projects related to drought risk reduction supported by other donors

Project Name	Donor	Period	Fund	Remarks
Climate Change Adaptation Programme (CCAP) in Puttalam and Kurunegala Districts	UNDP	-	-	-
Green Climate Fund	UNDP	2017-2024	US$ 38 mil.	Successor project of CCAP
Disaster Impact Monitoring System (Phase 1)	WFP	-2017	-	Phase 1 aims to dough DRR
Update of the National Climate Change Adaption Strategy for Sri Lanka	ADB	2017-2018	-	Including risk assessment for drinking water and irrigation
North Central Province Channel Project (NCPCP) under Mahaweli Water Security Investment Program	ADB	2016-2024	US$ 1,6 40 mil.	Phase 2 will start in 2019
Drought Response Plan - Department of National Community Water Supply -	UNICEF	2017	-	-

Source: Interview to Donors and relevant agencies, and report

(5) Issues

1) Strategy and Plan on Drought Risk Reduction at National Level

Recently, damages caused by drought are becoming serious. As result, it has been pointed out that not only the shortage of drinking water but also the future influence on agricultural products become severe. Urgent countermeasures to mitigate damages should be necessary. However, at this moment, the strategy concerning drought risk reduction has not been formulated at the national level, and most of the countermeasures related to drought risk reduction are depending on the activities which NDRSC and other relevant agencies conduct as an emergency response.

Therefore, it is important that the strategy and its plan at national level should be formulated as soon as possible in collaboration with relevant agencies under the strong leadership of MDM.

2) Impact on Agriculture by Drought

In the agricultural area of arid lands in the North Central Province, the number of farmers is high and their lives depend on agriculture. Therefore, if agriculture cannot be implemented due to drought, it makes a significant impact to agricultural production and famer's incomes. The farmers will be forced to move to other areas and engage in labor at the construction site and other kinds of work to earn a living. As a result, it is concerned that if those farmers will not return to the locality, the number of farmers may decrease in agriculture area.

3) Securing Water Supply in Remote Areas during Droughts

In the remote area of locality, community based water supply system and dug wells are the main water source of living and drinking waters. When the water source is exhausted as the drought becomes severe, government and private companies become the only water supplier. However, at this time the frequency of water supply to remote areas is low, so there is a possibility that sufficient water volume will not be obtained in the remote areas in the future. Therefore, it is necessary to establish a system that can secure water supply during drought. In this system, the central and local government shall prioritize a stable supply of drinking water in remote rural areas with the goal of setting the arias as drought scarcity areas.

4) Implementation of Preparedness against Drought

At the time of drought, according to damage information from DDMC, MDM supplies safe drinking water by bowsers and the plastic tanks to the residents through DDMCU. However, since such emergency operation must be urgently implemented without enough coordination with enough coordination among relevant agencies, is sometimes difficult. Therefore, it is necessary to establish a collaborative framework with relevant agencies such as NWSDB and DNCWS for effective water supply mechanism in advance.

5) Water Use for Drinking Water Considering the Mahaweli Development Project

The North Central Province Canal Project (NCPCP) is being implemented by ADB fund. In this project, diversion canals from Mahawel basin to the north central dry areas will be constructed. When the Mahaweli Basin Development Plan was formulated, drinking water supply was not included in the plan, since water demand was satisfied in that stage. However, water resource from Mahaweli basin becomes important for securing drinking water in drought period. In this context, sector coordination on water allocation from Mahaweli basin for drinking purpose is strongly required for future development plans.

6) Improvement of Groundwater Recharge Function in Dry Area

Removal of sediments in reservoirs and discharge channels is being carried out by the Irrigation Department (ID) for the purpose of increasing in the water storage capacity. The clean-up can result to recharge of groundwater into the main water source for dug wells. Therefore, continuous implementation of sediment removal is strongly required.

7) Monitoring to Maintain Sustainability of Water Resources Use

ID is monitoring the reservoir, and WRB is developing the monitoring system of the groundwater.

It is desirable to establish a systematic and coordinated monitoring system so as to incorporate those records into drought risk reduction.

8) Supply of Water during Drought in Consideration of Groundwater Quality

Water quality of groundwater varies depending on geology and circumstances. Prior to use of the groundwater, it is necessary to examine whether that groundwater is suitable for drinking or additional treatment is required. Such data on groundwater resources including water quality should be managed in a database. Based on the database, water use and necessary treatment of existing wells and abandoned wells should be conformed in preparation for emergency water supply.

9) Promotion of Efficient Water Use Contributing to Drought Risk Reduction

Regarding water use in Sri Lanka, irrigation and livestock account for 88% and urban water supply is 6%. These two sectors occupy the majority of water use in Sri Lanka. However the irrigation efficiency in Sri Lanka is only 35%[5], the non-revenue rate in pipe borne water supply is approximately 30%[6],. To improve irrigation efficiency and revenue rate will contribute to drought risk reduction. It is also pointed out that in both urban and rural water supply schemes, water is wastefully consumed, since water tariff is set to be low-priced. It is, therefore recommended that water saving society be introduced from long-term perspective.

10) Implementation of Drought Risk Reduction Considering River Basin Based Water Resources Management

Most important challenges are good coordination between water related sectors, and efficient water use of both surface water and groundwater. For drought risk reduction, it is necessary to incorporate the concept of basin-based water resources management undertaking by ID into drought risk management.

2.3.5 Hydro-Meteorological Observation and Information Dissemination

(1) Status and Efforts on Hydro-Meteorological Observation

The DoM, ID, NBRO and other relevant agencies conduct hydro-meteorological observation in Sri Lanka. The warnings for natural disasters are issued based on the observed data. Status and future plans for the hydro-meteorological observation by the relevant agencies are described below.

1) Department of Meteorology

The DoM operates manual/automatic observation networks throughout the country. In addition, DoM has GTS, weather satellite image receiver and other systems to collect and analyze meteorological data. Based on the meteorological data, DoM issues weather forecasts and warnings. The status and future plans for DoM's observation/information networks are described below.

[5] FAO Web Site; http://www.fao.org/nr/water/aquastat/countries_regions/LKA/
[6] NWSDB Web Site; http://www.waterboard.lk/

Manual weather station

The long weather observation records by DoM are in existence since 1860s. The manual observation networks currently operated by DoM are i) main weather stations (Synoptic): 22 stations, ii) rain gauge stations: 410 stations, and iii) agro-meteorological stations: 39 stations[7]

i) Main weather station

Twenty-two main stations (Figure2.3.25) conduct manual weather observation (rainfall, air temperature, air pressure, etc.) every 3 hours. The observed data is reported to the Communication Center of DoM by telephone and transmitted abroad through GTS. The observed data is also utilized for domestic weather forecasting and media release. Parts of the real-time observed data are available on DoM web site.

The observed data is booked on record papers and sent to Climate Division of DoM once a month. The Climate Division checks the data and sends them to the Computer Division. The Computer Division input the observed data into the DoM database.

Self-recording weather observation instruments (rainfall, air temperature, humidity and air pressure) are also installed at the main stations. The charts recorded from 1950s to present at 23 observation sites including an interrupted station are stored in the Data Division of DoM, but most parts of the charts are not digitized. Only the records from 2008 are digitized as one-hour interval data. CRIP team is now digitizing the rainfall charts from 1980. However, DoM has no clear plan to digitize the rest of the charts.

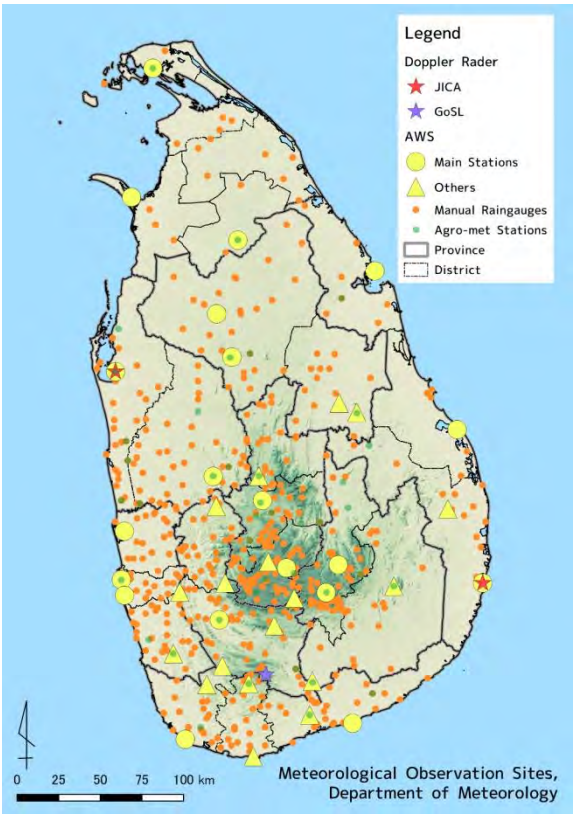


Figure2.3.25 Location of ground gauging stations of DoM and planned weather radars
Source: prepared from lists of observation stations of DoM

[7] Annual Report 2015, Department of Meteorology

ii) Rain gauge station

There are 487 manual rain gauge stations in the country. But, only 410 stations continuously observe and send rainfall data (Figure2.3.25). These rain gauge stations are maintained and operated under cooperation with DoM and governmental/non-governmental organizations and volunteers. Observation is conducted at 8:30 a.m. every day. The observed rainfall data is booked on record papers and sent to Rainfall Division once a month. The Rainfall Division checks the data and sends them to the Computer Division. The Computer Division input the observed data into database. Two hundred fifteen (215) rain gauge stations of the total 410 stations send daily observation data to DoM for daily weather forecasting.

iii) Agro-meteorological station

Agro-meteorological stations (39 stations) observe soil temperature, evaporation rate, duration of sunshine and other agro-meteorological parameters in addition to the general meteorological parameters. The record of observed data is managed and archived by the Agro- meteorology Division of DoM.

Automatic Weather Station

Thirty-eight (38) Automatic Weather Stations (AWS) were installed with support of the JICA project (The Project for Improvement of Meteorological and Disaster Information Network) and are operated by DoM. However, data transmission by a commercial satellite is unstable. Therefore, the JICA technical cooperation project (Project for Improving of Meteorological Observation, Weather Forecasting and Dissemination) is now trying to switch the transmission system to IP-VPN. The data transmission between DoM and all AWS, except Colombo station, is currently interrupted on the process of changing the transmission system. Early re-start of the data transmission is desired, but it takes time for bidding and instrument purchase procedures.

Regarding the maintenance of AWS instruments, technology transfer was carried out by the JICA technical cooperation project. Thus, there is no serious problem on the maintenance. Interval of the observation by AWS is 10 minutes. The observed data is transmitted and stored in the AWS server, monitoring PC and external HDD. When the data transmission resumes, all data can be monitored on the PC in NMC (National Meteorology Center). The real-time AWS data should contribute to monitoring current weather conditions and weather forecasting.

Upper atmosphere observation

The DoM conducts upper atmosphere observation at four stations. Observations by using GPS radiosonde (three times a week) and pilot balloon are conducted at Colombo. At the other three stations (Manner, Polonnaruwa and Hambantota), only the pilot balloon observation is conducted.

Doppler weather radar

Procurement of two Doppler weather radars is progressing under JICA's support. Additionally, DoM considers re-starting Doppler weather radar installation which was interrupted by an accident.

The two Doppler weather radar (C-band) will be installed at Puttalam located in north-western region, and at Pottuvil located in south-east region (Figure2.3.25). The two radars will cover the entire country. The installation of radars will be completed by 2020. Size of radar

observation mesh and temporal observation interval are 1km x 1km and 10 minutes, respectively. Hence, the radar will drastically improve the spatial and temporal resolution of the weather observation comparing with the existing ground observation system. It is expected that the radar will contribute to more accurate and timely weather forecasting and warning. In regard to operation of the radars, capacity developments on maintenance, calibration by using ground observation data and analysis should be done.

Before the installation plan of the two radars, the DoM started installing a Doppler weather radar at Gongala peak in 2008. However, an accident which occurred in the middle of installation interrupted the installation of the radar. Recently, DoM considers re-starting the installation of the radar. If the installation of the Doppler weather radar at Gongala peak is completed, it is necessary to operate the three radars on an integrated observation system.

Satellite image receiver and SATAID

Presently, the DoM receives satellite images (Himawari, EUMETSAT, etc.) through internet and/or satellite image receivers. The DoM utilizes the satellite images for weather forecasting. Chinese and Korean governments provided satellite image receivers in 2012. Satellite image of FY2 (China) is still available at NMC but receipt of COMS (Korea) image has stopped because of data transmission problem.

Himawaricast (satellite image receiver for Himawari) will be installed by June 2017 under the JICA technical cooperation project. Ahead of that, SATAID[8] was installed at NMC of DoM. Now, NMC downloads the Himawari image via internet, but direct image reception will be available after the Himawari Cast is installed. The basic observation interval of Himawari (10 minutes) is shorter than the other weather satellites. Hence, the Himawari weather satellite image will contribute greatly to weather forecasting.

Operators can utilize the SATAID to display and analyze not only satellite images but also ground/sea observation data, radar data, NWP data and other data. Therefore, improvement of weather forecasting and warning through integrated data operation after AWS and radar installation can be expected.

Others

WB project named CRIP2, plans to strengthen the capacities of DoM. A survey to design the CRIP2 activities is carried out by a WB team. The draft survey report identified modernization of the observation system as a possible CRIP2 component (detailed information is mentioned later). There is a possibility of introducing integrated meteorological and hydrological observation system including other agencies' networks and/or upgrade of observation system for Bandaranaike International Airport. In addition, the DoM has the intention to introduce lightning detection system. If the lightning detection system will be installed by CRIP2 or through other funds, synergistic effect by radar and the detection system is expected. It is important to monitor CRIP2 activities.

[8] SATAID: a visualization and analysis software for satellite images, developed by Japan Meteorological Agency

2) Irrigation Department

The ID issues flood warnings mainly based on observed river water level at manual gauging stations located throughout the entire country. In addition, installation of automatic water level stations is progressing through the DSWRPP, WB Project. Generally, rainfall gauges are also set at the water level stations. Hence, ID has the capacity of meteorological observation too. Following is status and future plan of ID observation networks.

Manual river water level and rain gauge station

i) Manual primary river water level and rain gauge station

The ID has 35 primary gauging stations throughout the country, and river water level observation is conducted at 34 stations of the primary stations (Figure2.3.27). The records of water level are available from 1950's at some gauging stations. Rating curves are prepared at most of the primary stations, and the observed water level is converted to discharge. All of the primary stations, except one station, have rain gauge. These observation stations are maintained and operated by the Hydrology Division (HD) of ID.

The ID local staffs check and record the water level by visual observation on hourly basis. The local staffs call HD every day to report the observation, and the observed data is transmitted to DMC and relevant agencies. Additionally, ID Operation Room (OR) staffs input the observed water level to Excel and share it with ID staffs and DMC via cloud service. ID issues flood warnings mainly based on the observed water level at the primary gauging stations.

The observed hourly water level is recorded on record papers and sent to HD once a month. HD inputs and archives the observed data on Excel (Figure2.3.26).

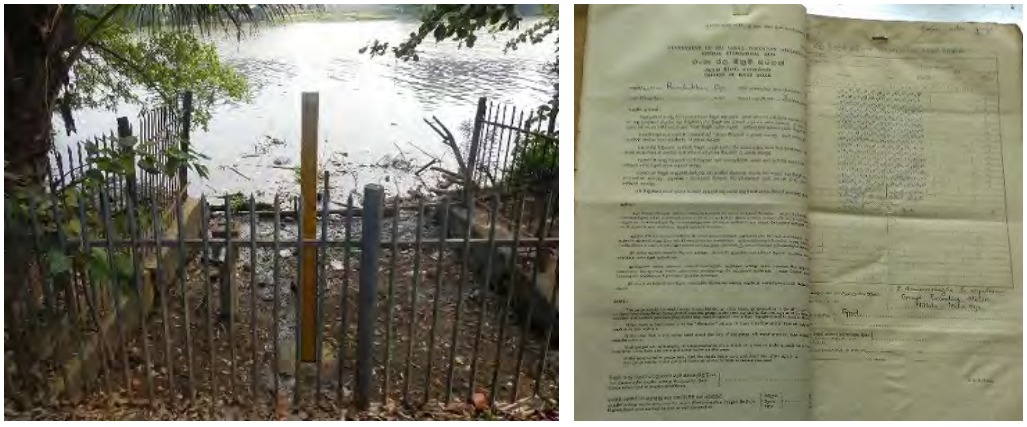


Figure2.3.26 Water level gauge and record paper

ii) Peripheral river water level gauging station

Forty (40) peripheral river water level gauging stations are operated by ID. Local care taker manually observes daily water level and sends record paper to HD once a month. The observed data isn't utilized to issue flood warning.

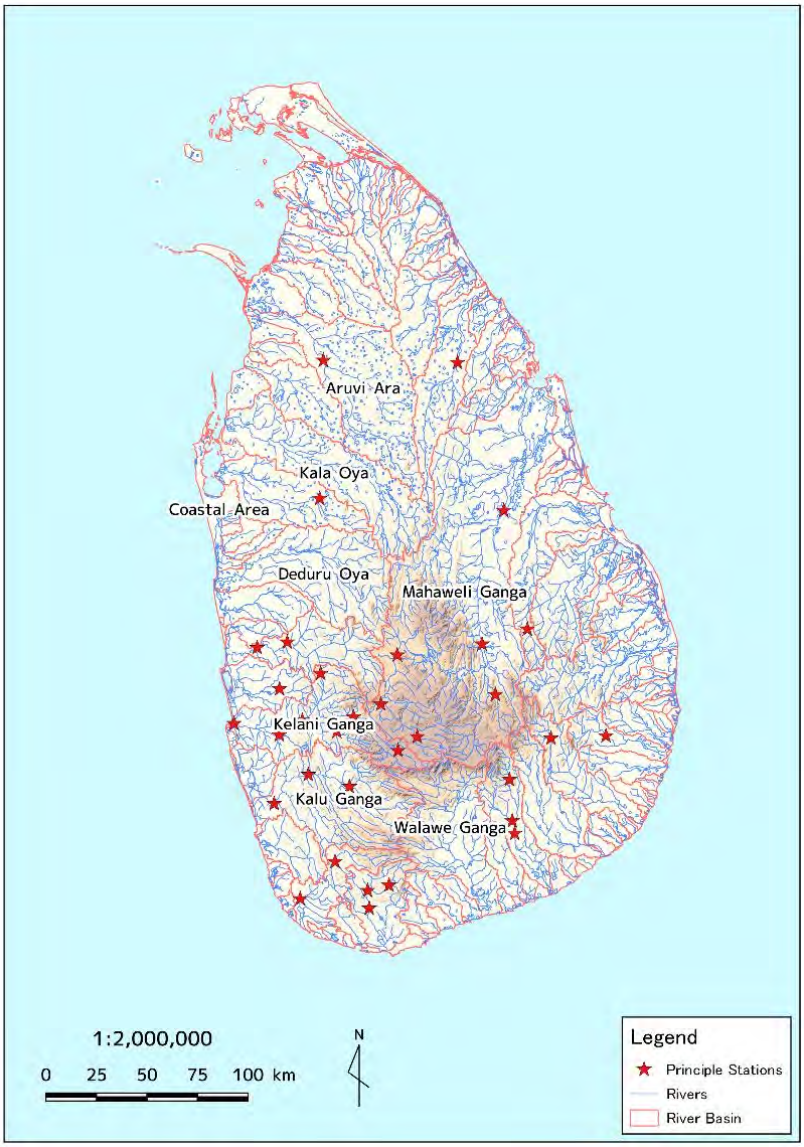


Figure2.3.27 Map of primary river water level and rainfall gauging stations of ID
Source: prepared from Gauging station list provided by ID

Automatic water level and weather station (HMIS)

The DSWRPP, WB project, is introducing automatic water level and weather stations (Hydro-Meteorological Information System: HMIS, Figure2.3.28). 122 stations and ca. 40 stations will be installed by Phase 1 activity and Phase 2 activity, respectively (Figure2.3.29). The implementation period of Phase 1 has been finished, but installation of some stations is not completed. Site selection for Phase 2 stations is underway. Authorities who manage the HMIS gauging stations are ID (Phase 1: 91, Phase 2: 15), Mahaweli Authority of Sri Lanka (MASL, Phase 1: 19, Phase 2: TBD), Ceylon Electricity Board (CEB, Phase 1: 7, Phase 2: TBD), Northern Provincial Council (NPC, Phase 1: 5, Phase 2: TBD). Type of the water level gauge is pressure gauge or radio gauge. Observation interval is 10 minutes. Observation items (water level of river or reservoir, discharge, rainfall, evaporation) differ from station to station depending on station location. Data transmission instruments for Phase 1 stations are GPRS and

satellite, while Phase 2 stations will use GPRS only. The observed data is received at data server of ID and displayed on HMIS web page. Now, limited staffs who have permission can see the HMIS web page because the system is closed for beta test. In future, the HMIS web page will be opened to the public. Tables and charts of observed time series of water level and rainfall and station maps are available on the HMIS web. However, those observed data are not utilized to issue flood warnings.

No major problem on the sensors appears at present, but defects occurred on the data transmission. The data transmission for over 10 stations is not available now. The automatic stations should be set up at the sites of existing manual stations, but the existing manual stations should remain after new automatic stations are set up.

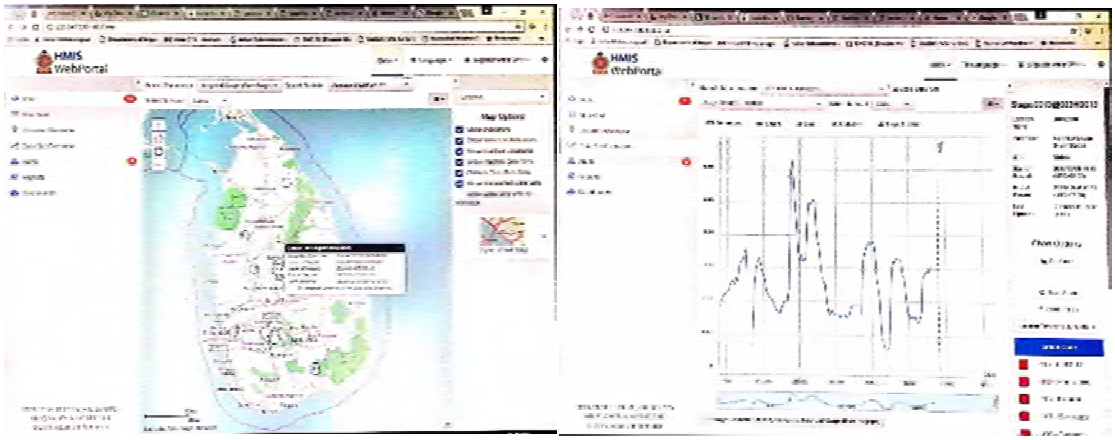


Figure2.3.28 Web monitoring page of automatic water level and weather stations
(Hydro-Meteorological Information System: HMIS)

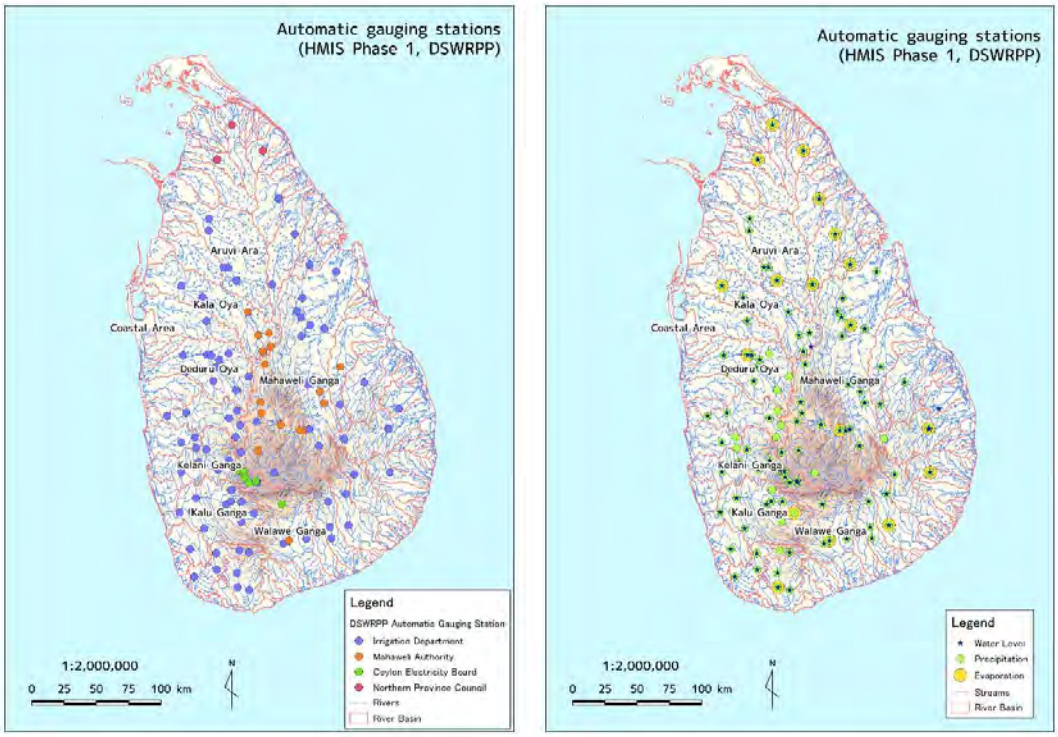


Figure2.3.29 Locations of HMIS automatic gauging stations.
Source: prepared from station list provided by ID

Other rain gauge stations

Additional 100 rain gauge stations are operated by district offices of ID. The OR collects daily observed rainfall by using telephone, e-mail and cloud service and records into Excel file. When above 75mm rainfall is observed, district officer reports to the OR immediately.

Reservoir gauging station

The ID conducts water level observation at reservoirs managed by ID. Water Management Division (WM) collects information about water level, water volume, gate operation and spilling through ID regional/divisional offices. Such information about reservoirs are uploaded on the ID web sites and collected by the OR.

Basin-wide monitoring system

As mentioned above, manually observed data is managed and recorded by HD, WM and OR, respectively. However, there are few mechanisms of integrated basin-wide monitoring system including river/reservoir water level and rainfall. User Interface of HMIS which covers entire country is not fit to basin-wise hydro-met. The main purpose of HMIS is nationwide monitoring of rivers and reservoirs.

Under the circumstances, ID introduced basin monitoring system for Malwathu Oya and Mee Oya basins by government fund in 2016 (Figure2.3.30). WM manages the monitoring system. Observed water levels of reservoirs and rivers, water volume, discharge and rainfall are transmitted to ID via GSM. These data are indicated on the electronic board set in the ID building. Monitoring on the web is also available for limited staffs. However, it seems better to improve some functions (e.g. water level and volume charts, spilling information).

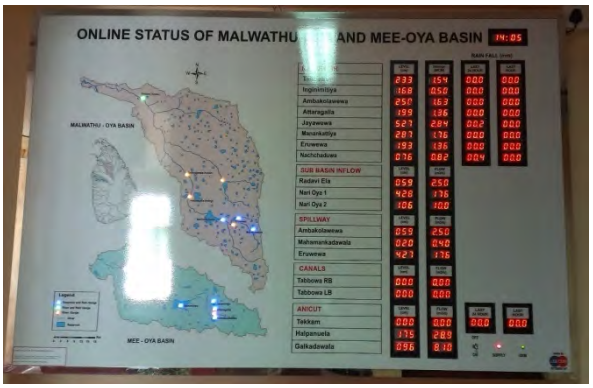


Figure2.3.30 Basin-wide monitoring system for Malwathu Oya and Mee Oya basins.

Additionally, there is a possibility that basin-wide monitoring system will be set up by CRIP2 activity. The Project funded by Green Climate Fund (UNDP) also plans to establish basin-wide monitoring system for integrated water resource management in eastern river basins located in the dry area. (detailed information is mentioned later).

3) SLLRDC

The SLLRDC who has responsibility for flood control in the metro Colombo area has manual water level stations in Ja Ela basin, Kalu Oya basin, Mudun Ela basin, Greater Colombo basin and Bologoda basin. Most of the stations had been abandoned, or observation has stopped by

2010, but part of the abandoned gauging stations have been rehabilitated or planned to be rehabilitated (Figure2.3.31). Seven (7) automatic water level stations are installed by donation, but observation has not yet started. The gauging stations installed by the JICA Project 2003 must be out of operation now.

The SLLRDC asks local people to check water level at the manual gauging stations twice a day (morning and afternoon). The local people records the water level on record paper and sends it to SLLRDC once a month. In case of emergency, SLLRDC sometimes telephones the local people to get information on real-time flooding level. SLLRDC inputs and archives the water level records by Excel. The gauging stations are operated and managed by Research and Design Division. Conversion from the observed water level to discharge is interrupted because current meter is broken. SLLRDC will procure new current meter and restart discharge observation. The observed water level is not utilized to issue flood warning.

The present condition of the manual water level gauging stations managed by SLLRDC is presented below.

Manual water level gauging station

i) Greater Colombo basin

Fifteen (15) stations are located in the basin, but only six (6) stations continue water level observation as of December 2016. After that, SLLRDC reconstructed all of the gauging station by February 2017. The oldest water level record is from 1995.

ii) Mudun Ela basin

SLLRDC started observation around 2004, but the stations were abandoned around 2006. Recently, development in Mudun Ela basin has increased, and retarding area became smaller. As a result, the flood risk may increase in Mudun Ela basin. Hence, SLLRDC reconstructed 13 gauging stations of which.

iii) Kalu Oya basin

Water level observation had been started around 1999-2000, but it stopped around 2009. SLLRDC rehabilitated and re-started the water level observation (8 stations) to collect hydrological data for review of the master plan prepared under JICA's support in 2003.

iv) Ja Ela basin

The SLLRDC had started water level observation around 1999-2000, but they stopped the observation around 2010 (11 stations). SLLRDC has a plan to rehabilitate the gauging stations. However, the plan is tentatively suspended, because demarcation of responsibility and authority between ID (CRIP) and SLLRDC is unclear in this basin. Cross-section surveys for drainage canals are in progress.

v) Bologoda basin

Water level observation had been started around 1996-2000, but had been interrupted around 2009. SLLRDC started rehabilitation of the gauging stations (33 stations). Further, installation of automatic gauging stations for important points is considered.

Figure2.3.31 Location and status of gauging stations of SLLRDC
Source: prepared from station list provided by SLRRDC and OpenStreetMap

Flood Control and Water Management Centre

The MMWD, SLLRDC and relevant agencies plan to establish the "Flood Control and Water Management Centre" which is for flood control and water management in the metro Colombo region including Greater Colombo basin and Kelani river basin. Detailed information is mentioned in Section 2.3.5(1) 5).

4) Other agencies

The NBRO operates 160 automatic rainfall gauging stations throughout the country.

Mahaweli Authority of Sri Lanka (MASL), Ceylon Electricity Board (CEB) and Northern Provincial Council (NPC) joined HMIS as managers of hydro-meteorological gauging stations.

Table 2.3.32 shows outline of hydro-meteorological observation networks in Sri Lanka.

Table 2.3.32 Outline of hydro-meteorological observation networks in Sri Lanka

Organ.	Cat.	Observation Stations/Systems	Data Archive	Remarks
DoM	Met	Manual stations: 22 (Synoptic), 410 (Rainfall), 39 (Agromet)	Climsoft Clicom	Partly available on web site
		Automatic stations: 38 by JICA	DB	
ID	Met	Manual stations: Over 100 (RF)	Excel	
		Automatic stations: 84+α	Web DB	HMIS
	Hyd	Manual for river: 34 (Principal), 40 (Peripheral) +for reservoirs: 73	Excel	Partly available on web site
		Automatic stations: 77+α	Web DB	HMIS
SLLRDC	Hyd	Manual: 6 (operational), 30 (rehabilitated), 44 (abandoned or under rehabilitation)	Excel	
NBRO	Met	Automatic stations: 160 (Rainfall)	Web DB	UNDP
MASL	Met	Rainfall data available		
		Automatic stations: 15+α	Web DB	HMIS
	Hyd	29 stations for reservoirs and rivers		Available on web site (PDF)
		Automatic stations: 19+α	Web DB	HMIS
CEB	Met	Rainfall data available		
		Automatic stations: 7+α	Web DB	HMIS
	Hyd	Reservoir water level available		
		Automatic stations: 7+α	Web DB	HMIS
North Province Council	Met	Automatic stations: 3+α	Web DB	
	Hyd	Automatic stations: 5+α	Web DB	

5) Planned/considered integrated hydro-meteorological observation system

As mentioned above, hydro-meteorological observations are conducted by several agencies. Therefore, their data formats and observation systems differ from each other. The most popular data transmission method between the agencies is FAX. Hence, it can be said that the data sharing system among the relevant agencies is not effective. Furthermore, it is pointed out that real-time visualization of observed data and basin-wide data sharing in ID are also not enough. Under these circumstances, the Government of Sri Lanka and donors propose establishing integrated observation system, inter-agency data sharing network and basin-wide monitoring system.

Integrated observation system and weather forecasting/warning service (CRIP2)

The CRIP2, WB project, plans an activity to strengthen capacities of DoM and ID. According to the draft survey report (Meteorological and Hydrological Services in Sri Lanka, WB), which was prepared to design the CRIP2 activities, a concern about disparate automatic observation networks was pointed out. The report proposed integrated observation network with the cooperation of relevant agencies.

The DoM operates 38 AWS in the country. Furthermore, ID and NBRO have over 100 automatic rainfall gauges operated independently. If an integration of these networks and/or data sharing among the agencies can be done, high benefit on weather forecasting and warning is expected. Improvement of temporal and spatial data resolution by introducing integrated

automatic ground observation network will contribute to strengthen the capacity to detect current weather conditions. In addition, the precision of calibration of the Doppler weather radars should be increased. Therefore, establishment of integrated observation system is considered in CRIP2 to strengthen weather forecasting. While the detail of the system is not fixed, some ideas have been proposed about the framework of the system. According to DoM, they expect that the integrated system can extract observation data from the existing systems and be displayed together, although the existing observation systems will remain under each agency. In this regard, a concern about observation data accuracy is pointed out, because it is difficult to keep data quality on the observation system which is managed by independent agencies. Therefore, it is necessary to conduct maintenance and calibration of equipment.

In addition, an activity to improve forecasting and warning service to support DMC works is proposed on the WB report for CRIP2. Target agencies of the activity are technical agencies (DoM, ID, etc.) and DMC. CRIP2 aims to improve flood early warning capacity by the following three steps 1) improvement of weather forecasting by capacity development and introducing ECMWF, 2) capacity development on real time flood forecasting by hydrological model, 3) utilizing the improved/quantified rainfall forecast on the flood forecasting model.

Basin monitoring system (CRIP2, Green Climate Fund)

The CRIP2 will implement flood countermeasures in four basins based on the investment plans prepared by CRIP and pre-feasibility study in Mundeni Aru basin. While the detail of components of CRIP2 is not fixed, there is a possibility that basin-wide monitoring system will be adopted as one of the soft components. ID conducts hydro-meteorological observation through regional/district offices, but real-time visualization of observed data and basin-wide data sharing in ID is not enough. Especially, problems occur when there are several regional offices within the same basin (e.g. reservoir gate operation without coordination among regional offices). Hence, the importance of basin-wide monitoring system is high.

The pre-feasibility study report in Mundeni Aru basin proposed a basin-wide monitoring system as indicated in Figure2.3.32. On the monitoring system, it is expected that real-time observation data is shared among relevant agencies and disseminated to other stakeholders through the internet. There is a high possibility to install basin-wide monitoring and early warning system in Mundeni Aru basin as a component of CRIP2.

While basin studies in the other basins are currently underway, there are possibilities that similar basin-wide monitoring systems are proposed in the other basin.

The project, which is for integrated water resources management in Malwatu Oya, Mee Oya and Yan Oya basin located in the dry area funded by Green Climate Fund (UNDP), started in 2016. Integrated basin monitoring system for drought (agriculture and drinking water) and flood will be installed. Further, capacity development on seasonal weather forecast for agriculture and high intensity rainfall forecasting is also one of the components of the project.

Flood Control and Water Management Centre (MCUDP...)

There are overlaps in basin monitoring works and lack of coordination mechanism among the relevant agencies in Sri Lanka. In order to solve these problems, the Cabinet approved the establishment of Flood Control and Water Management Centre in October 2016. The target basins of the Centre are the metro Colombo region including Greater Colombo Basin. Further, whole Kelani river basin is included to the hydrological model which will be operated by the

Centre because they must predict water level of Kelani River to protect central area of Colombo City.

Concept of the Flood Control and Water Management Centre is shown in Figure2.3.33. The main functions of the Centre are basin monitoring, accumulating rainfall and water level data observed by relevant agencies, analysis and forecasting by using hydrological models, disaster response including pump/gate operation and development planning by using the hydrological data. The Centre will be established in the ground of SLLRDC. Computers and other facilities will be provided by MCUDP. Details of the observation network are under consideration. Development of hydrological modeling is almost done. However, operation and maintenance mechanism of the Centre, including allowance for operation after the termination of MCUDP, are under consideration.

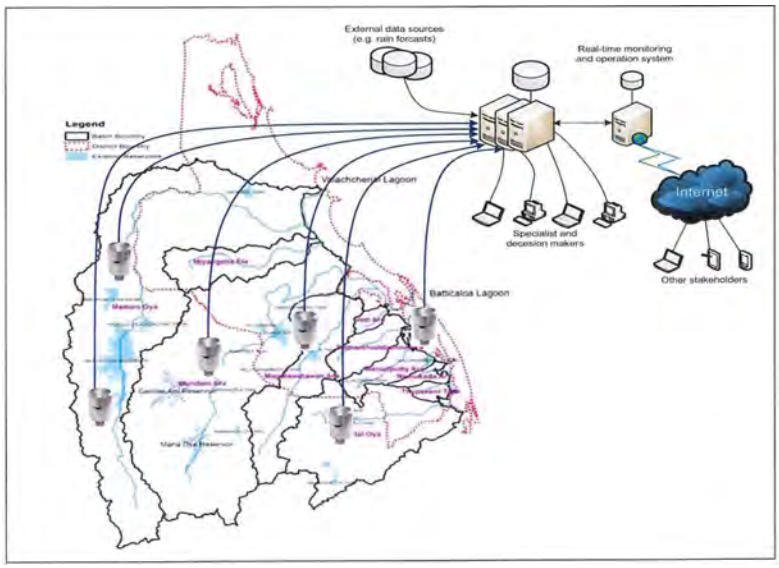


Figure2.3.32 Proposed basin-wide monitoring system
Source: Consultancy Services for Flood Risk Modelling and Pre-Feasibility Studies for Flood Risk Management in Mundeni Aru Basin in Sri Lanka, inception Report, WB

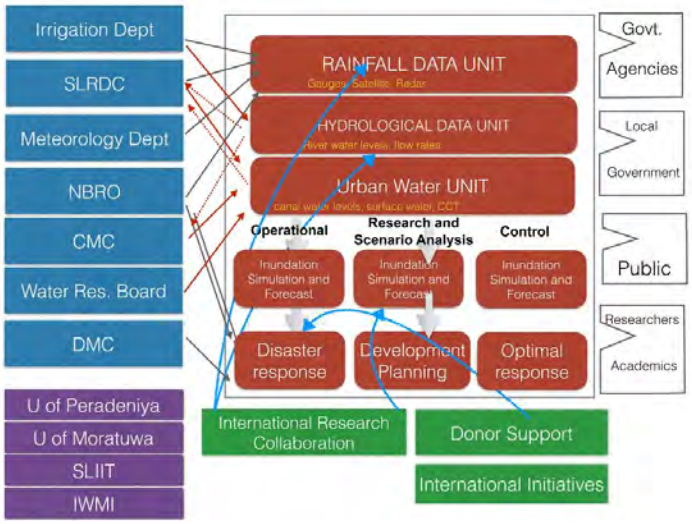


Figure2.3.33 Concept of Flood Control and Water Management Centre
Source: presentation by Dr. Herath, MMWD

(2) Status and Efforts on Warning and Information Dissemination

The technical agencies issue disaster warnings in Sri Lanka. The framework and standards of disaster warnings and information dissemination are described below.

1) Department of Meteorology

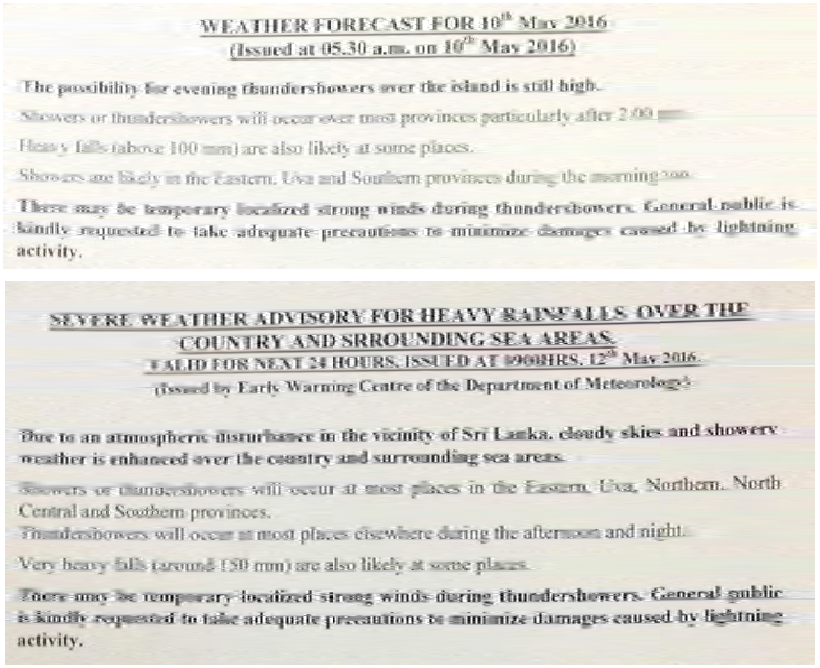
Organization regarding weather forecasting and warning

Weather forecasts and warnings (heavy rainfall, strong wind, cyclone, etc.) are issued from NMC (National Meteorological Centre), Forecasting Division. Two forecasters are assigned 24/7. In addition, two staffs in charge of NWP and marine forecasting are assigned. In case of emergency, DG, Directors and Deputy Directors also come to the office.

The NWP Division was established in 2016. They conduct downscaling NCEP/NCAR data to 5km mesh data four times a day and utilize it for weather forecasting. Marine Forecast Division was also established in 2016. They are engaged in forecasting and warning for ships, Navy and fisheries.

Contents and standards of warnings

Weather forecasts and marine forecasts are issued three times and twice a day, respectively. When severe weather conditions are predicted, warnings are issued from NMC. Weather forecasts are written in general description of predicted weather conditions for the entire country (Figure2.3.34). Town-pointwise quantitative forecasts are not issued. The format of warnings is similar to the weather forecasts. The warnings are issued when predicted weather conditions exceed the thresholds (e.g. heavy rainfall alert/advisory: >100mm/24hours or 50mm/6hours, heavy rainfall warning: >150mm/24hours). The thresholds are uniform throughout the country. Generally, the warnings are issued by province. But, sometimes the warnings are issued by district.



WEATHER FORECAST FOR 10th May 2016
(Issued at 05.30 a.m. on 10th May 2016)

The possibility for evening thundershowers over the island is still high.

Showers or thundershowers will occur over most provinces particularly after 2:00 pm.

Heavy falls (above 100 mm) are also likely at some places.

Showers are likely in the Eastern, Uva and Southern provinces during the morning too.

There may be temporary localized strong winds during thundershowers. General public is kindly requested to take adequate precautions to minimize damages caused by lightning activity.

SEVERE WEATHER ADVISORY FOR HEAVY RAINFALLS OVER THE COUNTRY AND SRROUNDING SEA AREAS.
VALID FOR NEXT 24 HOURS, ISSUED AT 0900HRS, 12th May 2016.
(Issued by Early Warning Centre of the Department of Meteorology)

Due to an atmospheric disturbance in the vicinity of Sri Lanka, cloudy skies and showery weather is enhanced over the country and surrounding sea areas.

Showers or thundershowers will occur at most places in the Eastern, Uva, Northern, North Central and Southern provinces.
Thundershowers will occur at most places elsewhere during the afternoon and night.

Very heavy falls (around 150 mm) are also likely at some places.

There may be temporary localized strong winds during thundershowers. General public is kindly requested to take adequate precautions to minimize damages caused by lightning activity.

Figure2.3.34 Examples of weather forecasts and heavy rainfall warning

Dissemination of observed data, weather forecasts and warnings

The weather forecasts are transmitted to DMC and other relevant agencies three times a day by FAX and e-mail. In addition, observed daily rainfall at representative points is also disseminated to ID, media and others. In the rainy season, observed daily rainfall and 7-day total quantitative precipitation forecasts provided by JMA are also sent to NBRO, ID, CEB, agriculture related agencies and others by e-mail

The warnings are transmitted to DMC, NBRO, President's Office, Cabinet Office, GA, Ministry of Fisheries and Aquatic Resources Development, forces, police, Coast Guard, regional office of DoM, media and others by FAX. E-mail is also utilized to transmit the warnings to some agencies. Additionally, DoM utilizes telephone (Inter-governmental Network, answer phone) and web page to disseminate the forecasts and warnings.

Long-term forecasts

The DoM prepares monthly and three-month forecasts about weather condition including rainfall trend based on analytical results of NWP models. The long-term forecasts are uploaded on the web sites and sent by e-mail to relevant agencies.

2) Irrigation Department

Organization regarding data collection and warning

Data collection and information/warning dissemination network of ID is shown in Figure2.3.35. Observation of river water level and rainfall is operated by HD. On the other hand, WM has responsibilities for observation, operation and management of reservoirs. In case of emergency, HD staffs stay in the office 24/7 and collect water level data from local staffs.

Flood Monitoring Committee (FMC) is established under Director General/Additional Director General (System Management). The members of the FMC are Directors of HD, WM, Drainage and Flood Systems Division and Assets Management. The members of FMC and relevant staffs hold meetings in the Operation Room (OR) and discuss about flood response.

The OR was established at the end of 2015. The OR also collects hydrological and meteorological data through HD, WM and other data sources. Three staffs are assigned to the OR. They receive observed water level and rainfall data from HD, WM and regional/divisional offices and input them to an Excel file. The OR also collects hydrological and meteorological data uploaded on the web by external agencies and records of reservoir gate operation. However, the OR is not operated 24/7 because of limited manpower.

The HD conducts discharge forecast for Kelani River by using hydrological model. Observed discharge is inputted to the model as an upstream boundary condition, and the discharge in the downstream near Colombo City is calculated. The simulation results are utilized as references when ID issues flood warnings.

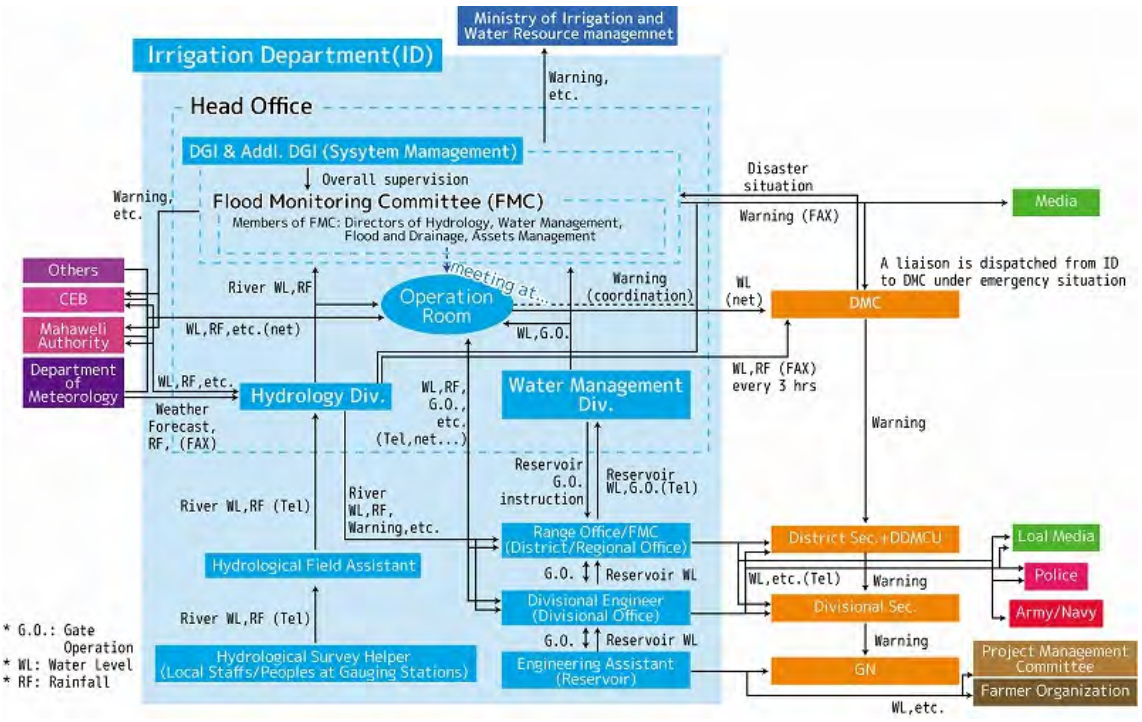


Figure2.3.35 Data collection and information/warning dissemination network of ID

Contents and standards of warnings

Basically, flood warnings are issued based on the observed water level. There are four levels of flood warnings based on expected flood damages (Alert: watching river flood, Minor Flood: inundation in farmlands and local roads, Major Flood: long-term inundation in residential area and major roads, Critical: severe damages including loss of lives). The water levels of each warning level at gauging stations are fixed based on the experiences of past floods.

An example of flood warning is shown in Figure2.3.36. In addition to water level, current weather conditions and spilling conditions of reservoirs are described as necessary on the warnings. Predicted high flood risk areas are also listed on the warnings.

Figure2.3.36 Example of flood warning

Dissemination of observed data, weather forecasts and warnings

The observed river water level is transmitted from HD to DMC by FAX (normal time: once a day, flooding time: three-hours interval). In addition, the OR shares the daily water levels of rivers and reservoirs and rainfall with ID divisions and DMC through cloud service. The flood

warnings which are prepared by HD and/or the OR and signed by ADG or Director of HD are submitted to DMC and media. In case of severe disaster, a liaison is sent from ID to EOC.

At district level, regional/divisional offices of ID usually communicate with GA, DDMCU, DS, forces, police, local media and others directly and disseminate current water level and condition of rivers.

Warning siren system for reservoir spilling

Warning dissemination to local people is basically conducted by DMC and local authorities. But, only one warning siren system for reservoir spilling was installed and operated in Deduru Oya basin by ID.

3) NBRO

The NBRO issues landslide warnings by engineer's judgement based on observed rainfall. The warnings are transmitted to DMC. Additionally, the warnings are uploaded on the web site. Detailed information about the landslide warnings is mentioned in Section 2.3.3(1).

4) Project Related to Early Warning

As mentioned above, there are some projects related to early warning funded by international donors. The projects are summarized below.

- Installation of early warning system in some river basin located downstream of major reservoirs is ongoing by CRIP budgets for reservoir rehabilitation.
- CRIP2 plans activities to improve weather forecasting (technical cooperation, introducing ECMWF, etc.) and to establish integrated hydro-met system. In addition, establishment of early warning system for Kelani river basin (capacity development for ID, installing hydro-monitoring system, utilization of weather forecasting data and hydrological flood forecasting model) is planned.
- As a part of investment by CRIP2, there is high possibility to establish early warning system in some river basins.
- Integrated basin monitoring system for drought (agriculture and drinking water) and flood will be installed by project funded by Green Climate Fund. Further, capacity development on seasonal weather forecast for agriculture and high intensity rainfall forecasting is also one of the components of the project.
- Flood Control and Water Management Centre for metro Colombo will be established under supporting MCUDP. The main functions of the Centre are basin monitoring, accumulating rainfall and water level data observed by relevant agencies, analysis and forecasting by using hydrological models, disaster response including pump/gate operation and development planning by using the hydrological data.
- ICHARM conducts training for ID engineers regarding runoff/flood analysis by RRI model for early warning and water resource management.

(3) Supports by JICA

Table 2.3.33 Projects relating to hydro-meteorological field supported by JICA

Scheme	Project Name / Contents	Period
Grant Aid	Improvement of Meteorological and Disaster Information Network - Installing Automatic Weather Stations(AWS)	2007 -2009
Technical cooperation	Disaster Management Capacity Enhancement Project Adaptable to Climate Change - DoM: Maintenance of AWS, technical transfer on short-term weather forecasting - NBRO: Technical transfer on landslide monitoring - DMC: Technical transfer on early warning and information dissemination	2010 -2013
Technical cooperation	Improving of Meteorological Observation, Weather Forecasting and Dissemination - Improvement of the maintenance and calibration capacity in the management of the meteorological observation equipment - Improvement of data transmission on AWS: under bidding and procurement - Replacement of the existing GTS/MSS - Installing weather satellite image receiver (Himawaricast): under procurement - Technical transfer for quantitative weather forecasting: Technical transfer to develop weather forecast guidance was done. However, it has not reached the practical level. - Reviewing standards of the warnings: Technology transfer about review of warning threshold by considering relationship between past disaster occurrence and weather condition was done. However, it has not started to revise the warning thresholds. - Public relations/educational activities: Renewal of DoM HP, making educational animation/goods	2014 -2017
Grant Aid	Establishment of a Doppler Weather Radar Network - Preliminary study was completed. M/M was concluded. - The project will be launched after cabinet approval. The radar network will be installed in July 2020.	2018 -2020

(4) Supports by other donors

Table 2.3.34 Projects relating to hydro-meteorological field supported by other donors

Scheme	Project Name / Contents	Period
WB	Dam Safety & Water Resource Planning Project (DSWRPP) - Hydro-Meteorological Information System (HMIS)	2008 -2018
WB	Climate Resilience Improvement Project (CRIP) Climate Resilience Improvement Project Phase2 (CRIP2) - Basin study and implementation - Basin monitoring system (suspense) - Composite observation (Hyd.&Met) system (suspended) - Institutional strengthening and capacity development	2014 -2019 2017 -2020
WB	Metro Colombo Urban Development Project - -Flood Control and Water Management Centre (for metro Colombo, Western Region)	2012 -2017
UNDP	Green Climate Fund - Strengthening the resilience of smallholder farmers in the Dry Zone to climate variability and extreme events through an integrated approach to water management - Establish effective monitoring systems for drought, floods and water management (basin monitoring, seasonal forecasting, high intensity rainfall forecasting, …)	2016 -2023
China	Weather satellite image receiver (FY2)	2012
Korea	Weather satellite image receiver (COMS)	2012

(5) Issues

1) Integrated hydro-meteorological database

There is no integrated database in Sri Lanka, while several agencies operate hydro-meteorological observation systems. The main data transmission tool between the agencies is FAX. Hence, it can be said that the data sharing system in Sri Lanka is not efficient. As a result, it appears that there are two major issues, 1) difficulty on real-time data sharing of weather and river condition, 2) inefficient utilization of the observed data on weather forecasting and warning.

Regarding issue "1)", it takes time and effort to visualize the observed hydro-meteorological data which is transmitted by FAX from the technical agencies to EOC in DMC. Therefore, EOC has difficulty on basin monitoring. Regarding issue "2)", while ID and NBRO operate a lot of automatic rainfall gauging stations which are more than DoM stations, the observation systems are not compatible with that of the DoM. Thus, DoM can't utilize the real-time observed data to monitor current weather condition and forecast.

Based on the current situation, there is a possibility to introduce an integrated observation system for weather forecasting by CRIP2. Additionally, data sharing by the OR of ID through cloud service is proving to be effective.

The observation system should be installed under grand design of comprehensive weather forecasting and disaster warning system. However, it seems that the technical agencies introduce the observation system without grand design. Assistance by many donors without coordination may be one of the reasons for inefficient network. JMA has an advantage on overall concept planning based on their experience. Thus, the JMA's know-how may be valuable for the system planning in Sri Lanka.

2) Basin monitoring system

The OR of ID collects hydro-meteorological observation data through ID divisions and releases of other agencies. However, the function of the OR is limited to data collection and recording because of insufficient manpower. Further, UI of HMIS, the nationwide hydro-met monitoring system, is also not suitable for basin-wise monitoring. Therefore, real-time visualization of observed data and basin-wide data sharing in ID is not enough especially in basins which are managed by several regional offices of ID. In those basins, reservoir gate operation without coordination becomes a big problem. Inadequate data sharing causes problem on basin water resource management too. In addition, there is an issue on location of river gauging stations. There are less gauging stations to monitor local floods even in urban area, because ID has responsibility on only reservoirs and rivers which extend over multiple provinces. In order to solve these problems, establishment of basin-wide monitoring system and enhancement of OR should be considered. In some basins, there are possibilities that the basin-wide monitoring systems will be installed (e.g. basin monitoring system by CRIP2 and Flood Control and Water Management Centre for metro Colombo region by MCUDP). It is desired that the monitoring system be installed in other important basins.

3) Quantitative weather forecast and detailed warning

Based on the interviews done by the Survey, there are some difficulties to utilize the weather forecast as basis for local evacuation advisory and issuing landslide warnings because the

description of the weather forecasts is not quantitative and not localized.

From the view point of improvement of meteorological observation, recovery of AWS data transmission and installation of weather satellite image receiver and Doppler weather radar network should improve the temporal and spatial resolution of meteorological observation in Sri Lanka. On the other hand, strengthening capacity about numerical analysis (e.g. utilization of ECMWF products) will also contribute to the improvement of weather forecasting. Given this consideration, CRIP2 is planning to conduct capacity enhancement on numerical analysis.

On the technical aspect about weather forecasting and warning, the JICA technical cooperation project (Improving of Meteorological Observation, Weather Forecasting and Dissemination) conducted technology transfer about developing weather forecast guidance, but it has not reached the practice level. Continuous supports by following JICA projects and WB projects are desired.

The improvements of equipment and systems are continuing under cooperation with the Government of Sri Lanka and donors. Meanwhile, there is still a need for capacity building and technical supports for staffs who operate and manage the hardware as these are equally important. Japan has a strong point on weather forecasting and warning relating to disasters, compared to Europe and America. Therefore, Japanese continuing supports are expected.

4) Revision of warning thresholds

The DoM issues warnings based on uniform thresholds over the country (e.g. 100mm/24hours). Hence, the local characteristics aren't reflected on the thresholds. To review and improve the warning thresholds, the JICA technical cooperation project tried to clarify the relationship between past disaster occurrence and observed weather condition, but no significant relationship appeared. This result suggests that the number of weather stations where short interval observation is conducted is so few that the representativeness of the observed data is low. The other factor to consider is the lack of detailed records of disasters (time, location, etc.). Revision and improvement of the warning thresholds are desired through improvement of the observation system (AWS, radar, etc.) as well as appropriate disaster recording system.

5) Beneficial and easy to understand warning

In the case of the last flood in May 2016, most of the local people didn't evacuate even if technical agencies and local authorities encouraged them to evacuate. The major reason of low motivation for evacuation is that they didn't understand the flood risk. Because no visualized information (e.g. flood hazard map) is currently attached to the flood warning, it is difficult for local people to understand flood risks. It is necessary to improve the warnings so that local people can easily realize actual disaster damage risk from the warning messages.

Local authority pointed that they don't use the weather warnings for instruction of evacuation because linkage between the weather warnings and estimated disaster risk level is not clear. To increase the effectiveness of the weather warnings, it is recommended to convert rainfall data to disaster index (e.g. soil rainfall index and basin rainfall index) and show estimated disaster risk level more clearly.

Some additional issues on warning dissemination were pointed out by the technical agencies. In some case, media omitted risk area information (e.g. GN names) mentioned on the warning message. In addition, the technical agencies upload the warning massages on their web sites but

few local people see the message. Therefore, the agencies needs to have their own media center to disseminate the warnings directly.

6) Capacity building for regional office of technical agencies

Regional offices of the technical agencies join in the District Disaster Management Committee. They contribute local level cooperation during emergency. In case of flood, regional/district offices of ID well collaborate with local authorities on emergency response. They share information about river conditions and work together to repair flood protection facilities. Corollary to this, it is desired to enhance their abilities (e.g. advisory for evacuation based on technical judgement).

CHAPTER 3 Survey on the Disaster in May 2016

3.1 Outline of the Disaster in May 2016

The heavy rainfall in May 2016 caused serious damages to Sri Lanka especially in the western region including Colombo Metropolitan area.

The rainfall observed in the Kelani Ganga basin records 15-20 year rainfall probability. Due to the flood caused by this heavy rainfall, about 500,000 people were affected and 59,000 houses were damaged. In Kolonnawa, Colombo district, located downstream of Kelani Ganga, 155,062 people were affected, that is approximately 81% of the total population of Kolonnawa. Additionally, the rainfall also triggered a number of landslides, affecting over 14,000 people, with over 150 deaths and missing. The huge amount of debris by the landslide occurred in Aranayake division, Kegalle district, covering three (3) villages completely[9].

In this chapter, the weather condition and the mechanism of the disasters in May 2016 are analyzed, and the responses of government of Sri Lanka for the disasters are evaluated in order to clarify the issues on flood management policies in Sri Lanka. In addition, the relationship between the magnitude of flood damages and increasing exposure along Kelani Ganga as well as efforts by Sri Lanka government, on-going and planned, are reported.

Inundation of recent developed urban area

Huge landslide occurred in Aranayake

Source: JICA Survey Report

3.1.1 Mechanism of the Disaster from viewpoint of Rainfall Characteristics

(1) Outline of meteorological condition

Outline of meteorological condition in the heavy rainfall event 2016 May is introduced below by referring to the JICA Survey Report.

The heavy rainfall was caused by the approach of a tropical depression which was the primary stage of cyclone growth process. According to the press release from NOAA, the tropical depression was generated in the Indian Ocean, south-southeast of Sri Lanka, 150 km from the island on the 14th of May. The tropical depression moved toward the north along Sri Lanka from 15th to 17th. The central pressure of the tropical depression was 1006 hPa and remained unchanged until it left for the Bay of Bengal. The heavy rainfall occurred in the north, East and south-east region of Sri Lanka on the 15th. The rainfall continued until the 16th in the

[9] Sri Lanka Post-Disaster Need Assessment, 2016

north-western region. The amount of rainfall was recorded at over 200 mm/day (Figure3.1.1). The tropical depression intensified from the 18th and reached 991 hPa on the eastern coast of India, the Bay of Bengal. The tropical depression was named "Roanu". After that, Roanu landed in Bangladesh and caused disasters in Bangladesh, India and Myanmar. Roanu dissipated on the 23rd.

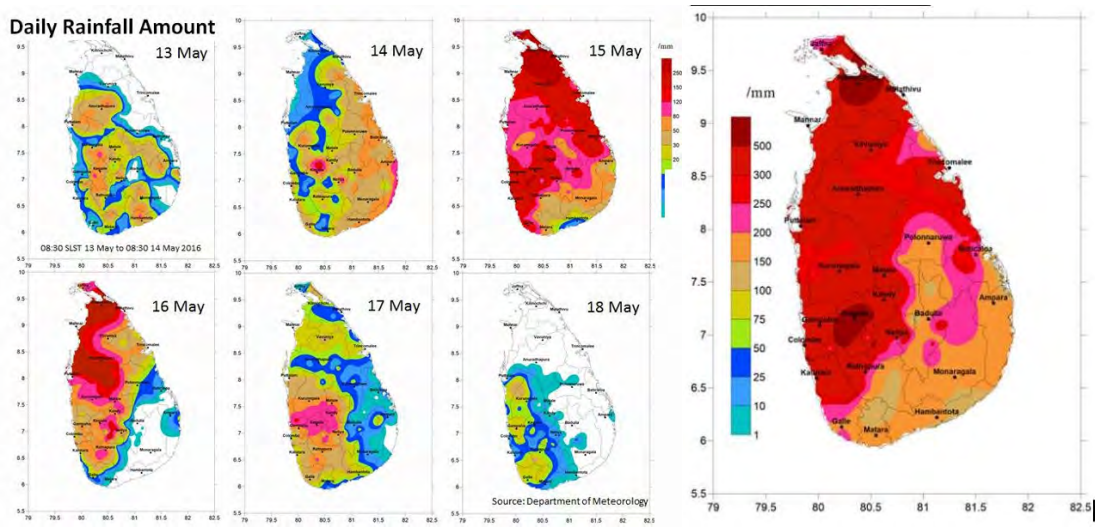


Figure3.1.1 Daily rainfall distribution in May 2016
Left: 13th-18th May 2016 / Right: total rainfall in 12th-18th May 2016
Source: JICA team survey report

(2) Rainfall characteristics in Kelani river basin

1) Rainfall record during the May 2016 Flood in Kelani river basin

Daily rainfall distribution during the May 2016 Flood (13th-18th) in Kelani river basin is shown in Figure3.1.2. On the 13th of May, over 100 mm/day rainfall was observed in the middle-stream area, but the rainfall weakened on the 14th. The peak of the rainfall happened on the 15th with over 200 mm/day rainfall observed in Kelani river basin widely. Basin average daily rainfall was 203 mm/day on the 15th. The central area of the rainfall moved to the upstream area of Kelani river basin on 16th and 17th. Basin average daily rainfall was 82 mm/day and 73 mm/day on 16th and 17th, respectively.

The maximum observed rainfall at Colombo (downstream of Kelani River) and Avissawella (middle-stream of Kelani River) were 257 mm/day and 240 mm/day, respectively. These rainfall amounts correspond to 15-20 years return period probable rainfall.

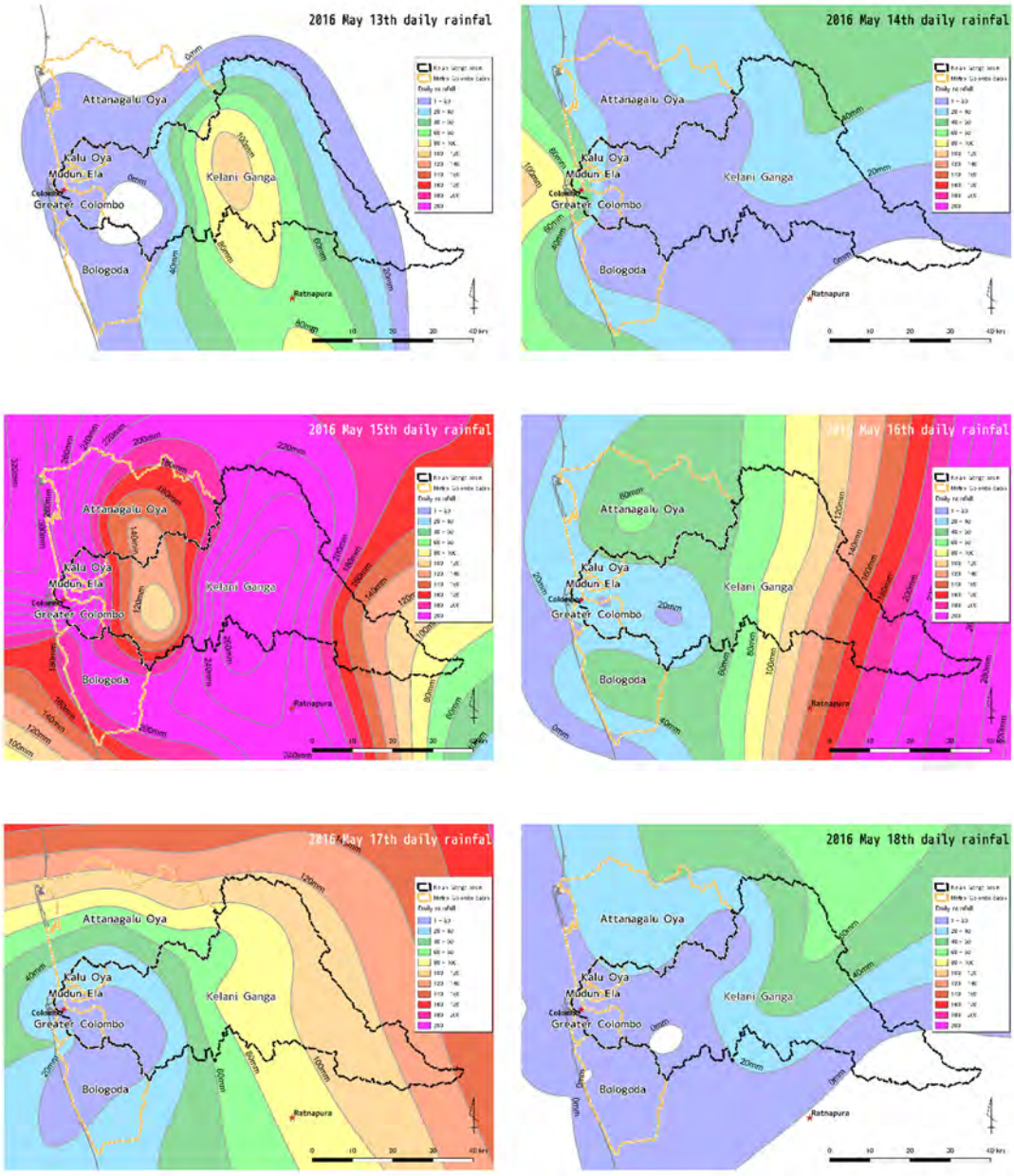


Figure3.1.2 Daily rainfall distribution during the May 2016 Flood
Source: prepared from observed rainfall by DoM

2) Comparison of rainfall pattern in Kelani river basin

Typical five-day rainfall distribution in Kelani river basin and Metro-Colombo river basins based on past flood occurrences are shown in Figure3.1.3. Generally, rainfall patterns can be classified into three: 1) heavy rainfall in the upstream area, 2) wide spread rainfall in the basin, and 3) heavy rainfall in the downstream area. The total rainfall during the May 2016 Flood exceeded 200 mm in most area of Kelani river basin. On the other hand, the rainfall during the June 1989 Flood mainly occurred in the upstream area. The rainfall at Colombo located in downstream area was ca. 100 mm only. During the May and November 2010 Floods, concentrated heavy rains were observed in the downstream area, and local floods dominated.

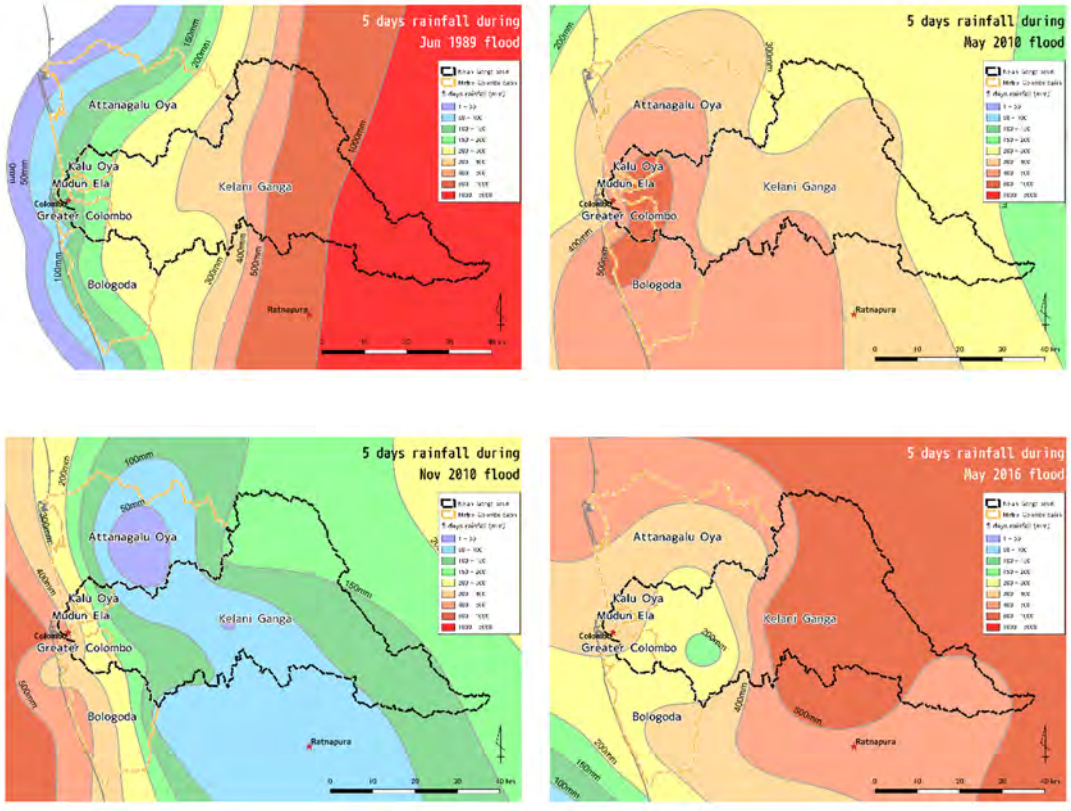


Figure3.1.3 Past typical 5 days rainfall distribution in Kelani river basin and Metro-Colombo river basins

Source: prepared from observed rainfall by DoM

Hourly rainfall during the flood events in November 2010 and May 2016 at Colombo are shown in Figure3.1.4. Both rainfall events have multiple peaks. The peak rainfall caused by concentrated rainfall in November 2010 was over 100mm/hour. On the other hand, the peak rainfall in May 2016 was only 57mm/hour. However, duration of the rainfall in May 2016 was longer than that in November 2010. The rainfall event in November 2010 ended within a half of day, and ca. 95% of the total rainfall amount was observed in 12 hours. In the case of May 2016, the heavy rainfall continued over one day, and the ratio of the peak 12-hours rainfall to the total rainfall was ca. 47% only.

Distribution of affected people of the flood in November 2010 and May 2016 are shown in Figure3.1.5. The affected people of the November 2010 flood concentrated in the coastal area reflecting rainfall distribution. The maximum daily rainfall of the event in Greater Colombo basin exceeded 50 years return period rainfall, but that at Avissawella located in the middle-stream of Kelani River was only 30mm/day. On the other hand, maximum daily rainfall during the May 2016 flood in Greater Colombo basin and upper Kelani river basin was at similar level (15-20 years return period). As a result, affected people were widely distributed in the event.

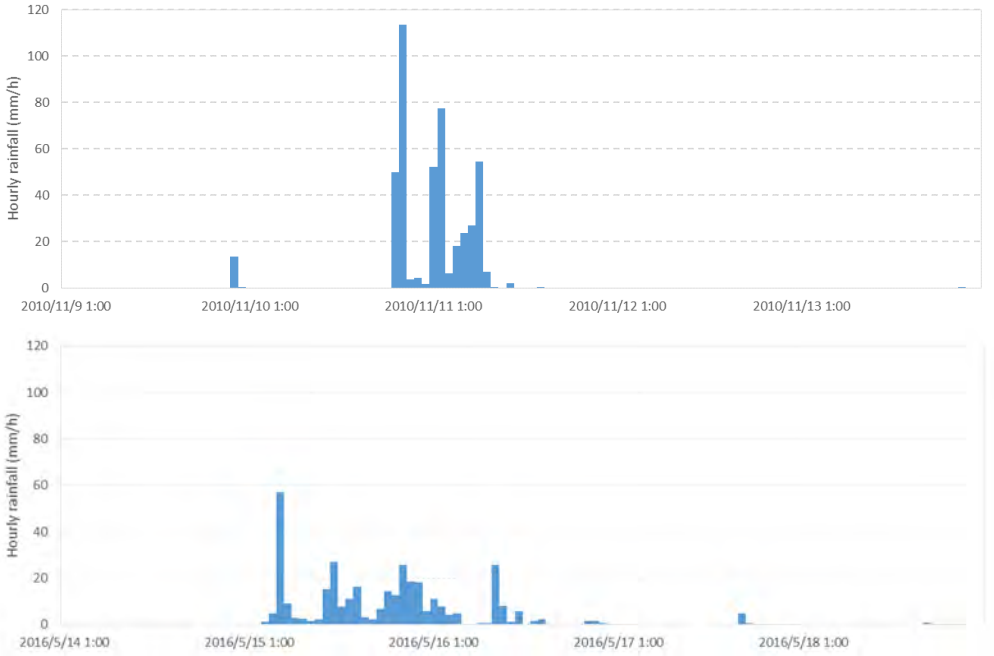


Figure3.1.4 Hourly rainfall during the November 2010 and May 2016 Floods at Colombo

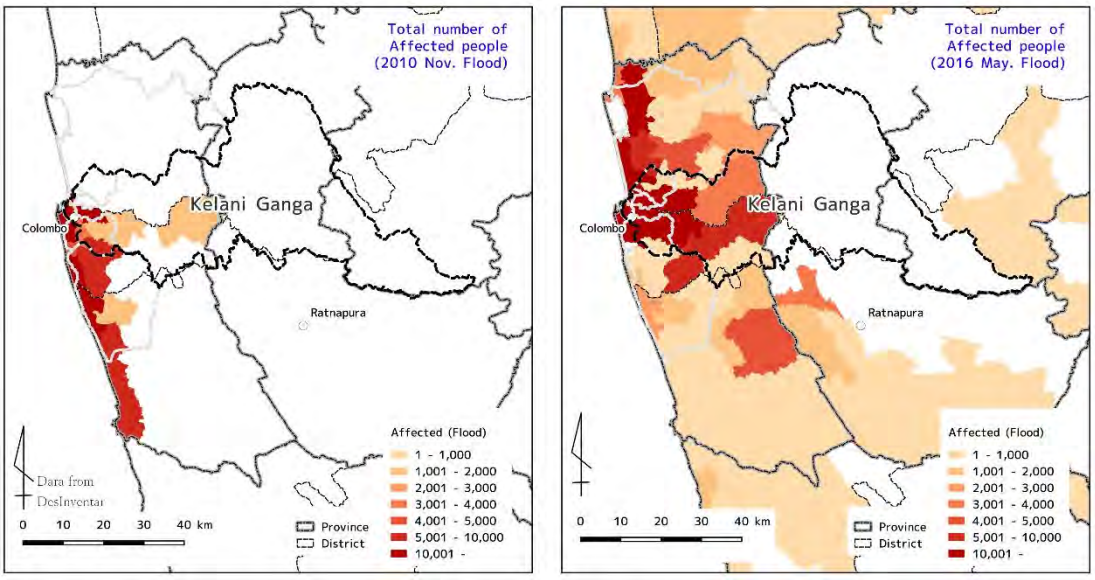


Figure3.1.5 Distribution of affected people by the November 2010 and May 2016 Floods
Source: prepared from DesInventar

3.1.2 Actions taken by the Government during the May 2016 Disaster

(1) Actions taken by relevant agencies

1) Warnings by technical institutions

Timeline of issued warning, actions taken by relevant agencies and disaster situations during the May 2016 Disaster is shown in Figure3.1.6. The timeline was summarized based on the records of warnings, a report prepared by EOC and interviews with relevant agencies.

Alerts before disaster

The DoM issued "Special weather bulletin" for heavy rain and strong wind especially in south-western region on the 13th of May, two days before the heavy rainfall occurred. NBRO also issued Landslide Alert level 1 (first level of three warning levels) for Ratnapura District.

Standby for emergency

The rainfall reached its peak on the 15th. DoM issued "Severe weather advisory" again, and NBRO expanded the coverage of the Landslide Alert to eight (8) districts including Ratnapura and Kandy. EOC requested the Tri forces to standby for the impending disaster based on severe weather warning.

The water levels at gauging stations along the Kelani River were still lower than warning levels, but water level had started to rise. Therefore, ID started checking embankments and flood gates and preparing flood prevention materials. Under the circumstance, landslides occurred in the mountainous area that claimed big number of deaths and missing people.

Initial response to disaster

The heavy rainfall continued on the 16th in the north-west region of Sri Lanka. The water levels at Glencourse and Hanwella located along Kelani River, upstream of Colombo exceeded "Minor" flood level at 0:00H, 16th. The water level at N'street located along Kelani River, near Colombo also exceeded "Minor" flood level at 7:00H. ID hence started flood gate operation to protect Colombo City. DMC had informed the public to evacuate, through media, at 8:25H before ID issued flood warning.

ID issued flood warning for Kelani River flood at 10:30H and for Daduru Oya reservoir sluice at 11:00H. ID urged the peoples and relevant agencies to pay attention and take necessary actions for floods. The observed water levels at Glencourse and Hanwella located along Kelani River, upstream of Colombo exceeded "Major" flood warning level before noon. Inundation occurred at some part of river side residential areas on daytime of 16th, and the residents evacuated independently. There was not enough time from the release of flood warning. Thus, it seems that lot of inundation occurred before flood warning was disseminated to local peoples. DMC requested the Tri forces and police to start rescue. DMC also asked fishers to provide boats for rescue.

The NBRO increased the Landslide Alert to level 2 (warning: prepare to start evacuation within short time) at 14:00H of the 16th. The target district of the Landslide Warning also expanded to 9 districts. Landslides continued occurring in the mountainous region, and the Tri forces and relevant agencies continued rescue activities.

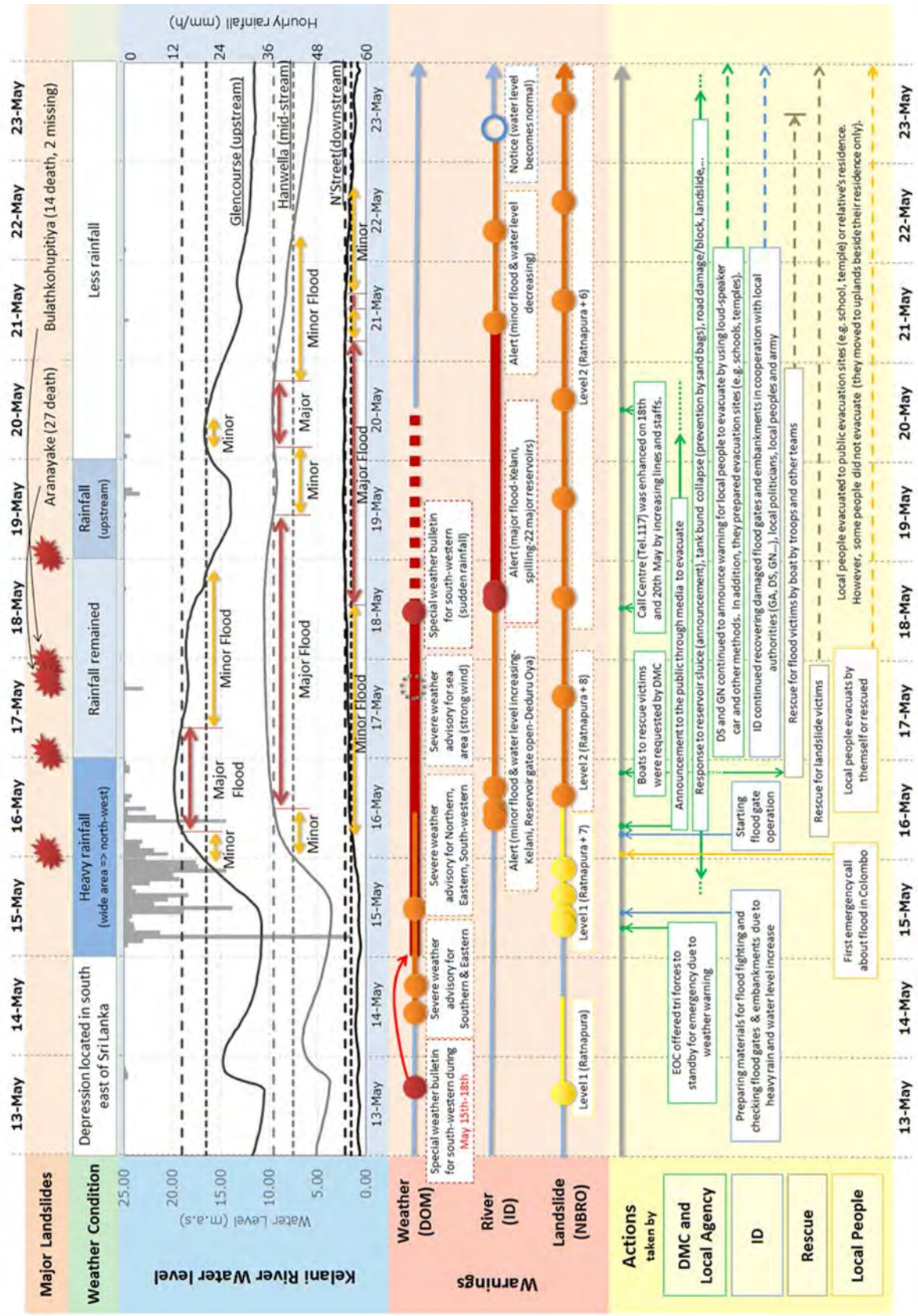


Figure3.1.6 Timeline of actions taken by relevant agencies
Source: EOC report, warning records and interviews with relevant agencies

Expansion of damages and occurrence of huge scale landslide

The rainfall peaked out on the 17th. However, the water level at N'street located along Kelani River, near Colombo was still increasing. Local authorities (GA/DDMCU, DS, GN) preceded preparing evacuation sites (e.g. schools and temples) and warning dissemination by using loud speaker car and/or visiting by police and GN staffs.

Rescue which was mainly conducted by the Navy had started immediately. 1,600 people were rescued on the 17th. ID conducted emergency rehabilitation of damaged embankment and flood gates in cooperation with local authorities, local peoples, troopers and relevant agencies.

In the mountainous region, huge scale landslides occurred. 27 deaths and 16 deaths and missing were caused by landslide at Aranayake (Kegalle) and Bulathkohupitiya (Kegalle), respectively. Rescue at Aranayake faced high difficulty. As the result, over 2,000 man-days of troopers and relevant officers were assigned to the rescue until 29th May.

Flood reached Colombo City

The ID issued "Major" flood warning in the afternoon of 18th May, because the water level at N'street located along Kelani River, near Colombo reached Major warning level. In addition, ID issued another warning about spilling at 22 major reservoirs due to high water level.

The target districts of the Landslide Alert (level 2) were scaled down to seven (7) districts, but the Alert was still issued from NBRO. DoM issued a new "Special weather bulletin" for isolated heavy rain in the south-western region. The rescue by Tri force, police and relevant agencies under coordination by DMC and local authorities was continued. ID also continued emergency repairing for embankments and flood gates. The Call Center (Tel.117) was overwhelmed with emergency calls. Additional staffs were assigned to the call center and more telephone lines were installed to strengthen the call center.

End of disaster

The gauging station at N'street, Kelani River, near Colombo recorded the highest water level on 19th May, and the total number of rescued people in the same day was also highest (12,119). It seems that spring tide also affects to increase the victims. After that day, the water level started decreasing. Therefore, ID lowered the flood warning level in accordance with water level decreasing. Finally, the flood warning was terminated on 23rd May. The number of rescued people also dwindled to zero (0) on 23rd. However, the repairing activities for embankments and flood gates and drainage from tributary retarding basin were continued until the following week.

2) Issues and challenges on warning and responses for the disaster

Based on interviews to EOC and relevant agencies, issues and challenges on early warning and emergency responses for the May 2016 Disaster are summarized as follows.

- It is difficult for the relevant agencies to understand flood situation and outlook because of ineffective hydro-met observation data sharing. For example, navy received observed water level data once a day via FAX only. Thus, it is difficult for them to judge whether the river water level will increase or not. As the result, there is a difficulty for rescue boat arrangement. On the other hand, DMC had announced recommendation for local people to

evacuate from river side area before ID issued flood warning. In theory, DMC who recognizes situation of local people and ID who monitors river condition can effectively cooperate to issue flood warning. Effective hydro-met observation data sharing and inter-ministerial cooperation for disaster response are desired.

- DMC and local authorities have a mechanism of warning dissemination from EOC to downward (GA, DS, GN), but no feedback mechanism from communities to the center. Thus, it is difficult to confirm that the communities have received the warnings or not.
- In some case of incidents, no sufficient information was transmitted from GA to the center because of insufficient staffs and/or no proper information network among relevant agencies.
- The Landslide Alert was issued for DS levels, but the warning area for evacuation was too large to conduct actual evacuation. Thus, the warning should be narrowed down to high risk land slide area or high risk communities The other issue on the landslide alert is period of the warning. The landslide alert wasn't cleared for one month after the disaster finished. It is necessary to improve quality of the warning to utilize it as a basis of precaution and/or evacuation.
- DMC and local authorities who received flood warnings have no materials or information to estimate inundation area. Therefore, they took action based on their own experience. It is possible to take efficient and effective actions, if flood hazard maps were prepared.
- In some area, there was not enough time to disseminate flood warning and evacuate because inundation started shortly after the warning was issued. Even though the water level at the gauging station located in upstream reached Major Flood Level, the flood warnings were issued mainly based on the water level in downstream. As the result, warning before flooding was not inadequate.
- DOM issued warning three (3) days before the disaster. However, there was a limitation to utilize the warning for actual preparations to the disaster because of too wide warning area and non-quantitative rainfall forecasting. Improvement of warning and quantification of forecasting are necessary.
- Most people didn't evacuate when instructed to evacuate because of a false confidence of past experience, fear of leaving their properties and uncomfortable environment of evacuation site. As a result, many local peoples were rescued by boat later.
- Active CBDRM (e.g. formulation of local people's DM unit, cooperation between local people and local administration, awareness, etc.) encourages appropriate evacuation when disasters are predicted. It was reported that CBDRM is relatively active in Badulla because of experience of severe landslide at Koslanda. On the other hand, CBDRM in Kegalle is not so active. Promotion of CBDRM and cooperation between local people and local office of NBRO are important.
- Under emergency situation, liaisons/engineers are sent from technical agencies to EOC, but no enough space is in EOC. In addition, it is pointed out that insufficient cooperation among DMC and technical agencies to interpret observed data and to decide reactions against the disaster.
- ID has responsibility to maintain and repair damaged embankments and flood gates. During this flood event, ID faced necessity to seek help from the Tri force and others

because of huge damages on embankments and flood gates. Actually, the local officers, local politicians, troopers and local peoples supported the ID for emergency repairing. However, in some case, DMC couldn't conduct effective coordination and support because the DMC does not have enough capacity to undertake these things.

- At the initial stage of the disaster, Call Center had no sufficient capacity.
- There was no media-unit in DMC at the present time. Thus, media officer announced evacuation information through media in addition to his regular duties.
- There are many mismatches of disaster records on the situation reports prepared by DMC and NDRSC. As a result, staffs did unnecessary works (e.g. confirmation to DDMCU about detail of disaster records and situations).

(2) Policy, Plan and Situation on Rehabilitation Programs in Related Agencies

1) Reconstruction Strategy based on PDNA

The Post Disaster Needs Assessment (PDNA) on the damages caused by the heavy rains on May 2016 was carried out under the auspices of the MDM and the Ministry of National Policies and Economic Affairs under the financial and technical cooperation of UNDP, WB and EU. The final report of PDNA has been drafted. However, it is still not publicly disclosed as of December 2016. Accordingly, the donor forum to discuss the rehabilitation program based on the results of PDNA has been postponed. The outline of PDNA is summarized below based on the available information at present such as the MDM Progress Report 2016.

The PDNA has covered nine (9) sectors and four (4) cross-cutting themes affected by floods and landslides. Around 45 institutions including UN agencies, Government Ministries, private sector and non-governmental organizations provided their contribution and consultancy to PDNA. At the end of PDNA losses and damages worth Rs 105 billion (Losses – 18 billion, damages - 87 billion) were calculated. The private Sector and the public sector incurred a loss of Rs. 95 billion and Rs. 10 billion, respectively.

A recovery strategy which spans four (4) years has been proposed to recover the aforesaid losses and the estimated amounts Rs 139 billion (refer to Table 3.1.1 and Figure3.1.7). It is expected to liaise with the relevant line ministries to formulate the policies that are required for reconstruction work, and also to obtain the financial allocations needed for the implementation of the plans. The rehabilitation strategy (Building a safer Sri Lanka) proposes the followings based on Build Back Better (BBB) of Sendai Framework.

- Structural measures: 1) Relocation of houses, two key health services and eight schools, 2) Strengthening of flood control system and 3) Relocation of Mehtomulla dump site
- Non-structural measures: 1) Promoting business continuity plans in all registered industries, 2) Targeted awareness to register and insure small scale businesses, 3) Preparedness of all basic services such as power supply, hospitals and schools to provide uninterrupted services in floods and 4) Stronger enforcement of existing regulations and land use plans

Table 3.1.1 Damages, losses and recovery needs in PDNA

Sector	Damage Million Rs.	Losses Million Rs.	Total Impact Million Rs.	Total Recovery Needs, Million Rs.
Social Sectors	56,826	473	57,299	123,939
Housing, Lands and settlement	55,822	256	56,078	122,493
Health and Nutrition	479	119	597	1,033
Education	526	99	624	413
Productive Sectors	23,594	10,972	34,565	2,439
Flood security, Agriculture, Livestock, Fisheries	1,698	1,902	3,600	2,412
Industry and Commerce	21,895	9,070	30,966	27
Infrastructure	6,441	574	7,015	6,990
Irrigation	1,723	0	1,723	1,968
Water and Sanitation	367	77	443	670
Transport	4,143	44	4,187	3,987
Power supply	208	454	662	365
Cross-cutting issues	167	5,851	6,019	5,700
Environment	27	543	570	231
Disaster Risk Reduction	140	254	394	320
Employment and Livelihoods	0	5,054	5,054	5,117
Gender and social inclusion	0	0	0	32
Total	87,028	17,870	104,899	139,066

Source: MDM Progress Report 2016

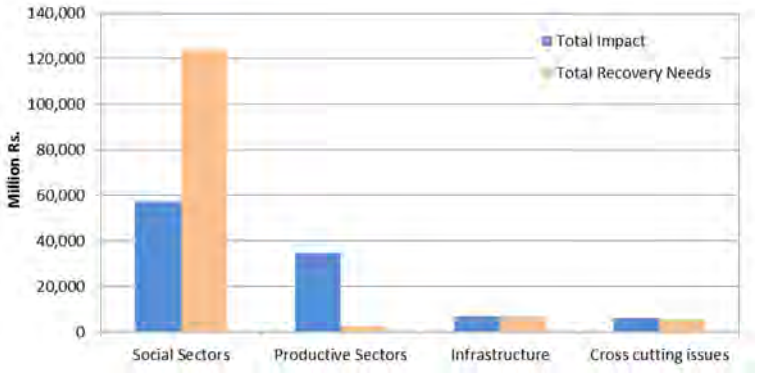


Figure3.1.7 Damages, losses and recovery needs in each sector
Source: MDM Progress Report 2016

2) Recovery and Reconstruction for Sediment Disaster in Kegalle

A lot of landslides in the mountain area were triggered by the heavy rainfall in May 2016. In Kegalle district, 36,121 people from 9,983 families were affected by the landslides. 168 houses completely collapsed and 1,631 houses, partially collapsed. In Anayarake, one of the most severely damaged areas, 2,401 people from 756 families were affected. The total death and missing people reached 127. Approximately 1,700 people from 500 families have evacuated to five (5) temporary resettlement areas such as schools, temples and public spaces.

As pointed in Section 2.3.3, there was no coordination agency for resettlement in Koslanda landslide in 2014. Learning from that experience, in this disaster, Kegalle District Coordinating Committee and District Secretary initiated the resettlement project with the support of MDM. Because of the large scale of resettlement, the government divided the resettlement process into

temporary resettlement and permanent resettlement. In these two phases, several government and non-government agencies were involved providing various services to the affected families.

The temporary resettlement was almost completed as of December 2016. The land acquisition and the housing construction for permanent resettlement have been implemented by the government, Army and donation from private enterprise. NBRO prepared Hazard Resilient Housing Construction Manual for the high landslide risk area and provided necessary technical advice for design and countermeasure depending on geological and topographical condition.

Outline of Resettlement Programme for Aranayake Landslide

The government of Sri Lanka has implemented "Housing Construction Programme for Landslide Victims" with an objective to provide housing for families affected by landslide on May 2016 in Kegalle District.

In the resettlement programme beneficiaries was selected from the families directly affected by landslide event in May 2016 and the families living in the landslide high risk area identified by NBRO. The programme implemented financial support for land acquisition and house construction. There are two options of supports for the families. One is land plot of approximately 10 perches (250 m^2) will be provided from the already identified lands with Rs. 1.2 million in cash to build the resilient core house. The other will be given the option of building on their own land with additional Rs. 0.4 million is given as an incentive.

Concept of Core House

This programme promotes the hazard resilient housing construction and disseminates the "Core House" as a model house. It is designed by NBRO under the Build Back Better concept. Following are the mandatory of features of the "Core House".

- Minimum floor area of 650 square ft. (around 60.4 m^2)
- Resilient foundation and upper structure (As directed by NBRO)
- Two bedrooms
- A Kitchen
- A permanent roof and
- A water seal toilet and the septic tank

Implementation of Programme

The resettlement programe is implemented under the initiative District Secretary of Kegalle with assistance of resettlement unit of NBRO. NBRO prepared guideline of this programme and distributed to district officers and beneficiaries. Necessary technical supports and workshops also be provided. The programme implementation structure and operational procedure are shown in Figure 3.1.7 and Table 3.1.3.

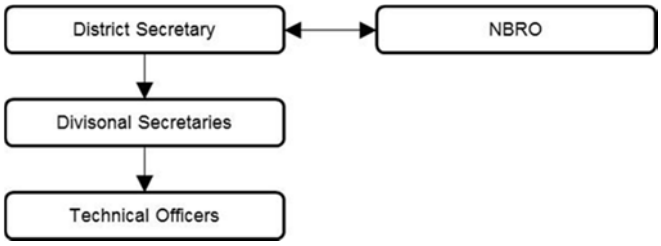


Figure3.1.8 Implementation structure

Source: Implementation Guidelines for Home Owner Driven Construction Programme for Landslide Victims – Kegalle District

Table 3.1.2 Operational procedure

Process	Content
Land Selection	NBRO's Kegalle District office along with Resettlement Unit will give its recommendations during land acquisition, land subdivision etc. on selected land for resettlement.
House Plan	House plan designed by NBRO and approved by the Cabinet are recommended for housing construction. Beneficiaries also could have their own house plans with approval of NBRO.
House Construction	NBRO will closely supervise the house construction along with Technical Officers of Divisional Secretary. And NBRO will provide the necessary guidelines in resilient house construction. After completion of the resilient core hose, a Certificate of Conformity should be obtained by the beneficiary before releasing the final installment.
Financial Assistance	Beneficiaries of the programme will be granted Rs. 1.2 million for house construction in five (5) installments based on the stage of completion. Beneficiaries who have obtained the approval for individual Resettlement Sites will be granted a lump sum of Rs. 0.4 million to acquire land for house construction.

Source: Implementation Guidelines for Home Owner Driven Construction Programme for Landslide Victims – Kegalle District

Land acquisition in safe area is also an issue for resettlement project. Besides, it is often difficult to get consensus with the local residents who are concerned about living and livelihood after resettlement. According to NBRO, it is expected to take about two (2) years to complete the resettlement project.

When landslide occurs in Japan, necessary structural countermeasures such as in-situ slope stabilization works are immediately implemented to prevent extent of damage. In Sri Lanka, however, resettlement is the main countermeasures.

Tents in temporary resettlement area

Monitoring of construction using drone

3.2 Situation of Flood Disaster in Kelani Ganga

3.2.1 Analysis on Causes of Flood Hazard

(1) Outline of Kelani Ganga and Its Tributaries

Kelani Ganga is the 7th largest river in Sri Lanka with catchment area of 2,314 km^2. It originates from the central portion of the country and flows across Western Province before reaching the sea. Precipitous terrain exists in the upper part of the basin, whereas low-lying area with less than 100 m above mean sea level (MSL) forms the downstream part of the basin. In the low-lying area, the river flows through the northern part of Metropolitan Colombo area in which many assets have accumulated. In the left bank side of the lowest reach of Kelani Ganga, there is Greater Colombo basin, a tributary of Kelani Ganga, which includes center of Colombo and Sri Jayawardenepura Kotte (refer to Figure3.2.1).

The entire basin is located in the wet zone of the country. The mean annual runoff is 3,400 MCM (million m^3). There are five (5) hydropower dams with the total capacity of 335 MW in the most upstream reach of the basin. In a tributary of the middle reach of the basin, there are two (2) dams to supply municipal water to Colombo Metropolitan area.

Paddy fields have been developed in the low-lying area from a long time ago. In order to protect the paddy field from flooding from Kelani Ganga, Minor Flood Control Scheme, hydraulic structures which are located at the confluence points of Kelani main stream and tributaries, have been constructed from the 1920s. These are the structures to prevent reverse flow from Kelani main stream into tributaries when small to medium scale flood of Kelani Ganga occurs, and consist of dyke and flap gates or lift gates. There are 20 and 26 schemes in the right and left bank sides, respectively, including damaged or non-existing ones. The target safety level of the Minor Flood Control Scheme is about 1/5 for the flood of Kelani main stream. When the flood with larger scale occurs, reverse flow from Kelani main stream into tributaries can happen and flooded water are tentatively stored in the low-lying area of the tributaries. This storage effect in the tributaries can contribute to reduce and retard flood flow in Kelani main stream, and consequently reduce flood risk in Colombo central area in the lowest reach of Kelani Ganga.

The bunds which are called as Major Flood Protection Scheme have been constructed from the 1920s in the lowest reach of Kelani Ganga. The bund in the left bank side protects Colombo central area and that in the left bank side protects Kelani. The width of the floodplain area between Kelani main stream and the bund in the left bank side reaches about 2km at the widest place. This area has large retarding function of flood flow, and has been regarded as “unprotected area” from a long time ago. However, many houses have been occupying the area recently.

Scheme of Organization and Standing Orders to Safeguard the City of Colombo from Floods in Kelani Ganga, which was prepared in 1993, determine the flood scale and necessary responses during a flood event. The flood is categorized as shown in Table 3.2.1

In Greater Colombo basin, a tributary of Kelani Ganga, the drainage plan was to maintain water level less than 2m above MSL when heavy rainfall with target safety level occurs, by improving drainage channels and retarding basins. The area where the ground level is less than 2 m above MSL is regarded as inundation area. The outlet of Greater Colombo basin is located at around Nagalagam gauging station. When the water level of Kelani main stream is high, the gate located

at around the confluence is closed to prevent reverse flow to Greater Colombo basin.

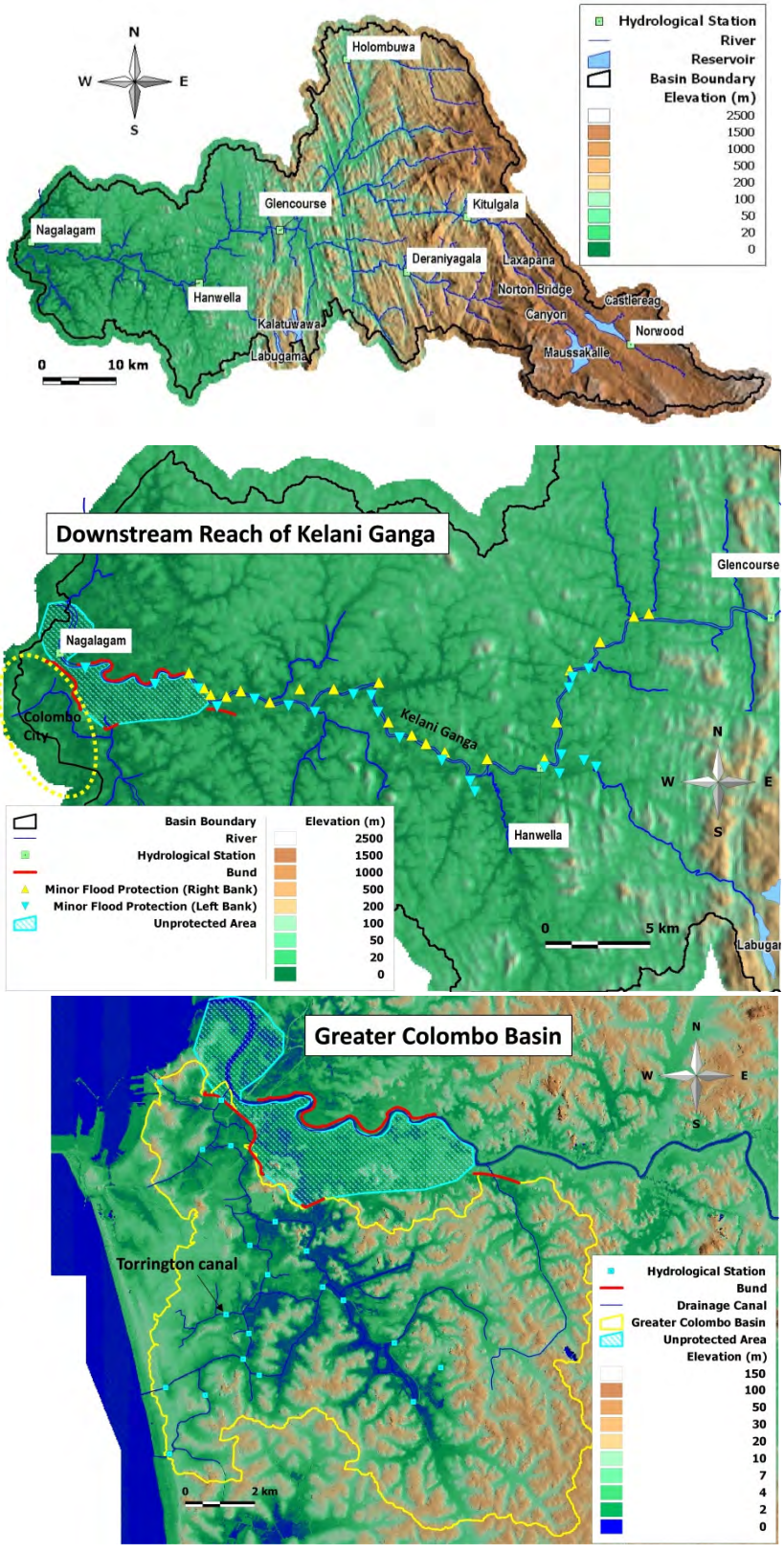


Figure3.2.1 Kelani Ganga Basin

Source: Prepared by JICA Survey Team based on GIS data provided by ID and SLLRDC

Table 3.2.1 Category of flood by water level at gauging stations in Kelani Ganga

Category of Flood	Nagalagam		Hanwella		Glencourse	
	Water Level (m MSL)	Return Period (year)	Water Level (m MSL)	Return Period (year)	Water Level (m MSL)	Return Period (year)
Minor	1.52	2	7.52	<2	16.5	2
Major	2.13	8	9.52	5	19.0	5
Dangerous	2.74	50	n.a.		n.a.	
Critical	3.66	>100	n.a.		n.a	

Source: Prepared by JICA Survey Team based on Scheme of Organization and Standing Orders to Safeguard City of Colombo from Floods in Kelani Ganga (1993) and data provided by ID

In 2009, JICA examined a flood mitigation plan for Kelani Ganga under Comprehensive Study on Disaster Management in Sri Lanka.

It was recommended that for short-term measures the existing Minor Flood Control Scheme be rehabilitated and enhanced.

As for long-term target, target safety level was set at 1/20. To achieve the long-term target, the combination of heightening of dyke along main stream of Kelani, construction of dam for flood control and conservation and enhancement of natural retarding basin was examined. As a result, the heightening of dyke along main stream of Kelani and the conservation and enhancement of natural retarding basin were recommended, mainly from the view point of cost-benefit. Figure3.2.2 shows the recommended measures.

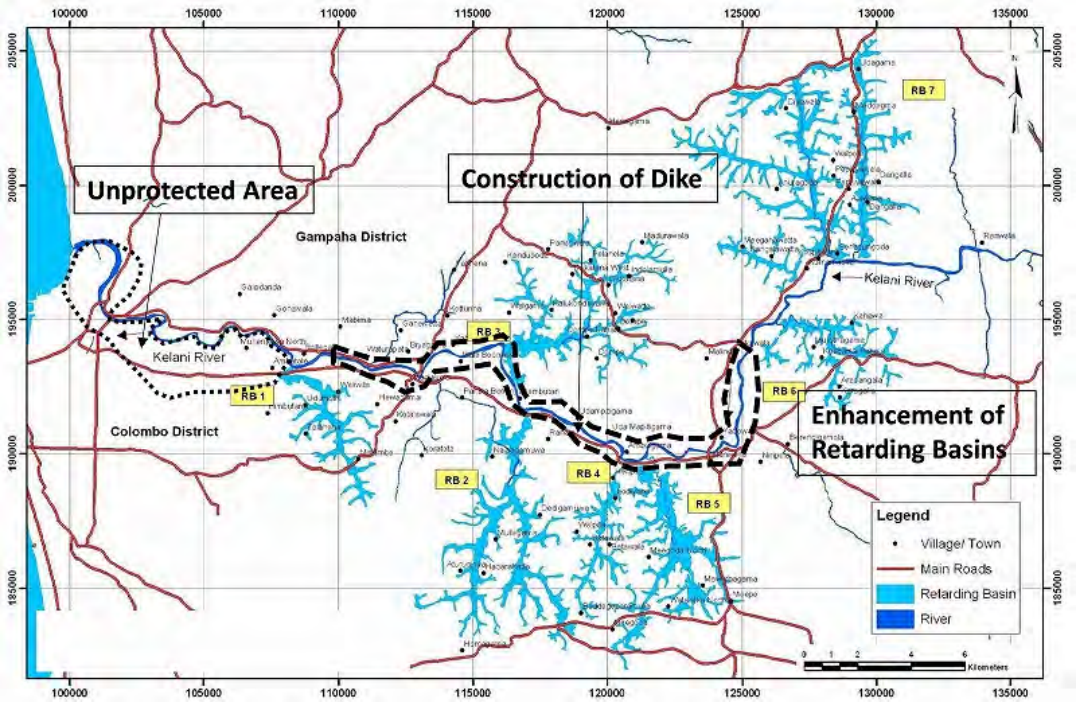


Figure3.2.2 Flood mitigation measures examined in Comprehensive Study on Disaster Management in Sri Lanka

Source: Prepared by JICA Survey Team based on Comprehensive Study on Disaster management in Sri Lanka (2009)

The recommended enhancement of natural retarding basin is to conserve and strengthen the existing function of flood retarding in tributaries. It is meaningful to clarify the effect of flood retarding in tributaries in the flood mitigation plan.

On the other hand, the recommended heightening of dyke along main stream of Kelani is limited

to the area upstream of the unprotected area. Therefore, the flood hazard in the unprotected area will not be mitigated even if the recommended measures targeted to achieve the safety level of 1/20 will be implemented.

The target safety level of Greater Colombo basin where many assets have been accumulated is set at 1/50. The long-term target of Kelani flood mitigation in the study was set at 1/20, which seems to be inappropriate compared to that in Greater Colombo basin. However, it could be justified because the main target of the flood mitigation in the study seemed to be the low development area.

According to ID, the recommended flood mitigation measures for short term have been partially implemented by government fund. However, the ones for long-term have not yet been implemented.

The flood disaster in May 2016 occurred under the above-mentioned circumstances.

(2) Water Level and Flooded Area

1) Water Level

Figure3.2.3 shows change in annual maximum water level at three gauging stations in Kelani Ganga. In the flood disaster in May 2016, the water level at Nagalagam station reached 2.33m, which exceeds the level for the major flood level of 2.13m, for the first time after 1989. The water levels at Hanwella and Glencourse also exceeded the major flood levels, and reached 10.51m and 19.81m, respectively. The return periods of the maximum water levels are evaluated at 1/15, 1/10 and 1/10 for Nagalagam, Hanwella and Glencourse stations, respectively.

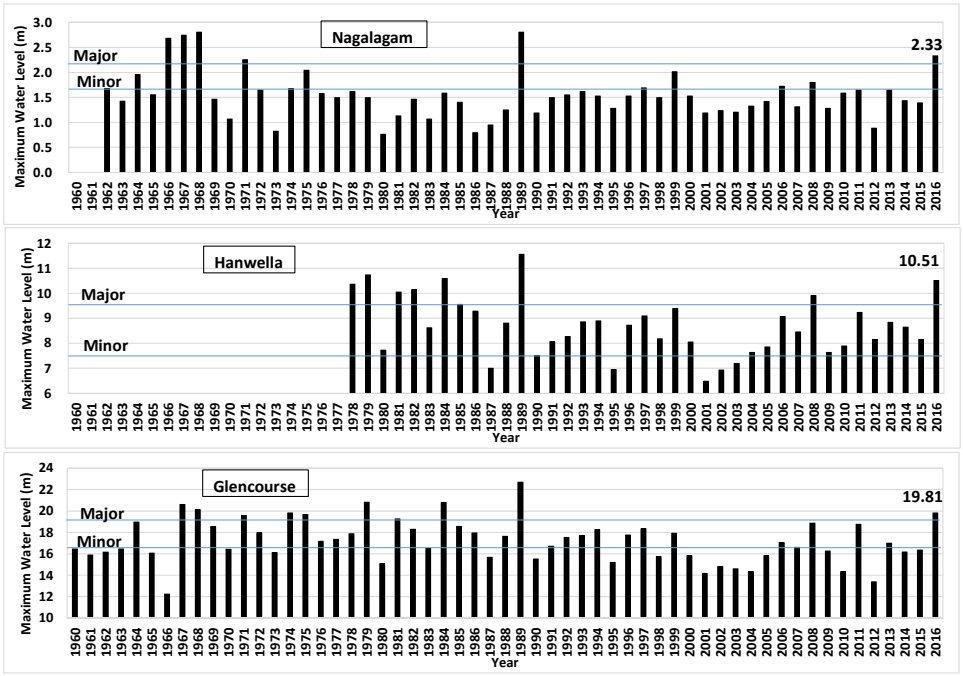


Figure3.2.3 Change in annual maximum water level
at three gauging stations in Kelani Ganga

Remarks: Year in horizontal axis means hydrological year (from October to next September), Source: ID

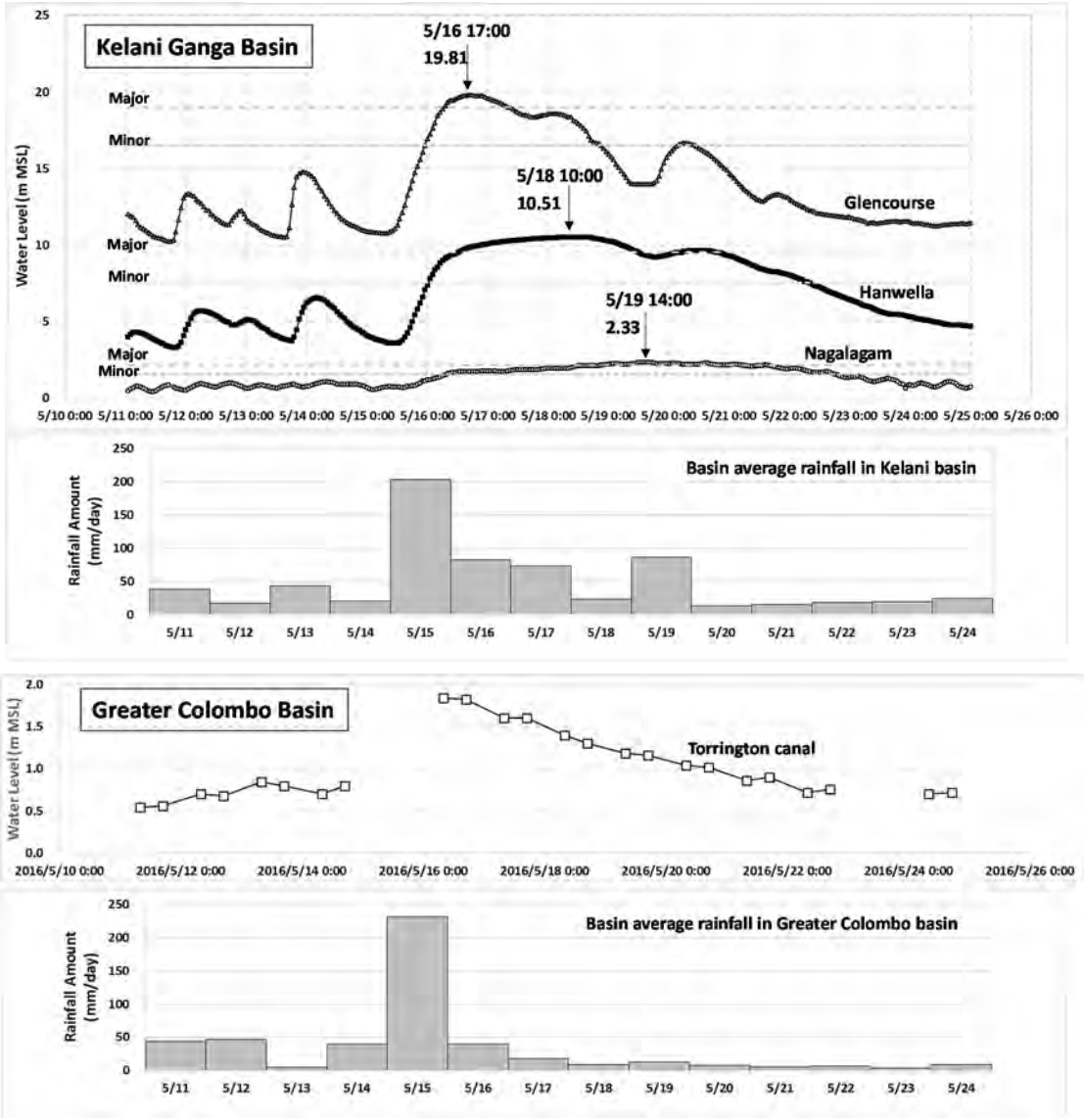


Figure3.2.4 Hyetograph and hydrograph
in Kelani Ganga and Greater Colombo Basins during flood disaster in May 2016
Source: ID, SLLRDC and DoM

Figure3.2.4 shows hyetograph and hydrograph in Kelani Ganga and Greater Colombo basins during flood disaster in May 2016. The hyetograph shows basin average rainfall.

The temporal pattern of rainfalls in Kelani Ganga and Greater Colombo basins are almost the same. The peak rainfall occurred on 15 May.

At Glencourse station, the maximum water level appeared at 17:00H on 16 May, one day after the peak rainfall. However, propagation of flood wave is slow, so the maximum water level at Hanwella and Nagalagam appeared at 10:00H on 18 May (lag time = 41 hrs.) and at 14:00H on 19 May (lag time = 69 hrs.), respectively. This indicates that there is effect of flood retarding by reverse flow into tributaries.

Although there is the delay in the peak water levels, the water level reached the minor flood level

at relatively early stage at all stations and water level more than the minor flood level continued 100-150hrs, as shown in Table 3.2.2. It is also noted that the time lag among the time reaching the minor food level in all the stations is relatively short: four (4) hours between Glencourse and Hanwella and 3 hours between Hanwella and Nagalagam.

Table 3.2.2 Situation of water level during flood disaster on May 2016

Flood Category	Nagalagam	Hanwella	Glencourse
Minor	16 May 7:00 – 22 May 18:00 （155hrs）	16 May 1:00 – 22 May 8:00 （151hrs）	15 May 23:00 – 20 May 10:00 （107hrs）
Major	18 May 13:00 – 21 May 15:00 （74hrs）	16 May 12:00 – 20 May 19:00 （103hrs）	16 May 7:00 – 17 May 8:00 （25hrs）
Peak	19 May 14:00	18 May 10:00	16 May 17:00
	Lag =28hrs	Lag =41hrs	

Source: Prepared by JICA Survey Team based on data provided by ID

At Torrington canal gauging station in Greater Colombo basin, the peak water level of 1.84m appeared at 8:00H on 16 May, quickly responding to the peak rainfall on 15 May. After the peak, the water level fell very quickly. Since the maximum water level did not reach the critical level of 2m, no significant inundation occurred in Greater Colombo basin.

2) Flooded Area

Flooded area around Kelani Ganga during flood disaster in May 2016 was surveyed by Survey Department immediately after the disaster, and a flood map was prepared. ID also conducted own survey sometime after the disaster, and another flood map was prepared.

The flood map prepared by Survey Department shows more details of flooded area. However, there are some places that were not identified as flooded area though they seemed to be flooded from satellite images. The one prepared by ID captured overall situation of flooded area.

Considering these observations in the present study, the flood map at downstream reach of Glencourse gauging station was prepared as follows.

- The flood map prepared by Survey Department is utilized as base data.
- As for the places that were not identified as flooded area although they seemed to be flooded from satellite images, the flooded area identified by the flood map by ID is added.
- If the identified flooded area is judged strange compared to Lidar topographic data, the flooded area is modified based on the topographic information.

The prepared flood map is presented in Figure3.2.5.

The flood water level was estimated by overlaying the edge of flooded area shown in the flood map and the Lidar topographic data. Although the estimated flood water levels were scattered in places, the maximum flood water level along the main stream of Kelani was approximately expressed. It was also assumed that inundation in tributaries occurred with same water level as the main stream of Kelani. By this assumption, the flood water depth in the flooded area was estimated as shown in Figure3.2.5.

One can see that the area where the estimated flood water depth under the above-mentioned assumption is more than zero almost coincides with the edge of flooded area shown in the flood map. This suggests that main cause of the inundation in tributaries is the reverse flow from the main stream of Kelani into tributaries. The area of deep flood waters extends to upper reach in some tributaries. The flood hazard is relatively large in such places even in tributaries.

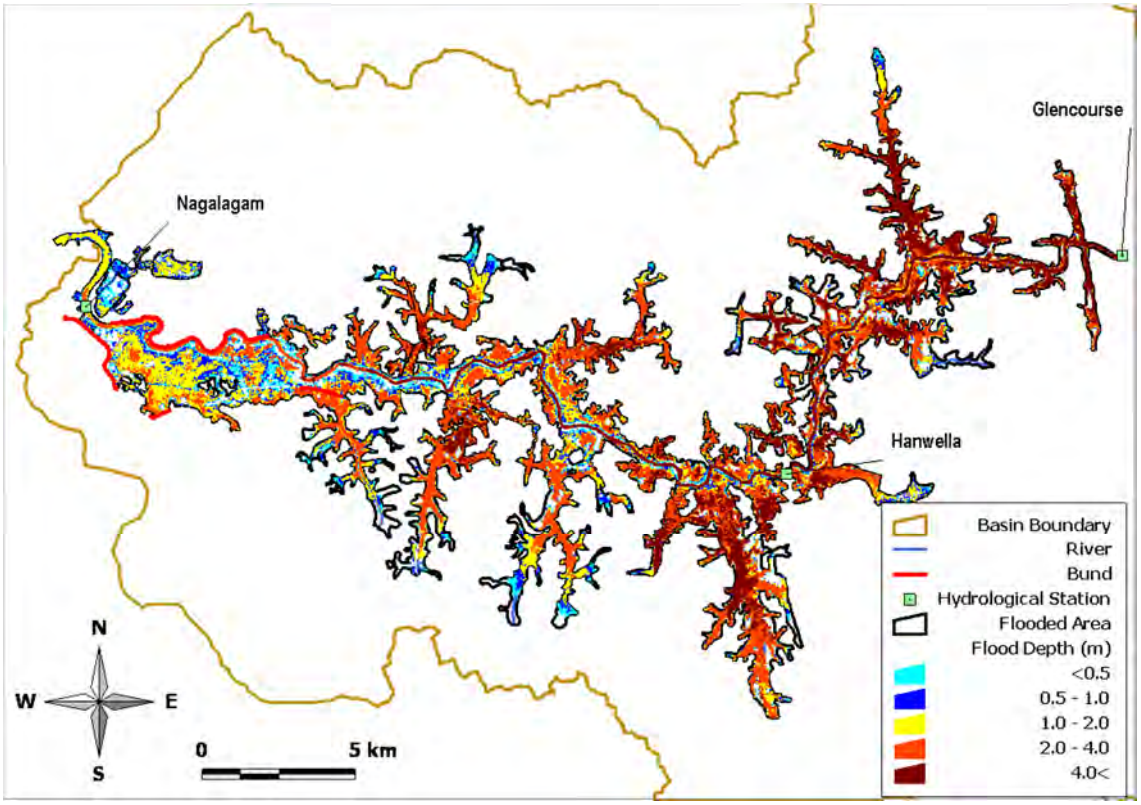


Figure3.2.5 Estimated flood depth and flooded area in flood disaster in May 2016
Source: JICA Survey Team

(3) Situation and Effect of Operation of Hydraulic Structures along Kelani Ganga

There are five hydropower dams in the most upper reach and two dams to supply municipal water in a tributary in the middle reach of the basin. Among the five hydropower dams, three dams have small storage. The effects of these dams on flood run-off would be negligible. Since the catchment area of the dams in a tributary in the middle reach is small, the effect of these two dams on flood situation would be minimal.

Although the actual operation of these dams during the flood disaster in May 2016 is not known, reduction of peak flood flow by effect of storage in some extent is expected, according to a review on meteo-hydrological situation conducted by CRIP[10].

[10] A World Bank Report on Meteorological and Hydrologic the need for Modernization Investment Plan, Meteorological and Hydrological Services in Sri Lanka, 2016.

There are gates at confluence of the main stream and tributaries under Minor Flood Protection Scheme along Kelani Ganga. Many of the gates are flap gates, so the gates are automatically opened or closed depending on water levels. As for the lift gates, staffs of ID operate them according to water levels in main stream of Kelani and tributaries.

During the flood disaster in May 2016, staffs in Gampaha Division (responsible for the right bank side of Minor Flood Protection Scheme), Colombo Division (responsible for the left bank side of Minor Flood Protection Scheme and Major Flood Protection Scheme) and some supporting members operated and checked the hydraulic structures continuously. The main activities are summarized in Table 3.2.3.

Table 3.2.3 Situation of operation of hydraulic structures along Kelani Ganga during flood disaster in May 2016

Day	Main Activities	
	Major Flood Protection Scheme	Minor Flood Protection Scheme
16 – 17 May	▪Checking flood bunds	▪Sand bags were set around some hydraulic structures.
18 May	▪Seepages were found in bunds in the right bank side at around 12:00H. Sand bags were applied as an emergency measure.	▪Due to high water level in Kelani, Minor Flood Protection Scheme did not function. Reverse flow into tributaries occurred. ▪Two hydraulic structures were damaged. Emergency measures were applied.
19 - 22 May	▪Continuous observation of the bunds by experts of ID ▪Sand bags were applied as an emergency measure at additional seepage portions.	
23 May		▪Checked if water in tributaries goes back to main stream of Kelani smoothly or not, after the water level in Kelani became low.
24 -31 May		▪The water in the tributary near Bomiriya in the left bank side of Kelani could not go back to the main stream of Kelani, because the Bomiriya gate did not function due to debris caused by destroyed houses. The emergency bypass channel was made by digging part of bund nearby, in order to reduce the water in the tributary.

Source: ID

The operation of hydraulic structures did not seem to worsen the flood hazard because the operation of gates seemed to simply follow the predefined operation rule which is based on the water level. However, there was the case that the flood hazard was worsened when water level of main stream of Kelani became low, because the gate did not function due to debris caused by destroyed houses.

(4) Comparison with Past Flood Events

As shown in Section 3.1.1(1), spatial patterns of rainfall in Kelani Ganga basin in the past representative flood events are different. Table 3.2.4 shows basin average rainfall and maximum water levels in Kelani Ganga and Greater Colombo basins in the past major flood events. The past flood events can be categorized into the following three patterns.

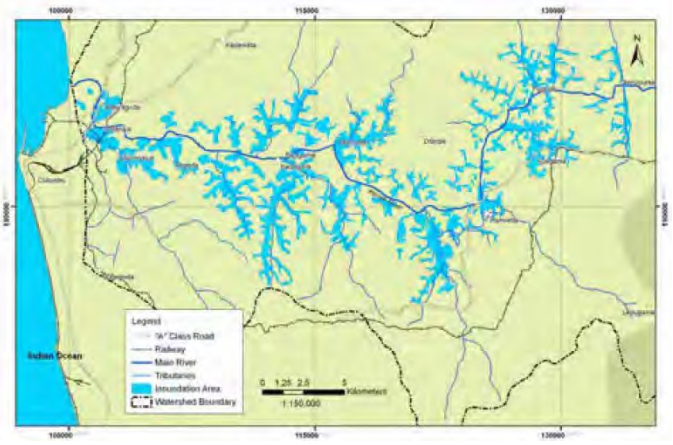
- Pattern 1: Rainfall volume is large only in the upper reach of Kelani Ganga basin. Riverine flood from main stream of Kelani is dominant.
- Pattern 2: Rainfall volume is large in the entire Kelani Ganga basin. Both riverine flood from main stream of Kelani and inundation by run-off from tributaries occur.
- Pattern 3: Rainfall volume is large only in the lower reach of Kelani Ganga basin. Inundation by run-off from tributaries is dominant and there is almost no riverine flood from main stream of Kelani.

The flood disaster in May 2016 is the typical case for pattern 2. Patterns 1 and 3 are represented by the flood disasters in June 1989 and in May and November 2010, respectively. The flooded areas for these events are shown in Figure3.2.6. Table 3.2.5 shows the characteristics of water level in the past representative flood events.

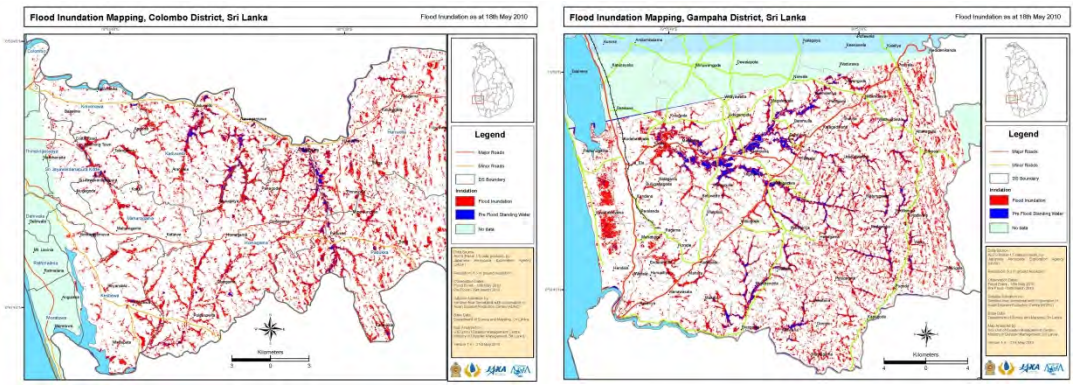
Table 3.2.4 Basin average rainfall and maximum water levels in Kelani Ganga and Greater Colombo Basins in past representative flood events

Event	Daily Maximum Rainfall（mm）		5-Day Total Maximum Rainfall（mm）		Maximum Water Level（m MSL）				Pattern
	Kelani Ganga basin	Greater Colombo basin	Kelani Ganga basin	Greater Colombo basin	Kelani Ganga basin			Greater Colombo basin	
					Nagalagam	Hanwella	Glencourse	Torrington Canal	
1989 Jun	188.5	72.1	**578.6**	135.7	**2.79**	**11.56**	**22.68**	-	**1**
1992 Jun	112.9	330.3	291.2	369.6	1.55	8.27	17.62	-	**3**
1999 Apr	129.6	253.4	301.0	320.3	2.01	9.39	17.92	1.28	**1**
2005 Nov	152.9	239.8	269.1	406.7	1.72	9.07	15.51	1.76	**(2)**
2008 Jun	102.3	78.5	315.0	206.4	1.80	9.51	18.04	2.26	**2**
2010 May	92.2	137.2	347.5	**473.2**	1.58	7.93	14.33	1.88	**3**
2010 Nov	61.2	**331.3**	149.0	343.8	0.96	4.99	12.92	**2.34**	**3**
2016 May	**203.0**	231.4	468.0	366.3	2.33	10.51	19.81	1.84	**2**

Source: Prepared by JICA Survey Team based on data provided by ID, SLLRDC and DoM



Flood in June 1989: Flooded area extended along main stream of Kelani and tributaries



Flood in May 2010: Flooded area was observed only in tributaries.

Figure3.2.6 Flooded areas in flood in June 1989 and flood in May 2010

Source: Flood in June 1989 - Comprehensive Study on Disaster management in Sri Lanka (2009), Flood in May 2010 – DMC

Table 3.2.5 Characteristics of water level in past representative flood events

Event	Nagalagam Maximum Water Level (m MSL)	Nagalagam Time when Maximum Water Level Occurs	Time lag between Glencourse -Nagalagam for Maximum Water Level (hrs.)	Nagalagam Time when Water Level reached Minor Flood Level	Nagalagam Duration of Minor Flood Level Continued (hrs.)	Nagalagam Duration of Major Flood Level Continued (hrs.)	Time lag between Glencourse -Nagalagam for Minor Flood Level (hrs.)
1989 Jun	2.79	6Jun 20:00	58	4 Jun 12:00	116	61	30
1992 Jun	1.55	5 Jun 17:00	42	5 Jun 15:00	5	0	22
1999 Apr	2.01	21 Apr 19:00	23	19 Apr 1:00	99	0	14
2005 Nov	1.72	22 Nov 23:00	15	22 Nov 12:00	24	0	-
2008 Jun	1.80	1 Jun 14:00	18	31 May 20:00	58	0	13
2010 May	1.58	17 May 17:00	7	17 May 15:00	4	0	-
2010 Nov	0.96	11 Nov 17:00	12	-	0	0	-
2016 May	2.33	19 May 14:00	69	16 May 7:00	155	74	7

Source: Prepared by JICA Survey Team based on data provided by ID

3.2.2 Flood Damages

(1) Damage of Hydraulic Structures

1) Major Flood Protection Scheme

During the flood disaster in May 2016, seepages were found in bunds in the right bank side at five (5) locations, and sand bags were applied as an emergency measure. The locations of the seepages are shown in Figure3.2.7. It seemed that the bund itself was at critical condition since the high water level continued for a long time. The bund was constructed in the 1920s. It is necessary to assess the condition of structure and to strengthen it. Furthermore, there were severe erosions of toe of the bund in some places, which endangers the stability of the bund structure. It is also necessary to apply some countermeasures to prevent further erosion to ensure the safety of the bund.

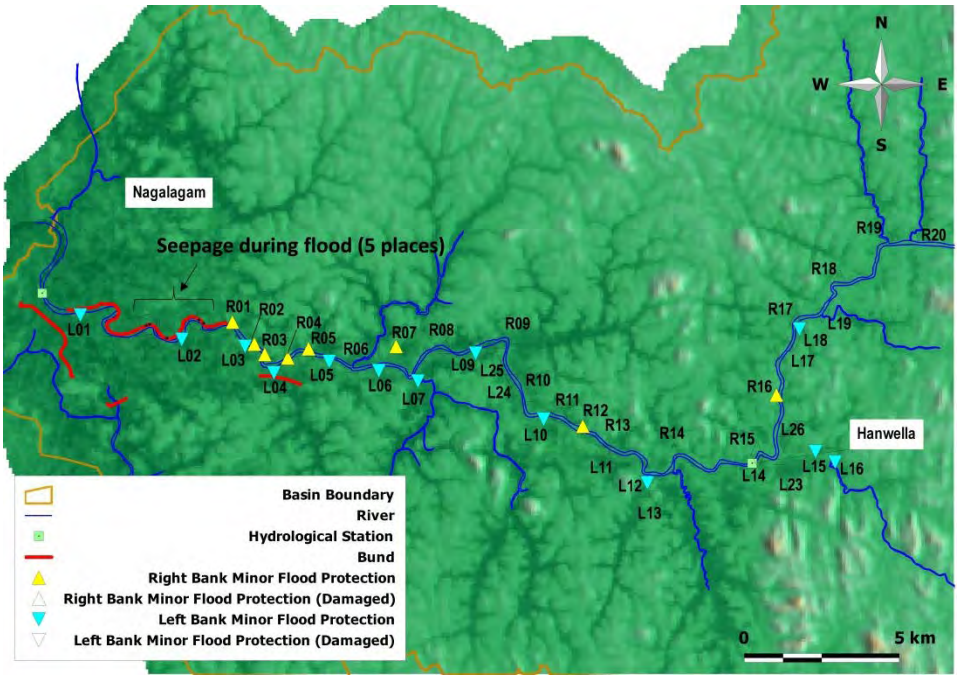


Figure3.2.7 Hydraulic structures along Kelani Ganga
Source: Prepared by JICA Survey Team based on data provided by ID

2) Minor Flood Protection Scheme

According to the ID, five (5) schemes among all 46 schemes had been completely destroyed before the flood disaster in May 2016. 18 schemes including the five (5) schemes need to be rehabilitated after the flood disaster in May 2016. The condition of Minor Flood Control Scheme is shown in Table 3.2.6.

The ID has already started the rehabilitation work for minor damages by usual maintenance budget. If the usual maintenance budget is not enough, special fund for rehabilitation will be applied. It will also be proposed to improve the structures if it is judged to be necessary to reduce future flood risk based on the experience of the flood disaster in May 2016.

Table 3.2.6 Condition of minor flood protection scheme

	MFP Scheme	Type of Gate	No. and Size of Gates	Flood Protection Level (m MSL)	Flood condition	Condition before the flood	Condition after the flood	Recommendations (by ID)
L01	Sedawatta	Flap Gate	10 x 1.52m x 1.22m	2.1	overtop	very good	very good	
L02	Kelanimulla	Flap Gate (new) Lift Gate	2 x 1.68m x 1.83m 2 x 1.68m x 1.83m		overtop	very good	very good	
L03	Nirmavila	Flap Gate (new) Lift Gate	0.61m (diameter) 0.61m (diameter)		overtop	very good	very good	
L04	Ambathale	Flap Gate	4 x 1.52m x 1.22m	5.2	overtop	very good	very good	
L05	Welivita	Flap Gate	3 x 1.52m x 1.52m	5.3	overtop	very good	very good	
L06	Hewagama	Flap Gate	2 x 1.52m x 1.22m	5.6	overtop	very good	very good	
L07	Bomiriya	Flap Gate	8 x 1.52m x 1.22m	5.6	overtop	very good	very good	
L08	Lanerol Mawatha	Lift Gate			overtop	very good	very good	
L09	Rada Ela	Flap Gate	0.305m (diameter)	5.6	overtop	very good	very good	
L10	Undugoda	Lift Gate				very good	very good	
L11	Ranala	Flap Gate	4 x 0.91m (diameter	7.3	overtop	very good	gates are in good condition, bund has been washed off at a particular section during flood.	bund section that has been washed off need to be reformed.
L12	Henpita	Flap Gate Lift Gate	6 x 1.52m x 1.22m 2 x 1.52m x 1.22m	7.6	overtop	very good	very good	bund section is not uniform and need to be reformed.
L13	Meegoda	Lift Gate	0.61m (diameter)	6.7	overtop		gate is not in working condition and bund is also not in good condition due to washing off during flood.	gate need to be replaced while the bund need to be reformed
L14	Polatta Wela	Lift Gate	1.22m (diameter)	9.1	overtop	Gate need to be replaced	Gate is not in operating condition and bund has been washed off in certain locations during flood and is not uniform.	whole structure need to be reconstructed and the bund need to be reformed.
L15	Brandigampala I	Lift Gate	2 x 1.22m (diameter	10.2	overtop	very good	very good	
L16	Brandigampala II	Lift Gate	4 x 1.22m (diameter	10.7	overtop	very good	very good	
L17	Kahatapitiya I			9.9		structure is broken.		whole structure need to be reconstructed.
L18	Kahatapitiya II	Lift Gate	0.61m (diameter)	9.9	overtop	very good	very good	
L19	Akaravita			9.1		structure is broken		whole structure need to be reconstructed.
L20	Korathota			4.6		structure is broken and only abutments are left.		whole structure need to be reconstructed.
L21	A small gate close to Korathota main structure	Lift Gate			overtop	-	gate is in good condition, drainage canal is not visible. and need to be dredged.	drainage canal need to be dredged.
L22	Dasawella	bund only		11.0		very good	very good	
L23	Wanahagoda	Flap Gate		9.1	overtop	gate needed improvements.	gate need to be repaired/replaced.	gate is temporary repaired, need to be replaced with steel.
L24	Madapena	Lift Gate		7.3	overtop	very good	gate is in operating condition, bund has been washed off in one location during flood.	washed off section need to be reformed.
L25	Ranwela Muttettupola	Lift Gate		7.3	overtop	very good	gate is in operating condition,a small crack is appeared in gated structure after the flood.	need to assess the structure for stability and need repairing.
L26	Giraimbula	Lift Gate			overtop	very good	Gates are in good condition, bund has been slipped off at a particular section during flood.	a strech of bund that has been slipped off and need to be reconstructed. (surveying is started on 17th June)
R01	Nagahawattha	Flap Gate	3 x 0.91m (diameter)		n.a.	n.a.	n.a.	
R02	Nagahawattha	Flap Gate	1 x 1.4m x 1.4m		n.a.	n.a.	n.a.	
R03	Seethawala	Lift Gate	1 x 0.91m x 0.91m		n.a.	n.a.	n.a.	
R04	Bollegala Pelawattha	Flap Gate	1 x 1.40m x 1.40m		n.a.	n.a.	n.a.	
R05	Pattiwila	Flap Gate Lift Gate	4 x 0.49m (diamater) 2 x 1.83m x 1.22m	5.2	n.a.	n.a.	n.a.	
R06	Rakgahawatta	Flap Gate	6 x 1.40m x 1.71m		n.a.	n.a.	n.a.	
R07	Kokkaluoya	Lift Gate	3 x 0.91m x 1.22m		overtop	Gates were good Condition	Gates are in good Condition	
R08	Yabaraluwa	Flap Gate	3 x 0.91m (diameter)	6.1	overtop	Gates were good Condition	Gates arein goodCondition. U/S R.B. Bund Collapsed	Public requested further lowering of Flap gates at bottom part of MFP. Since water stagnated at upstream locations. Need to study and reconstructed a new MFP.
R09	Malwana	Flap Gate	6 x 1.22m x 1.52m	6.6	overtop	Gates were good Condition but flood bund at Pahuru Oya side eroded in several location	2 gates are damaged. Flood bund breached. Flood bund at Pahuru Oya side furthereroded in several locations.	Removing of concrete logs at upper part of the MFP structure was difficult due to heavy weight. These logs were previously made of wooden . But those were reported lost in several occasions then concretes logs were incorporated in MFP structure. But for fast drawdown of water level ofPahuru oya removing concrete logs and construction of flap gates at upper part is recommended.
R10	Wellawaththa	Flap Gate	2 x 0.49m (diameter)		overtop	Gates were good Condition	Gates not in proper condition	
R11	Modarakada Waththa	Flap Gate	2 x 0.79m (diameter)		overtop	Gates were good Condition	D/S Protection damaged	
R12	Gonthota Ela	Flap Gate	1 x 0.91m (diameter)		overtop	Gatewas good Condition	Gate in good Condition	
R13	Mora Ela	Flap Gate	2 x 1.40m x 1.83m	8.1	overtop	Gates to be repair	02 No Gates full damaged	
R14	Kadathiyawatta	Flap Gate	2 x 1.40m x 1.52m	9.1	overtop	Gates to be repair	02 No Gates full damage	
R15	Yattowita	Lift Gate	2 x 1.49m x 1.52m		overtop	Gates were good Condition	D/S R.B. & bundDamaged	
R16	Modarakada	Lift Gate	2 x 1.40m x 1.52m		overtop	Gates were good Condition	Gates are in good Condition	
R17	Kapugoda	Flap Gate	5 x 1.22m x 1.83m	10.4	overtop	Gates were good Condition	05 No Gates damaged	-
R18	Nikawala (already collapsed)	Flap Gate	6 x 1.22m x 1.83m	10.1	overtop	Already collapsed	Already collapsed	Need to construct a new MFP structure
R19	Pugoda	Flap Gate	10 x 1.22m x 1.40m	12.8	overtop	6 Nos Gates Damage	All Gates are damaged	
R20	Senasungoda	Flap Gate	7 x 1.22m x 1.40m		overtop	Gates were good condition D/S Gabion collapsed	2 Nos Gates Damaged Stilling basin damaged	Need torepair D/S gabion and reconstruction of stilling basin

Source: ID, Comprehensive Study on Disaster management in Sri Lanka (2009)

(2) Estimation of Flood Damage

1) Land Use in Flooded Area

The estimated flooded area around Kelani Ganga (downstream of Glencourse station) is 101km^2, and encompasses 10 DSs (Colombo, Homagama, Kaduwela, Kolonnawa, Padduka, Seethawaka, Biyagama, Dompe, Kelaniya and Wattala) in Colombo and Gampaha Districts. In Kolonnawa the flooded area occupies about 60% of its territory.

The land use in and around the flooded area is shown in Figure3.2.8. Built-up area occupies in the lower reach and cultivated area dominates the upper reach.

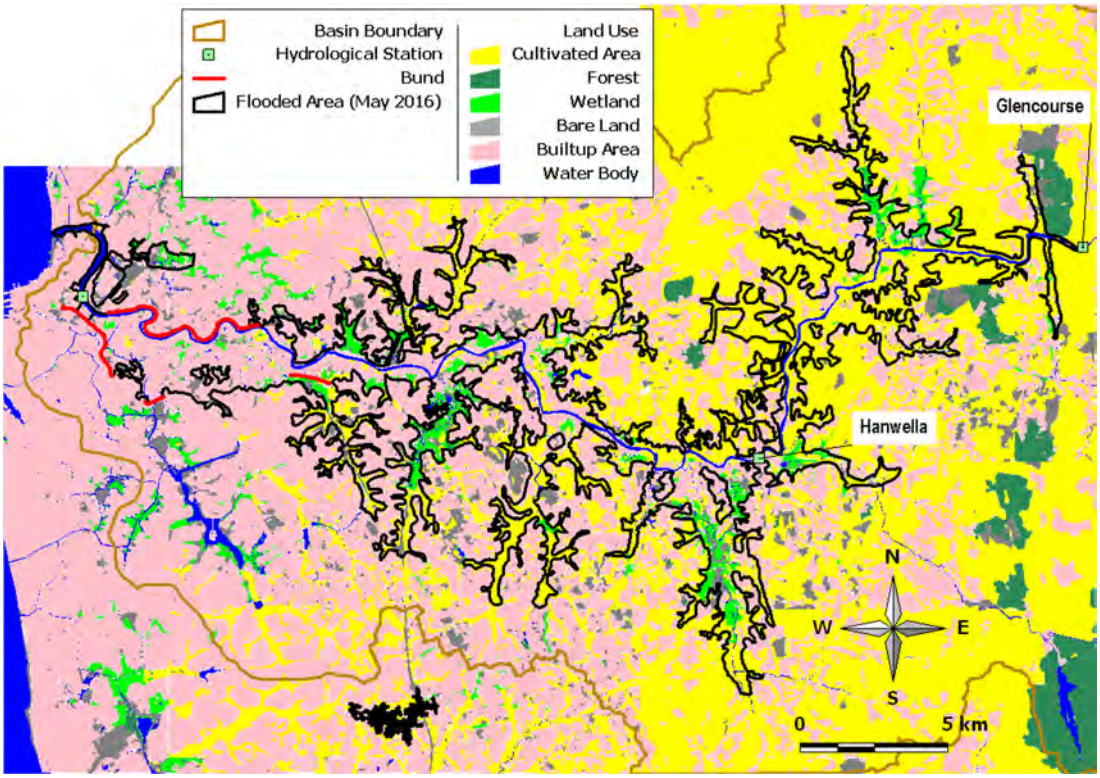


Figure3.2.8 Land use in and around the flooded area along Kelani Ganga
Source: Prepared by JICA Survey Team based on data provided by Survey Department

Table 3.2.7 shows land use condition in the flooded area for each DS. The cultivated area occupies 44% and built-up area follows with 34%. In Kolonnawa, share of built-up area is 70%, which is much higher than the other DSs.

Table 3.2.7 Land use condition in flooded area for each DS

	Total Area	Flooded Area	Bare land	Built-up Area	Cultivated Area	Forest	Water Body	Wetland
COLOMBO	**502.83**	**64.42**	**3.82**	**24.15**	**24.81**	**0.00**	**4.35**	**7.29**
Colombo	17.78	0.52	0.03	0.13	0.00	0.00	0.37	0.00
Homagama	119.57	8.12	0.49	1.92	3.89	0.00	0.40	1.43
Kaduwela	88.07	20.35	1.43	6.96	7.79	0.00	1.24	2.93
Kolonnawa	25.73	14.03	0.97	10.53	0.76	0.00	0.96	0.81
Padduka	105.62	1.09	0.00	0.19	0.83	0.00	0.06	0.01
Seethawaka	146.06	20.30	0.90	4.43	11.53	0.00	1.33	2.12
GAMPAHA	**319.95**	**37.33**	**1.43**	**10.15**	**19.09**	**0.06**	**3.07**	**3.53**
Biyagama	60.58	9.08	0.47	3.23	3.26	0.00	0.74	1.37
Dompe	179.07	24.89	0.37	5.36	15.79	0.06	1.58	1.73
Kelaniya	21.73	2.94	0.57	1.44	0.00	0.00	0.50	0.43
Wattala	58.57	0.43	0.02	0.12	0.03	0.00	0.25	0.00
Total	**822.78**	**101.75**	**5.25**	**34.30**	**43.90**	**0.06**	**7.42**	**10.82**

Unit:km^2, Source: JICA Survey Team

2) Estimation of Flood Damage of Assets

The PDNA conducted after the disaster in May 2016 reported that the total damage and loss in the entire country was estimated at US$572million and that in housing and land sector alone, the damage is estimated to be about 70% (US$ 382 million) of total estimated damage.

In the present study, damage of assets by the flood around Kelani Ganga is estimated by utilizing the estimated flood depth in the flooded area as well as the information on buildings in the flooded area, which is prepared by DMC, as follow:

- As for the information on buildings in the flooded area, GIS data prepared by DMC by tracing satellite images, which are opened at Open Street Map, are utilized. Since these data almost coincide with the information in the orthophotos used in developing Lidar DEM supported by JICA, it is judged to represent the latest information among existing data,
- The damage rate is estimated by the flood depth for location of each building. The damage function with flood depth is set based on the recent study by Komolare et al (2016)[11] which investigated flood damages around Kelani Ganga. They categorized buildings into 4 types (residential unreinforced masonry (URM), residential concrete frame with unreinforced masonry walls, residential wooden structure, and commercial building) to determine the damage function. In the present study, based on the census in 2012, the ratio of type of building is estimated for each DS, and average damage function for each DS is established. As for the household goods, the damage function used in Japan is applied,
- The values of building and household goods shown in Table 3.2.8 are employed in the present study. These are based on the Comprehensive Study on Disaster management in Sri Lanka (2009).The consumer price index is used to convert them into present values. Based on the census in 2012, the ratio of type of building is estimated for each DS, and average values for each DS is estimated and applied.

[11] A. A. Komolafe, S. Herath, R Avtar: Development of Generalized Loss Functions for Rapid Estimation of Flood Damages. A Case Study in Kelani River Basin, Sri Lanka, in preparation for publication (2016).

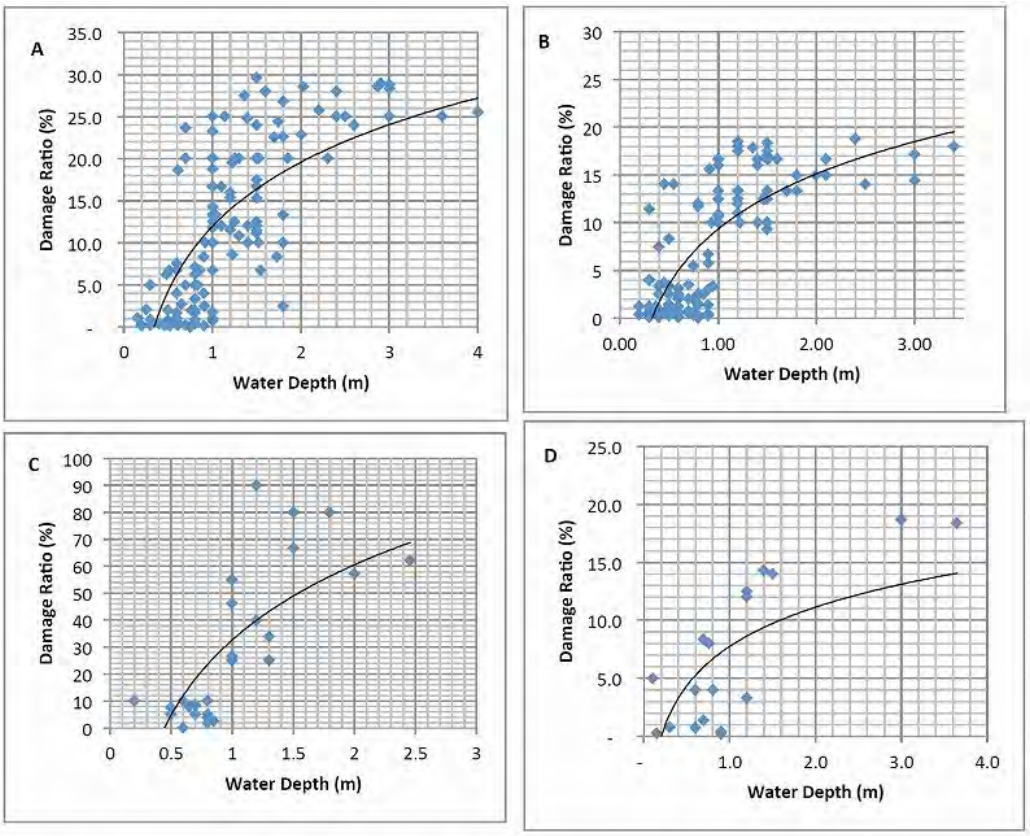


Figure 12: Flood damage curves for: **A** Residential Unreinforced Masonry (URM) **B.** Residential Concrete Frame with Unreinforced Masonry Walls **C.** Residential Wooden Structure **D.** Commercial Building

Figure3.2.9 Results of investigation of damage rate due to flood around Kelani Ganga in recent study report

Source: A. A. Komolafe, S. Herath, R Avtar: Development of Generalized Loss Functions for Rapid Estimation of Flood Damages. A Case Study in Kelani River Basin, Sri Lanka, in preparation for publication (2016).

Table 3.2.8 Values of building and household goods to estimate flood damages (May 2016)

Type	Average Value of Building (US$)	Ratio of Value of Household Goods against Building (%)	Average Value of Household Goods (US$)
Improvised	680	30	204
Semi-Permanent	10,270	30	3,081
Permanent	20,652	30	6,196

Source: Estimated based on Comprehensive Study on Disaster management in Sri Lanka (2009) and consumer price index
Exchange rate 1SLRs = US$0.00656 is used.

The estimated direct damage of assets due to the flood around Kelani Ganga is US$153 million. The direct damage, by DS, is estimated as shown in Table 3.2.9. The damage in Kolonnawa shares about 60% of the total.

Figure3.2.10 shows the distribution of the direct damage of assets by GN.

Table 3.2.9 Estimated direct damage of assets due to flood around Kelani Ganga by DS

	Direct Damage of Assets (US$ million)	Share (%)
COLOMBO	**125.90**	**82.3**
Colombo	1.40	0.9
Homagama	3.14	2.1
Kaduwela	17.83	11.7
Kolonnawa	91.47	59.8
Padduka	0.00	0.0
Seethawaka	12.06	7.9
GAMPAHA	**27.00**	**17.7**
Biyagama	7.61	5.0
Dompe	13.91	9.1
Kelaniya	4.23	2.8
Wattala	1.25	0.8
Total	**152.90**	**100.0**

Source: JICA Survey Team

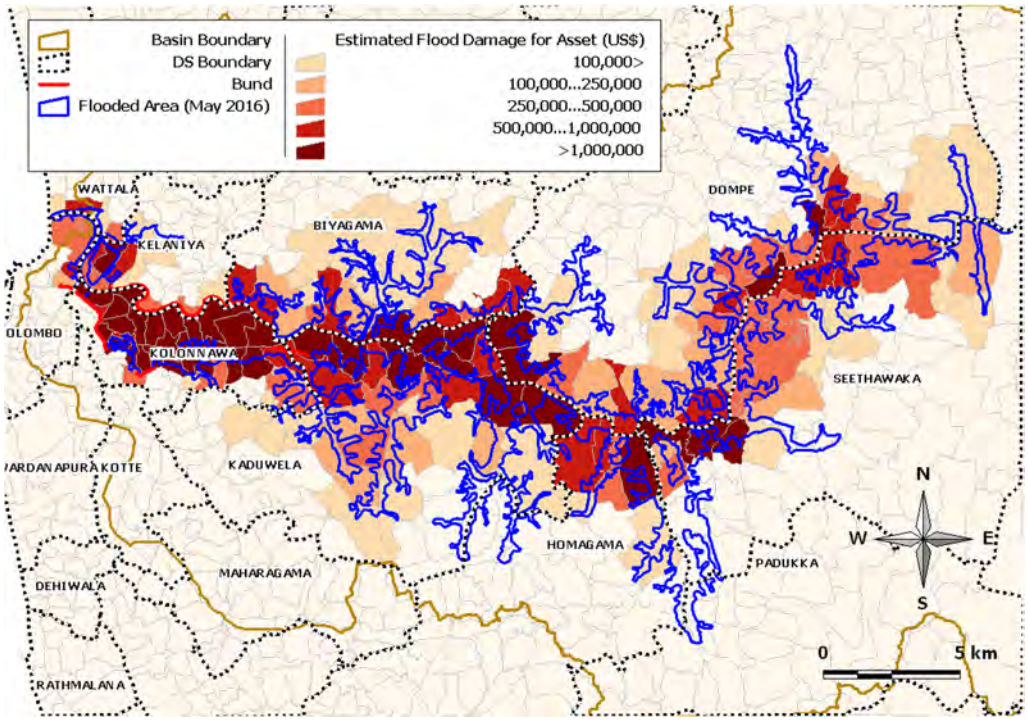


Figure3.2.10 Estimated direct damage of assets due to flood around Kelani Ganga by GN

Source: JICA Survey Team

(3) Trend of Exposure in Flooded Area

To clarify trend of exposure in the flooded area, overlay analysis with population data with grid basis in 2000 and 2015 (Land Scan Data. grid size = about 1km.) was performed. As for the flooded area, not only the actual flooded area in May 2016 flood disaster but also the simulated flood area for the extreme event with 1/50 in the Study on Storm Water Drainage Plan for the Colombo Metropolitan Region (SWDPCMA) (2003) for Metropolitan Colombo area were checked. Figure3.2.11 shows the flooded areas around Metropolitan Colombo area as well as Kelani Ganga and change in population distribution by Land Scan data.

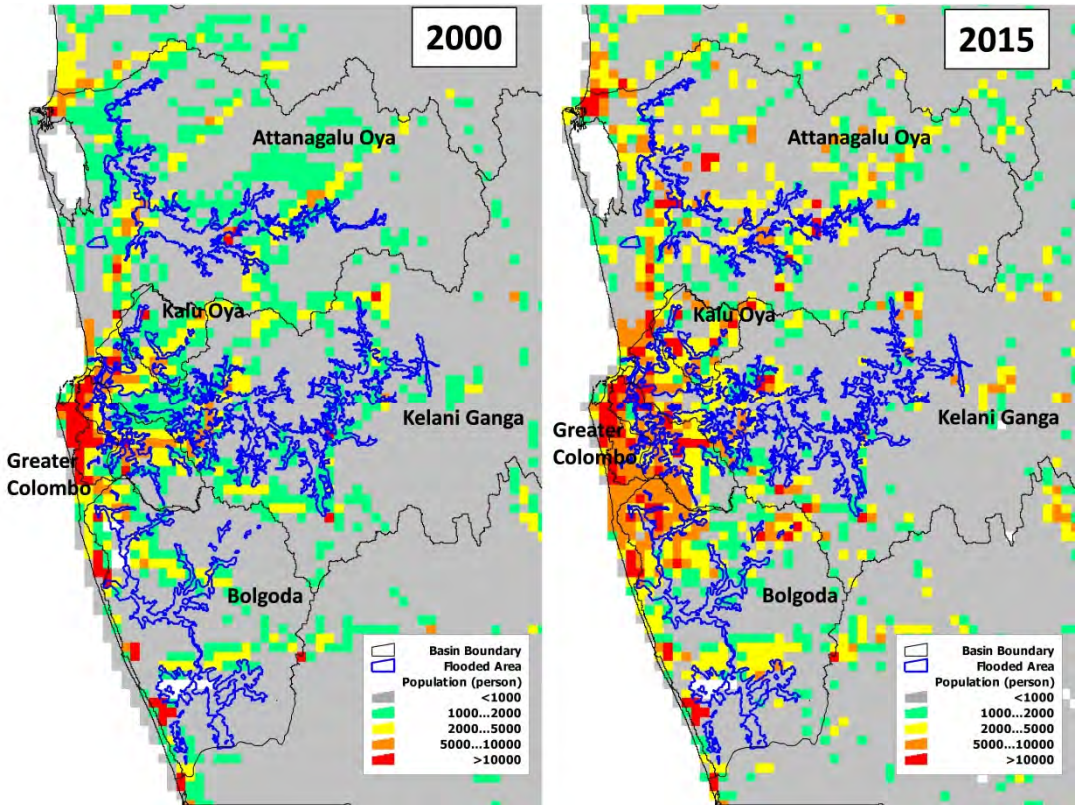


Figure3.2.11 Flooded areas around Metropolitan Colombo Area as well as Kelani Ganga and change in population distribution

Source: Prepared by JICA Survey Team based on Land Scan data and Comprehensive Study on Disaster management in Sri Lanka (2009)

Figure3.2.12 shows change in population in the flooded area from 2000 to 2015. The population in the flooded area increased from 2000 to 2015, which clearly shows the increase of flood disaster risk.

In the flooded area around Kelani Ganga, there is significant increase in population in Kolonnawa; the population in 2015 is almost three times as large as that in 2000. One can easily understand that such increase severely affected the damage in Kolonnawa.

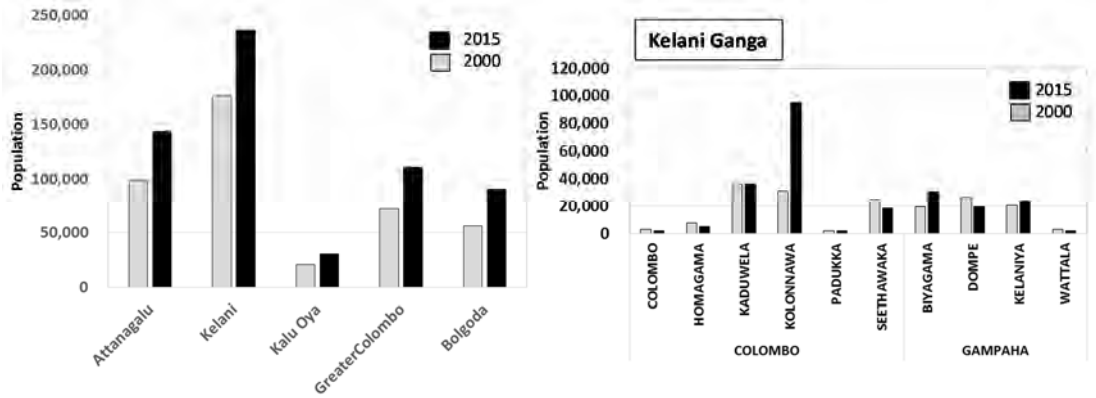


Figure3.2.12 Change in population in flooded area

Source: JICA Survey Team

In all other basins except Attanagalu Oya, the population in the flooded area increased from 2000 to 2015, which clearly shows the increase of flood disaster risk.

Figure3.2.13 shows spatial development plan in Western Region Megapolis Master Plan (WRMMP) together with the flooded area. It is expected that further development of Metropolitan Colombo area will be promoted based on the spatial development plan.

There is a plan to develop Science and Technology City toward the upper reach of Kelani Ganga. It is necessary to ensure that flood risk does not increase in the planned development area.

In Bolgoda basin, there is a plan to develop an Industrial City. Possible increase in run-off due to the development in the basin and consequent increase in flood hazard and risk should be considered.

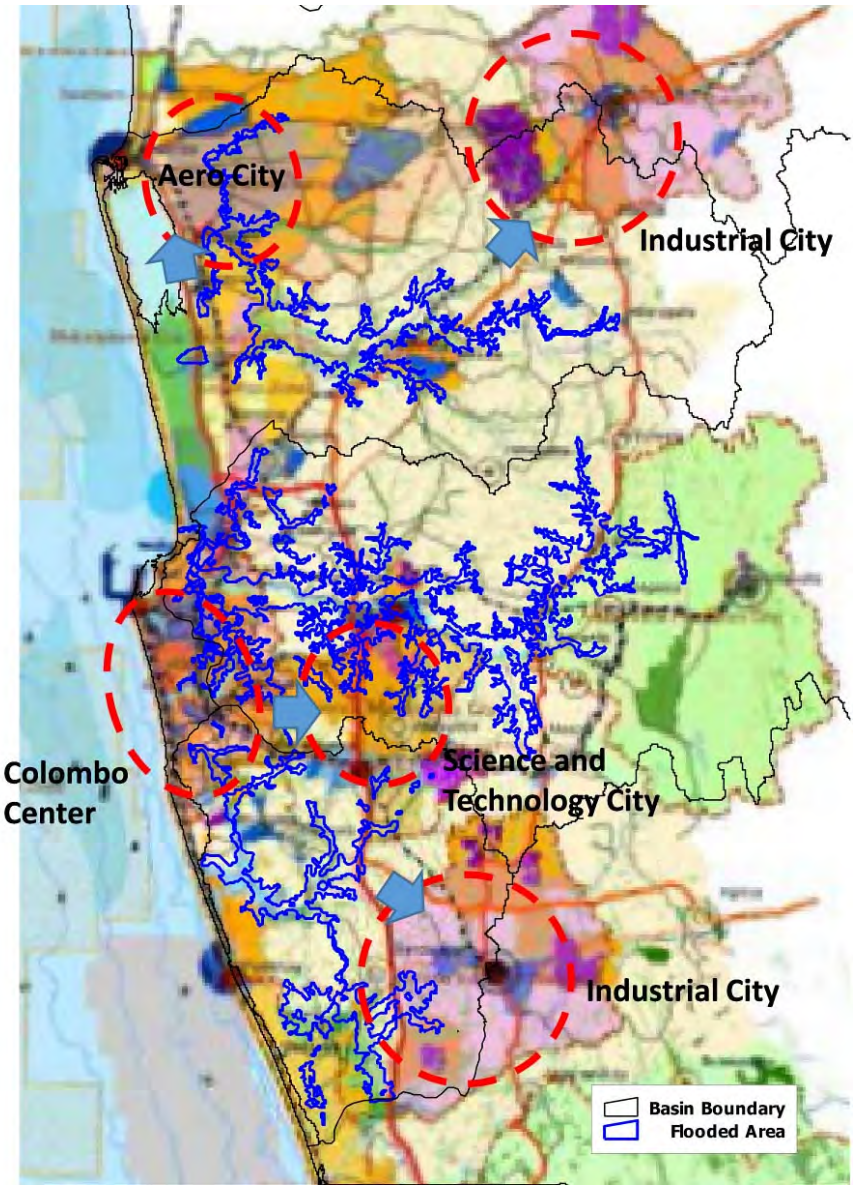


Figure3.2.13 Spatial development plan in WRMMP and flooded area
Source: Prepared by JICA Survey Team based on WRMMP

3.2.3 Future Plans to Mitigate Flood Disaster in Kelani Ganga

(1) Progress of Basin Investment Planning of Kelani Ganga by CRIP

In component 1 of CRIP supported by World Bank, basin investment plan for 10 river basins including Kelani Ganga basin will be prepared. The basin investment plan will consider both flood and drought mitigation. A mathematical model to cover the entire basin will be prepared. The high impact projects will be selected as priority projects, and 3-4 projects for each basin will be further studied at Pre-F/S level.

Before the disaster in May 2016, Kelani Ganga had been just one of the 10 river basins. However, it became the priority basin after the disaster, and has been implemented earlier than other basins. Also, depending on necessity, the mathematical modelling can be more detail in order to examine priority projects in detail. Because there had been no severe floods since 1989, the flood mitigation measures have not been implemented in Kelani Ganga basin. The flood disaster in May 2016 changed the situation and one can expect that some flood mitigation measures will be implemented.

According to the consultant implementing component 1 of CRIP, schedule and progress of the project are as follows.

Schedule

- Technical study will be completed by June 2017.
- Priority projects for F/S in Phase 2 will be selected by October 2017

Coverage of Mathematical Modeling

- The mathematical model will cover the entire Kelani Ganga basin which is defined by ID including tributaries. Greater Colombo and Kalu Oya basins are included in the tributaries.

Flood Mitigation Measures of Kelani Ganga

- The priority measures will be examined through cost-benefit analysis on several possible measures.
- The retarding function of tributaries will be re-evaluated. In addition, the following measures can be applied as possible measures; 1) construction of dams for flood control, 2) construction of diversion channels, and 3) heightening of dyke along main stream of Kelani Ganga.
- The heightening of dyke along main stream of Kelani Ganga needs to consider several aspects such as range and location of dyke. As for Kolonnawa area, how, where and by what safety level the area will be protected should be examined. It is not possible to leave it as unprotected area. It is desirable to minimize resettlement to reduce social impacts. Urban restructuring project with construction of flood-resilient building can also be considered, on the premise that flooding will remain in the area.

(2) Drainage Plan by SLLRDC

The SLLRDC has been implementing urban drainage improvement projects in Colombo Metropolitan area except the main stream of Kelani Ganga, on the basis of The Study on Storm

Water Drainage Plan for the Colombo Metropolitan Region (SWDPCMA) (2003). After the devastating flood disasters in Metropolitan Colombo area in 2010, Metro Colombo Urban Development Project (MCUDP) supported by World Bank has been implemented in Greater Colombo basin.

In MCUDP, design hyetograph was reviewed considering the heavy rainfall events in 2010. As a result, MCUDP concluded that it is necessary to implement more measures than the ones recommended by SWDPCMA to achieve the target safety level of 1/50. However, Madiwela South Diversion, which was recognized as the highest priority project, was not included in MCUDP, and its implementation remained as a big issue.

In the circumstances, the natural condition such as rainfall and socio-economic situation and urban development scenario has already changed. It is necessary to review and revise the master plan to reflect such changes.

The SLLRDC is now dealing with drainage problems from severe inundation in Mudun Oya in the right bank side of Kelani Ganga and Kolonnawa in the left bank side. It is desirable to include these areas in the revised master plan. It is also important to study very well the flood mitigation measures which will be proposed in the basin investment plan for Kelani Ganga.

(3) Issues on Flood Mitigation Planning

It can be understood that the basic concept of flood protection of urban area in Colombo has been to protect the most important area in central Colombo by installing bunds as well as to retard and reduce flood flow by storage effect in the basin using topographic characteristics as much as possible.

However, the urban area has been expanding rapidly to encroach in areas which were not considered for flood protection before. In the flood disaster in May 2016, severe flood damages occurred in such area. Considering this situation, preparation and implementation of better flood management plan is required, keeping the benefits of the original flood protection concept as well as considering the change in the urban structures.

Major issues on the flood mitigation planning of Kelani Ganga are listed below.

1) Necessity of Upgrade of Existing Hydraulic Structures

It seemed that the bund itself was in critical condition since seepages were found during the flood disaster in May 2016. Should the bund be breached, devastating damage may occur. It is necessary to assess the condition of the structure and to strengthen it.

There was the case during the flood disaster in May 2016 that the inundation in a tributary was prolonged because flap gates did not function properly when water level of main stream of Kelani became low. In order to manage properly the storage function in tributaries in major floods, it is necessary to upgrade the hydraulic structures to control the flow between main stream of Kelani and the tributaries. Necessary functions of the hydraulic structures should be reviewed carefully in line with the flood mitigation plan which defines the storage function of tributaries as one of important measures for flood mitigation.

2) Dealing with Unprotected Area

The unprotected area mainly in Kolonnawa has been occupied by many houses and severe flood damage occurred there in the flood disaster in May 2016. It is a big debate in the flood mitigation planning if this area will be kept as unprotected area or will be protected fully or partially in the future. If it is decided to protect the area by heightening of dyke, etc., the equivalent flood volume which currently stored by Kolonnawa plain should be absorbed at somewhere else in the upstream reach in the basin. Otherwise, the flood risk in the central part of Colombo where many assets have accumulated shall increases.

3) Pressure to Reduce Natural Retarding Basin induced by Urban Development under WRMMP and Its Coping Strategy

According to the WRMMP, there is a plan to develop Science and Technology City toward the upper reach of Kelani Ganga. It is possible for the surrounding area to be developed rapidly. In the planned development area, there are tributaries in which reverse flow from main stream of Kelani Ganga occurs. Since these tributaries are high risk area for flood and function as retarding basin, any development in the area whose elevation is lower than the high water level of Kelani Ganga during major flood should be avoided. Detailed land use plan and regulations should be prepared as soon as possible. It is deemed necessary that “well-managed development” should be executed.

4) Possibility on Optimum Operation of Hydraulic Structures Considering Condition of both main stream of Kelani and Tributaries

Since the propagation of flood wave is slow in the main stream of Kelani Ganga, the flood peaks in tributary basins such as Greater Colombo basin tend to appear with large time lag compared to that in the main stream of Kelani Ganga in the same rainfall event. By utilizing this phenomenon, for example, it may be possible to drain some volume of flooded water in Kelani Ganga through channels in Greater Colombo basin if the water level in Greater Colombo basin is lower than that in Kelani Ganga. It is desirable to examine the possibility of optimum operation of hydraulic structures considering the conditions of both main stream of Kelani and tributaries.

CHAPTER 4 Issues and Directions

4.1 Issues and Solution in Discussion with Individual Agencies

Existing issues and directions to implement Sendai Framework were discussed with individual agencies prior to discussion on entire Roadmap for DRR. The target agencies were DMC, NDRSC, DOM, NBRO, ID, SLLRDC, WRB, NWSDB and DNCWS. The issues, strategy/directions and activities based on the discussion are summarized as Table 4.1.1 to Table 4.1.5. The detailed implementation schedules are attached in Appendix 1.

The prepared activities and implementation schedules are proposed by individual agencies. Thease activities should be prioritized considering investment impact in Roadmap.

4.1.1 Comprehensive Disaster Management

Issues, directions for solution and expected activities on comprehensive DRR are indicated in Table 4.1.1.

Table 4.1.1 Issues and directions on comprehensive DRR

Status / Issues	Strategy / Direction	Activity
There is no unified database system on disaster records and disaster damages and losses. Basic data for disaster risk assessment is not sufficient. Methodology and guidelines for risk assessment have not been prepared.	1. To improve information management mechanism / capacity development for risk assessment	1-1 To improve mechanism on disaster information management
		1-2 To evaluate disaster risk assessment conducted by relevant agencies
		1-3 To improve research and development mechanism
Warning messages are issued from technical agencies to Media and DMC EOC, however local people are often not able to receive the message property. Mechanism and decision making process for warning and evacuation direction is not clear.	2. To improve early warning messages and to strengthen dissemination mechanism	2-1 To clarify role and responsibility of each agency
		2-2 To strengthen early warning and dissemination mechanism
		2-3 To improve early warning regulation based on risk profiling
SLCDMP is under implementation to promote mainstreaming of DRR. There are number of projects that have not been approved or not been funded. Monitoring and evaluation mechanism should be improved.	3. To establish legal provisions and procedures for mainstreaming DRR into development at national and local levels	3-1 To promote legal arrangement for mainstreaming DRR
		3-2 To conduct impact assessment (DIA) on national level development projects
		3-3 To improve capacity on development planning in GN level
		3-4 To further promote SLCDMP
NCDM has not been functioned. Coordination mechanism between relevant agencies should be strengthened.	4. To strengthen coordination mechanism among relevant agencies	4-1 To improve coordination mechanism among agencies
		4-2 To strengthen NDMCC
		4-3 To establish monitoring system on national and local DRR
		4-4 To improve DRR in disaster types that have not any designated agencies
There is no DRR strategy in local administration line. Local DRR planning and disaster response depend on national, districts and divisions.	5. To strengthen capacity of districts, divisions, GN and local authorities on DRR planning	5-1 To formulate local DRR plan in districts and divisions, especially prevention and mitigation plan and recovery & reconstruction plan
		5-2 To prepare legal arrangement and

Status / Issues	Strategy / Direction	Activity
		guidelines for local level DRR
		5-3 To strengthen DRR capacity of private sector and schools
		5-4 To prepare Emergency Operation Plan in all levels
		5-5 To strengthen capacity to conduct PDNA
There is no mid- to long-term implementation plan for community awareness activities. Therefore, the activities by government, NGO and international donors seem to be ad-hoc. Training programme to enhance capacity of MDM and DMC staff.	6. To improve awareness raising program / campaign for government officers, public and schools	6-1 To develop awareness programme for communities and schools
		6-2 To implement awareness programme in communities and schools
		6-3 To develop and implement DRR awareness programme for government staff
		6-4 To adopt DRR curriculum into schools and universities
Due to lack of database system, manual and plans for disaster relief, prompt activities for relief and resettlement is difficult. Evacuation shelter management should be improved.	7. To strengthen disaster relief mechanism and implementation	7-1 To formulate disaster relief and resettlement plans, database and manuals
		7-2 To develop database system for relief materials and its mobilization
		7-3 To prepare guideline for evacuation shelter management
		7-4 To promote resettlement programme
National Natural Disaster Insurance Programme was started last year. However, compensation for drought is not covered by the insurance. Domestic and international funding support mechanism for emergency are necessary to promote BBB.	8. To strengthen disaster insurance scheme and risk finance system	8-1 To review and strengthen NNDIP to extend compensation area
		8-2 To improve compensation procedure and management systematically using prompt database
		8-3 To strengthen domestic and international disaster financial support mechanism
		8-4 To promote Build Back Better in recovery and reconstruction

4.1.2 Flood Risk Reduction

Issues, directions for solution and expected activities on flood risk reduction are indicated in Table 4.1.2.

Table 4.1.2 Issues and directions on flood and basin management

Status / Issues	Strategy / Direction	Activity
With the increasing trends of flood and drought risk due to change in climate and social conditions, the recognition of flood and drought risk in details using the latest natural and social data is urgently required.	1. To prepare detailed flood and drought risk information	1-1 Updating topographic map
		1-2 Updating river cross-section and rating curve
		1-3 Preparation of detailed flood hazard and risk map for river basins
		1-4 Preparation of detailed flood hazard and risk map for urban areas
		1-5 Evaluation of drought risk in terms of water balance for river basins
		1-6 Preparation of risk profile based on updated flood and drought risk information

Status / Issues	Strategy / Direction	Activity
Sharing of roles and responsibilities on flood management among relevant agencies are not clearly described in the existing flood ordinance. The existing SLLRDC law is not enough to prevent unregulated development of wetland where flood risk is high. To improve this situation, it is necessary to revise the existing laws and promote well-coordinated flood mitigation measures among relevant agencies.	2. To enhance legal and institutional arrangement on flood mitigation	2-1 Revision of flood and irrigation acts
		2-2 Preparation of water resources act
		2-3 Enhancement of coordination frameworks for riverine management
		2-4 Revision of SLLRDC act
		2-5 Establishment of permanent regional office of SLLRDC
It is expected that the basin investment plan considering both flood and drought mitigation will be prepared for the priority basins under CRIP. The priority projects will also be implemented. It is necessary to prepare basin plans for other basins, in order to promote further investment.	3. To promote basin investment with IWRM concept	3-1 Preparation of basin investment plans
		3-2 Rehabilitation and upgrade of the aged main flood mitigation facilities
		3-3 Implementation of basin investment plans
Many proposed projects in drainage master plan for Metropolitan Colombo area in 2003 have not yet been implemented. Meanwhile, the natural conditions such as rainfall and socio-economic situation and urban development scenario have already changed. It is, therefore, necessary to review and renew the master plan to reflect such changes.	4. To promote investment in storm water drainage improvement	4-1 Preparation of storm water drainage investment plans
		4-2 Implementation of storm water drainage investment plans
There are cases that existing land use plan does not coincide with planned protected area from flood. The information on buildings in flood risk are is not enough. It is necessary to update the land use plan considering the detail information on flood risk area and to enhance monitoring of buildings in flood risk area.	5. To ensure "Well managed urban development " considering flood disaster risk	5-1 Update of urban development and land use plans in accordance with the formulated basin investment plans and drainage investment plans
		5-2 Monitoring of buildings in flood risk area
ID launched a flood operation room to execute integrated flood operation including hydrological information and release from reservoirs, which urgently requires enhancement of its capacity. Based on the enhanced hydrological monitoring systems so far, it is necessary to establish monitoring and flood warning system at basin level.	6. To strengthen flood and drought operation	6-1 Improvement of hydro-met observation system
		6-2 Enhancement of flood operation room of Irrigation Department
		6-3 Enhancement of basin monitoring and flood warning system
		6-4 Enhancement of coordinated operation of river management facilities such as tanks and gates
		6-5 Promotion of CBDRMPs
		6-6 Establishment of flood control and water management center for urban flood

4.1.3 Sediment Disaster Risk Reduction

Issues, directions for solution and expected activities on sediment disaster risk reduction are indicated in Table 4.1.3.

Table 4.1.3 Issues and solutions on sediment disaster risk reduction

Status / Issues	Strategy / Direction	Activity
NBRO is developing landslide hazard maps. However, estimated affected areas of debris flow are not shown on the hazard maps because the hazard maps are based on assessment of slope stabilities only. Therefore, there is a difficulty on utilization of the hazard maps for land use planning and communities.	1. To develop and update landslide hazard zonation maps	1-1 Preparation of detailed base maps in landslide prone area
		1-2 Development of 1/10,000 hazard maps
		1-3 Preparation of detail maps (1:5000) specially in town centers and newly developing areas
		1-4 Preparation of guideline to ensure appropriate land use planning based on the hazard maps
		1-5 Development of community level hazard maps
		1-6 Setup web-based database system for landslide hazard zonation maps
Importance of activities and advices by NBRO for developments including road construction and landslide countermeasures in mountainous area because of recent increase of severe landslides. However, legal basis of NBRO is unclear. Therefore, NBRO does not have legal authority to restrict improper developments.	2. To strengthen legal framework and institutional capacity for landslide risk reduction	2-1 Enforcement of NBRI Act and development of Landslide Policy
		2-2 Formulation and implementation of Landslide Risk Management Plan
		2-3 Strengthen institutional capacity under Landslide Risk Management Plan
		2-4 Legislation on development control in landslide prone area and implementation
		2-5 Introducing legal framework for safer construction and developments better land use practices
NBRO has constant budget for landslide countermeasures, but continuous implementation based on master plan is necessary. Implementation of slope protection for the main national roads and railways to strengthen core transportation system under emergency is required.	3. To implement projects for priority area and infrastructure	3-1 Development of investment plans for landslide mitigation
		3-2 Development of investment plans for slope protection for roads and railways
		3-3 Implementation of mitigation projects based on the investment plans
NBRO plans to install 160 rainfall gauges and establish rainfall observation network. But, criteria of landslide warnings are still uniform in the entire country. Regional disaster characteristics are not reflected on the warnings because correlation between rainfall and occurrence of landslides are not well clarified in Sri Lanka.	4. To develop landslide warning criteria	4-1 Strengthening rainfall observation network
		4-2 Examination of new warning criteria based on working rainfall
		4-3 Updating user interface for rainfall observation system
		4-4 Evaluation and revision of warning criteria
		4-5 Examination of new criteria based on Soil Water Index
		4-6 Developing new warning mechanism in cooperation with other agencies

Status / Issues	Strategy / Direction	Activity
Community-based awareness activities are important, but the activities are limited. There is no housing code. Therefore, housings are vulnerable for floods and landslides.	5. To strengthen local resilience under concept of Disaster Resilient Village	5-1 Formulation of implementation programme for CBLDRM
		5-2 Conducting CBLDRM programme in collaboration with DDMC
		5-3 Promotion of Hazard Resilient Housing Construction Manual
		5-4 Preparation of guideline for disaster resilient housing concept
There are no enough experiences and techniques on landslide countermeasures and building materials. It is difficult to implement high investment effect countermeasures.	6. To enhance technical capacity and R&D for landslide mitigation	6-1 Effecting science technology exchange agreement with international institutes
		6-2 Strengthening laboratory testing capacities

4.1.4 Drought Risk Reduction

Issues, directions for solution and expected activities on drought risk reduction are indicated in Table 4.1.4.

Table 4.1.4 Issues and solutions on drought risk reduction

Status / Issues	Strategy / Direction	Activity
Drought damage is becoming more severe recently due to changes in climate and social environment. It is necessary to gather the latest weather and hydrological data, etc. as well as detailed data on agricultural product and social life damages (food security, drinking water shortage), and economic loss of hydroelectric power generation, etc. Accurate assessment on drought risk shall be conducted scientifically based on data and information.	1. To collect and analyze detailed information on drought risk and strengthen scientific approach system	1-1 Collection and review of past and present drought data
		1-2 Risk assessment on drought nationwide
		1-3 Risk assessment on drought (affected district by drought)
		1-4 Update of drought risk profile
		1-5 Regular holding of technical study on drought risk reduction (scientific basis)
		1-6 Development of monitoring system on drought impact
In recent years, the drought damage in arid regions has become increasingly serious and the influence on the national economy is extremely increased. For this purpose, it is urgent to formulate a new national drought strategy aimed at reducing drought risk, and to formulate a national drought risk reduction plan following it.	2. To strengthen capacity of organizational and institutional aspects for reducing drought damage	2-1 Establishment and operation of drought countermeasure committee (MDM and relevant agencies)
		2-2 Formulation of National Drought Risk Reduction Strategy
		2-3 Formulation of District Drought Risk Reduction Plan
		2-4 Formulation of Water Securing Programme in Drought Affected Areas (Drought affect districts)
It is expected that basin investment plan considering both flood and drought mitigation will be prepared for the priority basins under CRIP. The priority projects will also be implemented. It is necessary to prepare basin plans for other basins,	3. To promote basin investment with IWRM concept	3-1 Formulation of basin investment plans
		3-2 Implementation of basin investment plans

Status / Issues	Strategy / Direction	Activity
in order to promote further investment.		
A large-scale water diversion schemes to drought affected areas by Mahaweli Authority of Sri Lanka is planned and implemented at present. However, these are mainly for the supply of irrigation water and use for hydroelectric power generation, therefore, supply of drinking water to local residents is not definitely clarified	4. To integrate drought risk reduction of drinking water supply into water resources management plan at initial stage.	4-1 Formulation of water resources management plans considering drought risk reduction.
		4-2 Preparation of management manual regarding surface and groundwater, and reservoir water.
In terms of emergency drought response, supply of drinking water to affected people becomes the most important matter, but at present, emergency response at water supply by bowsers is mainstream. Stable supply system has not been developed.	5. To establish drawing drinking water system from groundwater as emergency response, and to prepare appropriate distribution plan of water.	5-1 Establishment of an emergency drinking water supply system combining rehabilitation of abandoned and aged tube wells, and construction of new deep tube wells
		5-2 Preparation and implementation of operational plan for drinking water supply system in case of emergency.
In Sri Lanka, activities are being conducted towards a water-saving society by government agencies, donors, and NGOs, etc. However these activities are not unified at this moment. Drought gives a tremendous loss to the national economy and it is necessary to prepare comprehensive plans from the viewpoint of reducing drought risk.	6. To create a water saving society from a long-term perspective	6-1 Improvement of rainwater use system, promotion of awareness raising activities on water use and water conservation
		6-2 Promotion of awareness raising activities related to water reuse and water conservation towards a water-saving society that considers drought risk reduction.
In many reservoirs in dry areas, sediments deposited in reservoirs are in place, and the water storage capacity and groundwater recharge function have declined. Improvement of this function is indispensable for proper water resource conservation.	7. To improve capacity to storage water in reservoirs, and facilitate groundwater recharge from reservoirs and channels.	7-1 Water storage capacity by periodic removal of silt accumulated in reservoirs and discharge channels, improvement of the function of groundwater recharge mechanism
		7-2 Coordination among agencies on operation and maintenance of irrigation tanks and channels (central and provincial government and local authorities).
Systematic monitoring of surface water and groundwater in the drought area has not been implemented so far. In the future, it is necessary to record surface water and groundwater fluctuation including water qualities in time series for determining the condition of drought and applying drought risk reduction activities, and it is necessary to introduce monitoring system as soon as possible.	8. To enhance surface water and groundwater monitoring system including water qualities.	8-1 establishment of surface and groundwater monitoring system
		8-2 Continuous observation of surface water and groundwater levels, and water quality

4.1.5 Hydro-Met Observation and Information Dissemination

Issues, directions for solution and expected activities on sediment disaster risk reduction are indicated in Table 4.1.5.

Table 4.1.5 Issues and directions on hydro-met observation and information dissemination

Status / Issues	Strategy / Direction	Activity
Generally, weather warnings are issued for too wide area (e.g. province-wise or region-wise). In addition, criteria of the warnings are uniform in the entire country. Therefore, local disaster characteristics are not reflected on the warnings. Quantification and improvement of forecasting and warnings are required to utilize them to decide starting evacuation at local level.	1. To strengthen observation network for improvement of forecasting and warning.	1-1 Establishment of stable AWS data communication
		1-2 Updating AWS network
		1-3 Installation of Doppler radars
		1-4 Installation of lightning detection system
		1-5 Developing a composite network on meteorological and hydrological observation
		1-6 Calibration of Doppler radars with AWS and provision of analyzed rainfall data
		1-7 Ensuring proper operation of rainfall and other observation instruments
		1-8 Digitization of historical weather data and enhancement of data management system
	2. To quantify and improve forecasting and warning	2-1 Improving NWP system
		2-2 Quantification and improvement of weather forecasting
		2-3 Introduction of nowcasting
		2-4 Improving nowcast/forecast based on accumulated observation data
		2-5 Building seasonal forecasting capacity
		2-6 Developing climate change scenarios
		2-7 Preliminary study to improve warning criteria and development of impact-based warning system
		2-8 Improvement of spatial/temporal resolution of warning
		2-9 Revision of warning criteria and introducing warning indices
Data sharing of observed hydro-met data among relevant agencies is inadequate. There is a difficulty on understanding of current hydro-met situation and warning dissemination to public under emergency situation.	3. To improve dissemination of weather nowcast/forecast/warning to relevant agencies and public	3-1 Development of data sharing and communication system among relevant agencies
		3-2 Developing and implementing integrated nowcast/forecast/warning services by relevant agencies
		3-3 Improvement of nowcast/forecast/warning dissemination to public through media unit, web and others
		3-4 Improvement of weather services for special sectors
Capacity development for weather forecasting and warning including	4. To enhance technical capacity for weather	4.1 Capacity development to achieve the strategies

Status / Issues	Strategy / Direction	Activity
above two issues is insufficient.	forecasting	4.2 Enhancement of overall atmospheric research capacity
Insufficient development of legal framework and long-term strategy for hydro-met area.	5. To enhance institutional capacity	5.1 Develop and update National Strategy for Weather, Climate and Hydrological Services
		5.2 Review/re-formulation of legal framework related to the weather services
		5.3 Preparation of appropriate funding mechanism

4.2 Dialogues in the Seminar

A seminar was held on 28th February 2017 in order to share the prepared issues and directions of individual agencies in participation of all DRR related agencies. The conclusion of the seminar is summarized in Table 4.2.1.

In the seminar, the participated agencies discussed that strengthening DRR governance and land regulation in disaster risk area are the most urgent task to be prioritized. The participants also acknowledged the importance of strengthening monitoring mechanism and disaster risk assessment as well.

Table 4.2.1 Discussion in the seminar

Item	Discussion
Monitoring Mechanism	Monitoring and evaluation mechanism for Sendai Framework should be strengthened under initiative of Ministry of Disaster Management with National Disaster Management Coordination Committee (NDMCC) in order to ensure the implementation.
Roadmap	The roadmap in the survey shall be a reference for formulation of National Disaster Management Plan 2018-2022 and Comprehensive Disaster Management Programme.
National Target	National Target should be reconfigured based on normalized statistical data as a baseline. The methodology for normalization should be established in consultation with international agencies.
Local Governance for DRR	Target year of “Over 80% of local authorities have adopted disaster management strategies and plans by 2025” is controversial. Legal arrangement should be accelerated rather than individual activities.
Urban Drainage	Flood mitigation works should be planned in collaboration with local authorities because they have more information on flood situation in local level.
Early Warning Mechanism	Role and responsibility on forecasting / early warning and issuing warning messages to residents should be clarified. Moreover, all hydro-meteorological information should be shared among agencies through a common database system.
Data Sharing	Data sharing mechanism among agencies should be enhanced. Especially detailed topographical datasets are essential for accurate risk assessment prepared by NBRO, ID and SLLRDC.
Land Use Planning	High resolution hazard zonation map should be prepared and shared with UDA for appropriate land use planning and land development regulations.

4.3 Discussion in Invitation Programme in Japan

4.3.1 Outline of Invitation Programme

For the purpose to understand Japanese DRR efforts, technologies and experiences in order to promote discussion on future DRR strategy in Sri Lanka, key agencies of DRR sector were invited to Japan during 2nd April to 8th April, 2017. 13 high-rank government officers from each agency participated in the invitation programme. The participated agencies and names, and programmes are shown in Table 4.3.1 and Table 4.3.2.

Table 4.3.1 Participants of invitation programme

No	Name	Organization / Position
1	Mr. Sena Srinath Miyanawala	Ministry of Disaster Management / Secretary
2	Mr. Iraj Chaminda Pathiraja	Ministry of Disaster Management, NDRSC / Director
3	Ms. A Arachchillage Anoja K K Seneviratne	Ministry of Disaster Management, DMC / Director
4	Mr. Kehelella Herath M S Premalal	Ministry of Disaster Management, DOM / Director
5	Mr. Senarath Bandara Ranaweera Mudiyanselage	Ministry of Disaster Management, NBRO / Director
6	Mr. Mohammadhu Faleel Ahamadh Mubarak	Ministry of National Policies and Economic Affairs, NPD / Director
7	Mr. Seenithamby Mohanarajah	Ministry of Irrigation and Water Resources / Additional Secretary
8	Ms. Thushari Andra Hennadige	Ministry of Megapolice and Western Development / Deputy General Manager
9	Ms. M Arachchilage Srimathi M K Senadheera	Ministry of Megapolice and Western Development, SLLRDC / General Manager
10	Mr. Chalukya Budhindra Amarasinghe	Ministry of Megapolice and Western Development, SLLRDC / Deputy General Manager
11	Mr. Sampath Sumedha Pujitha Ratnayake	Ministry of Megapolice and Western Development, UDA / Director General
12	Mr. Dematagoda Kankanamalage R Swarna	Ministry of Higher Education and Highway, RDA / Director General
13	Mr. Kapilasiri Pemasinghe Kodituwakku	Ministry of Higher Education and Highway, RDA / Project Director

Table 4.3.2 Invitation programme

Date	Time	Contents	Sites
Apr-02 (Sun)		Arriving at Tokyo, Japan	Colombo to Tokyo
Apr-03 (Mon)	10:00-10:15	▪ Opening Ceremony / Orientation ▪ Explanation of Schedule	JICA Ichigaya
	10:15-11:45	▪ Group Discussion	
	13:30-14:30	▪ Fundamental Plan for National Resilience (Cabinet Secretariat, Cabinet Office)	
	15:30-17:00	▪ Courtesy Call ▪ Flood Management in Japan	Ministry of Land, Infrastructure, Transportation (MLIT) HQ

Date		Time	Contents	Sites
Apr-04 (Tue)		10:00-12:00	▪ Weather / flood forecasting by JMA ▪ Mechanism of Sediment Disaster Warning	Japan Meteorological Agency (JMA) HQ
		14:30-16:30	▪ Urban flood protection in Tokyo Metropolitan ▪ Arakawa Downstream Timeline	Arakawa Lower River Office, MLIT
Apr-05 (Wed)	Flood	10:00-12:00	▪ Flood management for small-middle basin ▪ Conservation of retarding pond	Kanagawa Pref. Sakai River
	Landslide	10:00-12:00	▪ Road Slope Stability Management	PWRI
		14:00-15:00	▪ Site visit slope stability construction site	National Route 125
Apr-06 (Thu)		10:30-12:10	▪ Community Disaster Management	Life Safety Learning Center
		14:00-15:10	▪ Urban flood protection in Tokyo Metropolitan ▪ Site visit flood gate operation center	Floodgates Control Center, Koto River Improvement Office
Apr-07 (Fri)		09:00-10:30	▪ Group discussion	JICA HQ (Yotsuya)
		10:30-11:30	▪ Courtesy call to Deputy Director General, South Asia Department, JICA	
Apr-08 (Sat)			▪ Leaving for Colombo, Sri Lanka	Tokyo to Colombo

4.3.2 Site Visit and Discussion

(1) Site Visit

At the beginning of the invitation programme, Cabinet Secretariat Japan explained “Fundamental Plan for National Resilience” which is a basic policy for building resilient society in Japan. After the lecture, the invitees visited Ministry of Land, Infrastructure, and Transportation (MLIT) to have a lecture on outline of Comprehensive Flood Management Plan (Watershed Management Plan), and role and responsibility of central government, provincial governments and local authorities. In Sri Lanka, new Flood Ordinance is under preparation to clarify administrative demarcation among government agencies. The participants were interested in the Japanese river management system and legal background.

The participants visited Arakawa Lower River Office, MLIT. Arakawa River was constructed as a diversion channel to protect Tokyo metropolitan area in 1924. The participants understood how the Arakawa diversion has contributed economic development of Tokyo. In the Arakawa Lower River Office, the integrated hydrological monitoring systems as well as comprehensive flood management involving local authorities were explained by MLIT staff. On the other hand, at Sakai River, Kanagawa prefecture, the participants visited a retarding basin functioning to reduce flood peak discharge to the downstream urban area. Retarding basin is one of the practical countermeasures for flood control in Kelani Ganga in Sri Lanka.

Regarding sediment disaster risk reduction sector, the participants visited PWRI to have a lecture for road maintenance and slope stabilization work in Japan. In response to question from the participant from National Planning Department, it was explained that the number of sediment disasters along national roads has been particularly decreased in recent 15 years because of continuous investment for the stabilization. After the lecture, the participants visited an actual slope stabilization site where a Japanese slope stabilization technology is applied for a national road bypass construction. It was a good opportunity for participants from RDA and NBRO to see the actual construction, because the construction of “Landslide Disaster Prevention Project

(LDPP)" will be started soon.

As for meteorological forecasting and early warning, the participants visited Japan Meteorological Agency (JMA) to have explanation on weather forecast, heavy rainfall, flood and sediment disaster warning in addition to coordination mechanism between JMA prefectural office and local authorities. In Sri Lanka, role and responsibility on advisory and waning are not clearly designated at each level. The findings may contribute to improve early warning mechanism in Sri Lanka.

Site visit to flood control gate

Site visit to slope stabilization site

(2) Group Discussion

At the beginning (3rd April) and the closing (7th April) of the programme, the participants had group discussions involving representatives from JICA Headquarters.

In the first discussion, representatives from the agencies had brief presentations on issues and directions for their own fields, which were prepared during the 2nd phase of the Survey in February 2017. After that, JICA proposed a slogan of "Safe and Resilient Sri Lanka" to promote DRR investment to secure safety in urban area and important infrastructure and to build resilient society in local area in order to implement Sendai Framework.

In the closing discussion, the agencies gave their impression on the invitation programme and DRR efforts in Japan. The secretary of MDM presented future DRR efforts and possibility to apply Japanese technology and legal institution to DRR in Sri Lanka. JICA emphasized the importance of prioritization of DRR investment. The participants discussed and agreed the principles and procedure to finalize a roadmap.

Closing discussion after invitation programme (JICA Headquarters)

CHAPTER 5 Roadmap for DRR

5.1 Principles of DRR Roadmap

As a conclusion of the Survey, a Roadmap for DRR in Sri Lanka was prepared. It is titled as "Safe and Resilient Sri Lanka", which means to promote DRR investment both structural and nonstructural measures to secure safety in urban area and important infrastructures and to build resilient society in rural areas. The Roadmap was prepared through discussion among relevant agencies and JICA considering consistency with the Global Targets and the four Priority Actions of Sendai Framework as well as Sustainable Development Goals (SDGs).

"National Disaster Management Plan (NDMP) 2018-2022" is now under preparation by MDM. Based on NDMP, "Sri Lanka Comprehensive Disaster Management Programmes (SLCDMP)" will also be updated and combined with NDMP as an Implementation Section. On the other hand, MDM has formulated "National Action Plan (NAP)" to promote and monitor DRR efforts to implement Sendai Framework.

The prepared "Roadmap for DRR -Safe and Resilient Sri Lanka-" is expected to be fundamental information to formulate NDMP 2018-2022.

5.1.1 Global Target in Sendai Framework

Sendai Framework gives seven (7) Global Targets to monitor the DRR efforts by each country. The Global Targets are divided into "Output Targets" and "Input Targets". Target (a) reducing mortality, (b) reducing affected people, (c) reducing economic loss and (d) reducing damages of important infrastructure are regarded as "Output Target". Target (e) national and local DRR strategies, (f) international cooperation and (g) access to risk information are regarded as "Input Target". The "Input Target" can influence "Output Targets".

Reducing mortality (target (a)) is the first priority in DRR. However, even if the mortality is reduced by the efforts of early warning and/or strengthening disaster response capacity, damages of infrastructures (target (d)) and economic losses (target (c)) cannot be reduced. Consequently, the society cannot escape from repeating disasters damages. It gets in the way of sustainable development of the country. However, if economic losses are reduced by priority and early warning mechanism is improved as a supplemental measure, the others including mortality and damage of infrastructure could be reduced.

From this viewpoint, the Roadmap gives higher priority on investment for (a) reducing economic

losses by natural disasters. It is also important to prioritize each DRR effort and to invest in suitable and adequate protective targets (mortality, infrastructure or economy) depending on the situation and disaster types in order to maximize the benefit with limited budget.

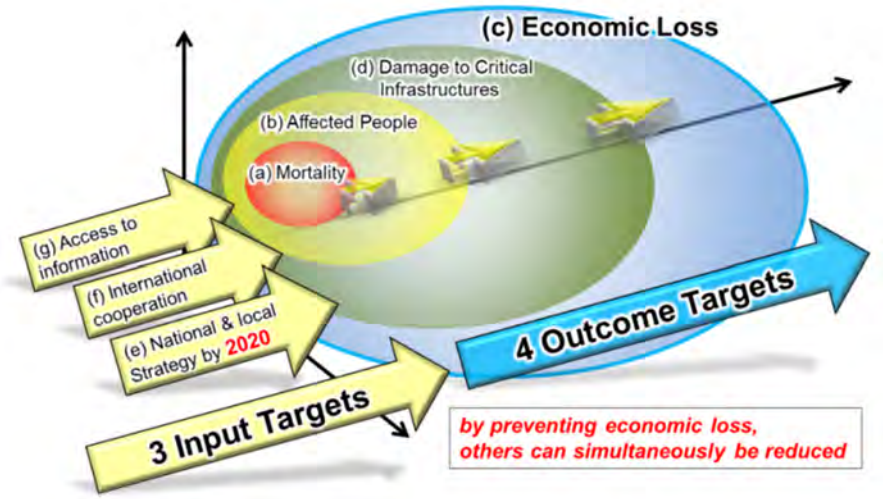


Figure5.1.1 Image of Input and Output Targets in Sendai Framework

5.1.2 Discretionary Investment considering Overall Balance

In disaster countermeasures, the impact by initial investment is relatively high, but the impact curve gradually flattens as the investment amount increases. Therefore, investment should aim to meet a certain level where an optimum investment impact ratio is ensured, instead of aiming for the highest hazard level with complete countermeasures.

For instance, Kelani Ganga is one of the highest priority river basins in Sri Lanka. Even in Kelani Ganga, it is not cost effective to target highest hazard level. Instead of that, investment should be focused on optimum investment level, and the remaining budget should be delivered to the other basins where higher impacts are expected.

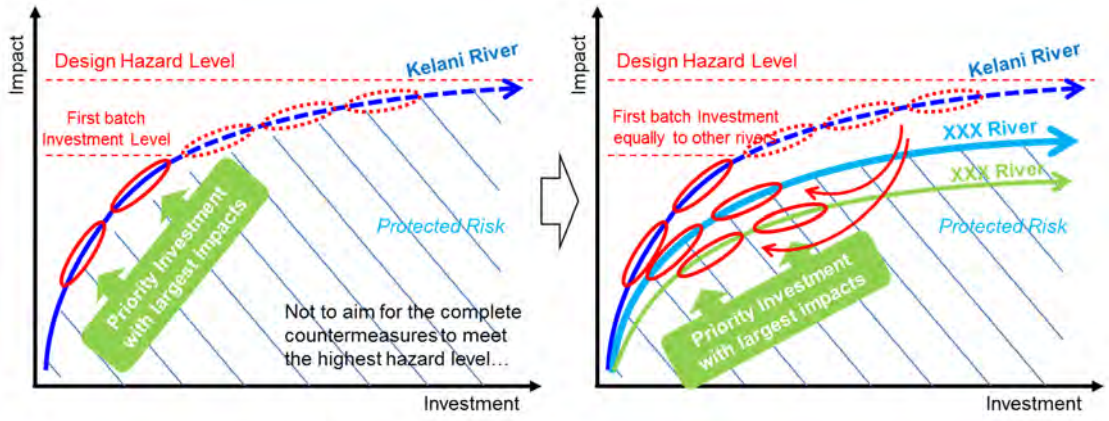


Figure5.1.2 Image of optimum investment in higher impact projects

5.1.3 Strengthening Local DRR Governance

DRR strategy and plans based on the good governance are the foundation of entire DRR activities. In Sendai Framework, therefore, the target year of Global Target (e) "national and local DRR strategy and plan" is set by 2020. To establish practical and realistic DRR strategies and plans are the most urgent task to be achieved as soon as possible.

As described in section 2.3.1 (1), DMC has supported to formulate District and Division Disaster Management (DM) Plans. As of now, all 25 districts and 187 out of 333 DS divisions formulated DM plans. The DM plans are composed 3 parts of "Prevention & Mitigation Plan", "Preparedness & Emergency Response Plan", "Rehabilitation, and Reconstruction Plan". However, only "Preparedness & Emergency Response Plans" have been formulated in most districts and divisions because they tend to lack disaster risk assessment necessary for the other two types of Plans. These two components are closely related to Sendai Framework Priority Action 3: "DRR Investment" and Priority Action 4: "Build Back Better" respectively. Therefore, it is highly required to complete these plans based on appropriate scale of hazard maps.

5.1.4 Basin-based DRR Strategy

Disaster often occurs beyond administration boundaries. Especially in flood, several local administrations are suffered by one disaster event. To deal with the flood, therefore, holistic DRR strategy covering entire basin beyond administration boundaries is important. "Basin-based DRR strategy" which aims to maximize bulk benefit of the basin should be developed through the basin stakeholder meeting among concerned sectors and local authorities. Based on the Basin-based DRR Strategy, structural and non-structural measure as well as local DRR plans should be formulated. Accordingly, the basin investment and local DRR plans shall be consistent for comprehensive and phased countermeasures.

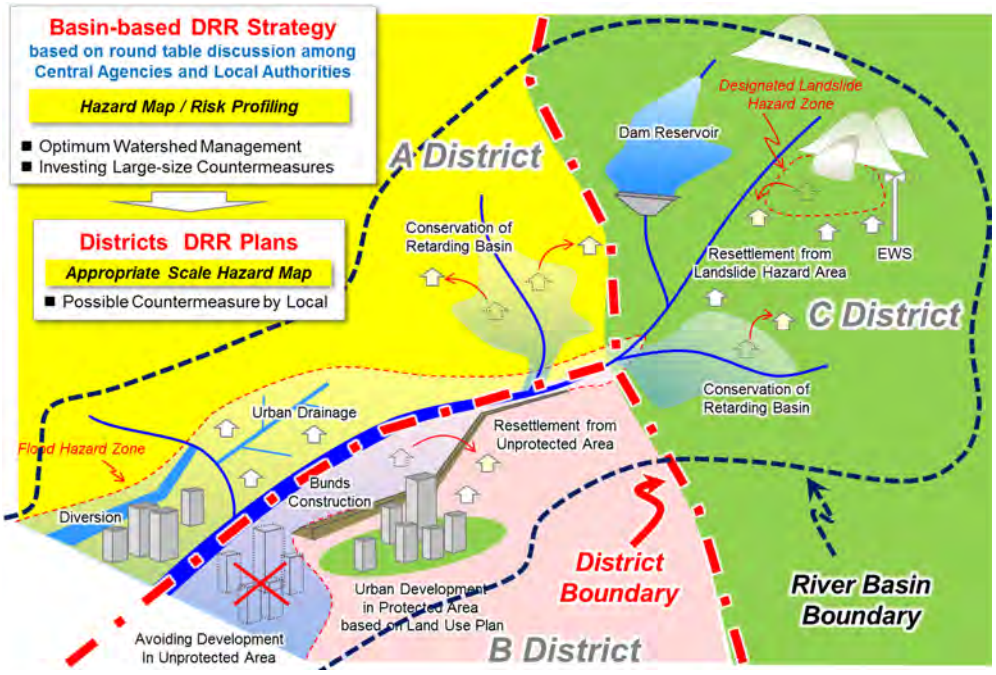


Figure5.1.3 Image of Basin-based DRR Strategy and Local DRR Plans

5.2 Selection of Priority Actions and Monitoring Mechanism

Considering above principles on the Roadmap for DRR, the programmes to be taken are shown in the next page. Each programme is summarized in short-term target (by 2020), mid-term target (by 2025) and long-term target (by 2030). The programmes in the short-term target are regarded as "Priority Actions". The blue colored boxes in the "Priority Action" indicate the actions that are already implemented or ongoing by GoSL and international donors. The yellow colored boxes indicate the action to be taken as soon as possible.

The list of "Priority Actions" and status are shown in Table 5.2.1.

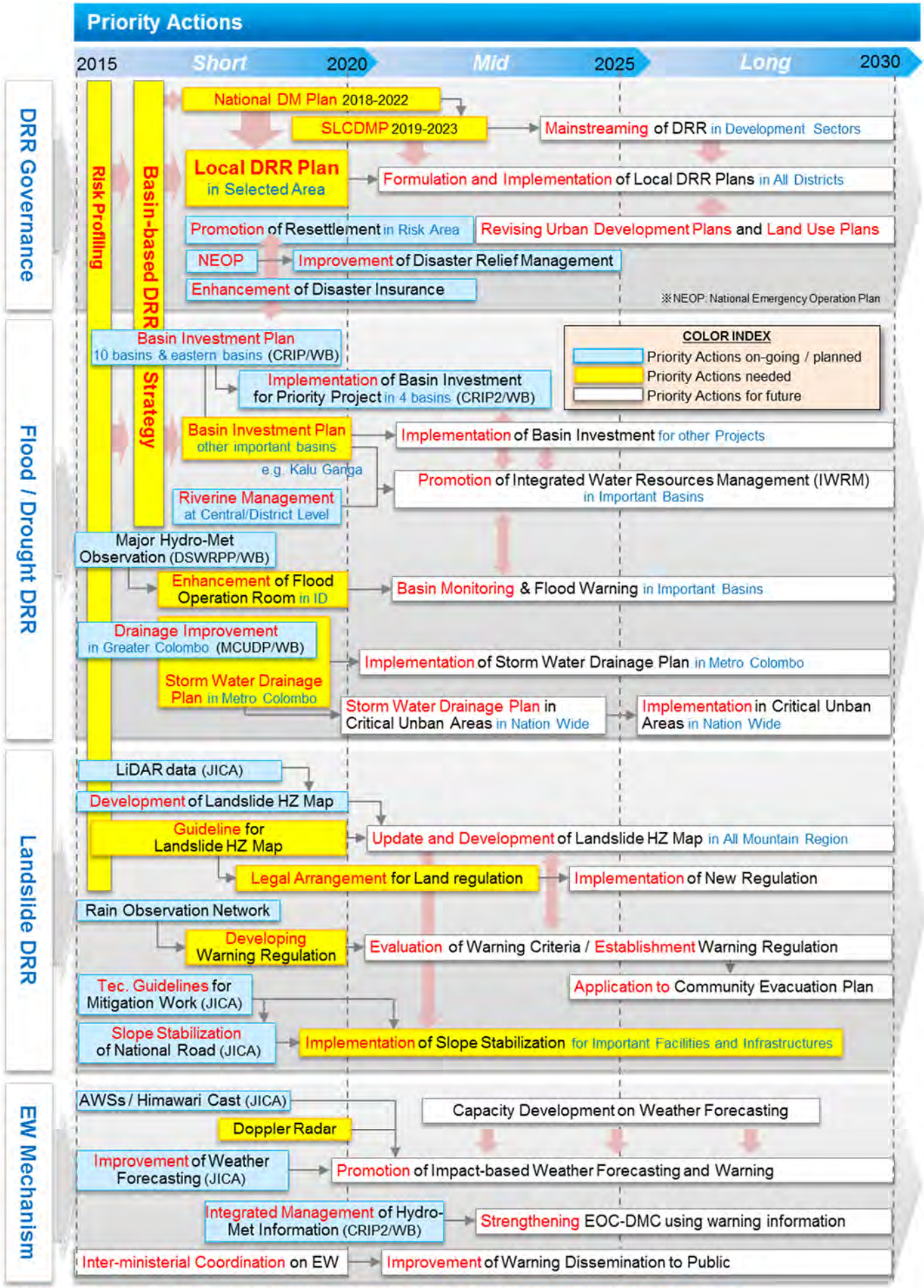
Table 5.2.1 Priority Actions in Roadmap for DRR

Priority Programmes	Status
Comprehensive DRR Governance ▪ To revise NDMP / SLCDMP and to promote mainstreaming DRR in local development sectors ▪ To develop local DRR plans (District and DS Divisions) based on appropriate risk profile ▪ To finalize NEOP and to strengthen national relief structure ▪ To promote disaster insurance scheme	▪ NDMP is under preparation by MDM. It will be supported by JICA advisor. ▪ CRIP will conduct risk profiling at selected river basins. Basin-based local DRR plan is necessary. ▪ NEOP will be finalized soon. Disaster relief database for better activities is required.
Flood Risk Reduction ▪ To formulate investment plan in important basins and to promote Integrated Water Resources Management (IWRM) ▪ To strengthen flood monitoring system ▪ To review urban drainage plans to strengthen drainage systems	▪ Investment plans for 12 river basins will be formulated by CRIP and other projects. IWRM should be promoted at each basin. ▪ Many hydro-met monitoring facilities were installed by DSWRPP. ▪ MCUDP is ongoing. Comprehensive drainage plan and up scaling to national level are required.
Sediment Disaster Risk Reduction ▪ To develop land development regulation based on updated landslide hazard zonation map ▪ To improve landslide warning structure ▪ To invest in stabilization of important infrastructures	▪ There is no guideline for hazard zonation and legal arrangement for land regulation. ▪ Rainfall observation network was developed by NBRO. Warning criteria and regulation should be improved. ▪ LDPP is ongoing.
Drought Risk Reduction ▪ To formulate National Strategy on Drought Risk Reduction based on Drought Risk Assessment, and to formulate District Drought Risk Reduction Plan as next step. ▪ To establish drinking water supply system as emergency response to severe drought affected areas, and to formulate appropriate drinking water distribution plan (drought affected districts). ▪ To promote awareness activities related to water use and water saving in view of realizing water saving society .	▪ In drought prone areas in dry zone in Sri Lanka, relief activities are mainly proceeding, however, strategy on drought risk reduction at national level has not been formulated yet. ▪ As current disaster relief activities undertaken are drinking water distribution to drought affected people by bowsers. Securing drinking water supply system and adequate water distribution plan has not been formulated. ▪ Some government agencies as well as donors and NGOs have been promoting to create a water saving society, however, there are no integrated awareness scheme view of drought risk reduction
Forecasting and Early Warning ▪ To improve hydro-met observation system and weather forecasting ▪ To integrate hydro-met data and to coordinate among relevant agencies	▪ Doppler radar and Himawari cast will be installed soon. ▪ Coordination mechanism among agencies should be initiated by MDM.

The Roadmap for DRR "Safe and Resilient Sri Lanka" is a guide to implement Sendai Framework by the Government of Sri Lanka. To ensure the implementation and promotion of the selected Priority Actions, it is important to organize periodical "DRR Roundtable Meeting" with concerned agencies under the initiative of MDM. It is to monitor individual activities by designated lead agencies.

Presently, National Disaster Management Committee (NDMC) is constantly held about once in few months as a collaborative meeting among disaster-related stakeholders including government agencies, international organization and donors. The member of NDMC discusses ongoing disaster situation and government's responses as well as preparation for international conferences. The NDMC may be an appropriate opportunity for monitoring the progress of Roadmap. In addition, it is strongly recommend ensuring report mechanism to the Prime Minister and concerned Ministers for necessary corrective actions and securing financial supports.

The Roadmap shall be revised according to amendment of Sri Lanka Disaster Management Act, formulation of NDMP and progress of each activity. Such revision should be done by MDM in cooperation with DRR Advisor mentioned in Chapter 6.



※Priority actions only for main disasters are indicated. The other shall be considered as needed.

CHAPTER 6 Recommendation on Support by JICA

6.1 Applicable Japanese Technology and Institution

Considering issues on DRR in Sri Lanka indicated in Chapter 4 and the roadmap in Chapter 5, the following Japanese technology, experience and legal institution might be applicable to DRR Sri Lanka.

6.1.1 Comprehensive DRR

(1) DRR Investment and Monitoring in National Resilience Policy

After the great earthquake and tsunami in 2011, Government of Japan established "Basic Act for National Resilience" in 2013 as a master plan of national resilient in Japan. Based on the act, National Resilience Fundamental Plan and its Action Plan were presented out. In Japan, "Disaster Countermeasure Basic Act" in 1974 is the most basic DRR strategy to stipulate role and responsibility of national agencies and local administrations. The "Basic Act for National Resilience", which is in higher position of "Disaster Countermeasures Basic Plan" and "National Land Plan" in national resilience as an "Umbrella Plan", is to be a guideline for the other national plans aiming to prevention & mitigation and immediate recovery and reconstruction after disasters.

The "National Resilience Fundamental Plan" shall be revised in every five years. The "Action Plan" shall be revise every year. The annual targets and indicators of the each programme are clearly indicated in order to monitor and evaluate the progress. The SLCDMP in Sri Lanka seems to be similar to the "Action Plan". The monitoring mechanism and indicator setting might be refereed in SLCDMP.

(2) DRR White Paper for Inter-Ministerial Coordination

The Government DRR White Paper (Official Annual DRR Report) has been published annually since 1963 in Japan. The White Paper is prepared by the Cabinet Office based on the Disaster Countermeasure Basic Act, Japan to report the outline of the DRR measures taken and DRR planning to the Diet. The White Paper compiles 1) status of disasters and measures, 2) outline of the DRR measures taken in previous year, 3) DRR planning for the next year and 4) status and issues on DRR measures.

Source: Cabinet Office Japan Website
http://www.bousai.go.jp/kaigirep/hakusho/h28/

Especially, "1) status of disasters and measures" deals with the latest information on various DRR activities, which covers the information on law amendment, achievement of DRR activities by various organizations, budgeting on DRR and the information on the measures for each disaster (natural disaster (earthquake and wind/ flood) and manmade disaster).

Although MDM issues annual reports for progress and performances of the affiliated agencies,

there is no comprehensive report to publish summary of disasters, damages, expenses and governmental DRR efforts in the year in cooperation with relevant agencies. If such White Paper is prepared in initiative of MDM, the coordination and information sharing mechanism among government agencies shall be further strengthened.

(3) TEC-FORCE for Immediate Relief and Recovery

Source: MILT Website
http://www.mlit.go.jp/river/bousai/pch-tec/index.html

TEC-FORCE (Technical Emergency Control Force) was established in 2008 in the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), a main agency responsible for DRR in Japan. When large natural disaster happens or due to the risk of disasters, TEC-FORCE is dispatched based on a request from local governments to provide technical supports on the prompt understanding of damage situation, the prevention of the occurrence and expansion of secondary damages, the early recovery of damaged areas. Before the establishment of permanent TEC-FORCE, ad-hoc supports on a temporary basis had been provided in each disaster.

The member of TEC-FORCE is the experts on disaster response selected from nationwide MLIT staff, that is, the staff have experiences of disaster response and the staff conducting technical site trainings on a daily basis. The member brush up their skills even during ordinary times by conducting simulations and trainings.

In Sri Lanka, when large-scale disaster occurs, MDM and technical agencies were convened and dispatched to the affected area as Task Force under strong initiative of the President. However, the scope of activity and authority are not regulated in legal basis. One of the differences between TEC-FORCE in Japan and Task Force in Sri Lanka is that the TEC-FORCE is dispatched based on request from local administration not by central government. TEC-FORCE is important for local administration not only to consult on disaster response but also to receive emergency financial supports from the central government.

(4) Participatory Disaster Response “Firefighting Group”

Source: Toyooka City Web Site
http://www.city.toyooka.lg.jp/www/
contents/1287709712574/index.html

Firefighting Groups in local governments (city, town and village) in Japan are composed of volunteer general citizens. The Groups are established based on Fire Organization Act and are under the jurisdiction of Fire Fighting Agency, Ministry of General Affairs. There are 2,200 Groups composed of 0.86 million citizens (among which 73 % is office workers). The activity of the Groups are voluntary basis in principle, local governments give a few salary and equipment to the Group members, though.

At the time of disaster, the Firefighting Groups conduct

not only firefighting but also the flood fighting activities such as piling up sandbags, search and rescue, security inspection and evacuation guidance. Even during normal times, the Groups implement the awareness raising activities on first aid and firefighting, special security activities and public relations. Some local governments have established Flood Fighting Groups other than Firefighting Groups, however, the actual situation is that the member of Firefighting Groups work as the member of Flood Fighting Groups in most cases.

In Sri Lanka, the main actor of disaster response in the field is military. There is no permanent organization to conduct systematic rescue and relief activities in local authorities. However, the philosophy of self-help and mutual-help during disaster takes root in the history of Sri Lanka. If the participatory disaster response team will be organized in institutional arrangement, it could be a strong power to supplement disaster response by military.

(5) Serious Disaster Act to Promote Build Back Better

The objective of the Serious Disaster Scheme in Japan is to support local administrations by the central budgets in rehabilitation and recoveries to deal with extremely severer disasters. It is a practical structure to promote Build Back Better in Japan.

The prime minister decides the application of "Serious Disaster". The application is judged based on the exceeding ratio of the total damage cost against the tax income of the local governments located in affected area. Therefore, it is necessary to estimate the total damage cost as soon as possible.

After applied as Serious Disaster, as special measures, the ratio of subsidies from central government to local governments raises from 70 – 80 % to maximum 90 % for the recovery and rehabilitation of roads, rivers, schools, damaged houses, agricultural lands and fishery facilities, and infection control measures.

Principle of disaster emergency countermeasures in Japan is "Reoccurrence Prevention", which means to renew and upgrade countermeasures to prevent the same magnitude of previous disaster not to restore to original. It is an idea to promote investment for Build Back Better. Financial support mechanism in the Serious Disaster Act might be referred in Sri Lanka to realize Build Back Better.

6.1.2 Flood Risk Reduction

(1) Comprehensive Flood Risk Reduction and Countermeasures on Watershed

Comprehensive flood risk reduction consists of river improvement, countermeasures on watershed and mitigation of damage. In Japan, the comprehensive flood manage net has being promoted by identifying specific rivers which has severe flood damage due to rapid urbanization. These rivers are called as "Specific Rivers for comprehensive flood manage net".

In the process of formulation of "Basin Flood Management Plan", suitable measures are selected among possible measures in the comprehensive flood risk reduction based on characteristics of the river basin. This planning methodology can be utilized in food management planning for

rapidly urbanized river basins in Sri Lanka.

Among several measures, countermeasures on watershed could be useful for flood risk reduction for urban flooding in Sri Lanka, especially. Table 6.1.1 shows menu of the countermeasures on watershed.

Table 6.1.1 Menu of countermeasures on watershed

Area	Characteristics	Menu of Countermeasures
Retention Area	Area where rainfall infiltrates to ground and retains runoff to rivers.	・ Consideration of flood risk area on setting urban development zona ・ Conservation of natural area ・ Retention ponds ・ Retention facilities of rainfall ・ Permeable road and trench
Retarding Area	Area where rainfall and overflowed water flow rivers tentatively stored.	・ Consideration of flood risk area on setting urban development zona ・ Regulation of land filling ・ Improvement of agricultural activities
Low-lying Area	Low-lying urban area along rivers where in natation occurs due to accumulation of rainfall and overflows from rivers.	・ Facilities such as drainage channels and pumps ・ Retarding facilities ・ Promotion of flood resilient buildings

Source: Website of MILT, Japan

In Japan, technologies related to the above-mentioned countermeasures have been developing by private sector, which could be useful for promotion of the countermeasures on watershed in Sri Lanka.

Example of multi-purpose retention ponds (Left: normal condition, Right: flooding time)
Source: Web-site of MLIT, Japan
https://www.mlit.go.jp/river/shinngikai_blog/past_shinngikai/gaiyou/seisaku/sougouchisui/pdf/2_2genjou.pdf

(2) Coordinated Operation of Flood and Water Resources Facilities

In metropolitan Tokyo which has been developed in low-lying area, many large scale flood control facilities such as flood gates, locks and pumping stations have been installed and they are operated with well-coordinated way. These systems also consider back-up mechanism for emergent cases. In Sri Lanka, currently there is only small and simple facilities for small scale flood events. However, according to progress of flood control measures for urban flooding, it will be necessary to operate the complicated facilities appropriately in future. The Japanese experiences on the coordinated operation of complicated flood control facilities could be referred.

In Tone river basin which is next to Tokyo metropolitan area, there are many dams constructed for flood control as well as water resources development. The integrated operation and management of these dams have been implementing to obtain maximum benefit from each of dams. By this, Tokyo metropolitan area has been protected from flood and irrigation and municipal water has been stably provided.

In Sri Lanka, there has been a lot of water resources development by construction of dams. However, these operations are not always coordinated well, because manager of dams are sometimes different in same river basin. The Japanese experience on the integrated operation and management of dams could be useful for improving the operation of dams considering the benefit for entire river basin in Sri Lanka.

(3) River Management

In Japan, objective of river management is flood management, water use and environment, on the basis of River Law. The river management in Japan is characterized by strict management of river management area and water quantity and quality management of river basin based on appropriate monitoring in rivers.

In Sri Lanka, there is no comprehensive law on water resources, accordingly there is no water use premising system. MIWRM has intention to enact new water resources law, in parallel with revision of irrigation act and flood control act. MIWRM is also establishing Riverine Management Division under the ministry for enhancing river basin management. It indicates that Sri Lanka government promotes water resources management at basin level by enhancing river management. The river management based on River Law in Japan could be referred for improving river management and water resources management for Sri Lanka.

6.1.3 Sediment Disaster

(1) Designation of Sediment Disaster Hazard Areas and Landuse Regulation

In Sri Lanka, UDA is a responsible organization for land regulation in large-scale development projects. The projects can be implemented based on approval by UDA including technical advices from relevant agencies in urban planning, infrastructure, disaster management sectors. The disaster risk assessment (flood, sediment disaster, strong wind, and others) of the project area is conducted by NBRO according to existing hazard map and past disaster record. However, practical land use regulation/law based on the disaster risk assessment has not been formulated yet.

The Sediment Disaster Prevention Act is one of the major laws in Japan (refer to Table 6.1.2). The law aims to identify dangerous area of the sediment disaster and to clarify necessary countermeasures that should be taken by local governments. The sediment disaster hazard areas are designated with unified methodology according to the law. The local government enforces certain restrictive for land use and development activity in the designated area. The law contributes to secure safety, reduce damage from landslide disaster and raise awareness of people.

Table 6.1.2 Designation of sediment disaster risk areas in Japan

Name	Designation	Disaster Type
Sabo Designated Area	Designation based on "Sabo Law" by Minister of Ministry of Land, Infrastructure and Transport (MILT)	・ Remarkable area of the production and deposition of sediment by river erosion or collapse ・ Required area to install the prevention measure due to the sediment deposition
Landslide Prevention Area	Designation based on "Landslide Prevention Act" Minister of MILT	・ Landslide
Dangerous Area of Slope Failure	Designation based on "Act for Prevention of Disasters due to Steep Slopes" by prefecture	・ Steep Slope
Dangerous Spots for Sediment Related Disasters	Designation based on guideline of MILT	・ Steep Slope Failure ・ Debris Flow ・ Landslide
Sediment Disaster Hazard Areas (Yellow Zone) Sediment Disaster Special Hazard Areas (Red Zone)	Designation based on "Sediment Disaster Prevention Act" by Prefecture	・ Steep Slope Failure ・ Debris Flow ・ Landslide
Dangerous Area of Mountain Disaster	Designation based on guideline of Ministry of Agriculture, Forestry and Fisheries	・ Hillside Collapse ・ Debris Flow ・ Landslide

Source: JICA Study Team

In the Project of TCLMP, the methodology of designated Sediment Disaster Hazard Area (Yellow Zone Setting) for debris flow and steep slope based on Sediment Disaster Prevention Act has been introduced and examined for some pilot area as examples. That result will be used for the update of existing LHZM and land use regulation. There remain some issues on difference of land use on the slope between Japan and Sri Lanka, and lack of necessary past disaster records. An example of Yellow Zone Setting in Aranayake landslide is shown in Figure6.1.1.

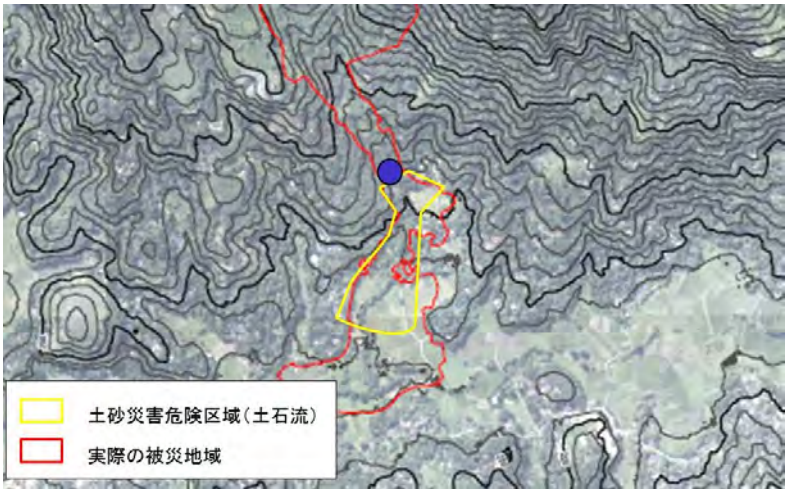


Figure6.1.1 Sample of Yellow Zone Setting in Aranayake Landslide
Source: Technical Cooperation Project for Landslide Mitigation Project, JICA

(2) Warnings for Sediment Disasters

It is difficult to evacuate from sediment disasters after the disasters occur. Further, the sediment disasters have high destruction force. Therefore, the sediment disasters usually causes loss of lives compared with the other disasters. Conversely, reduction of human damages is expected by suitable appropriate evacuation. Therefore, early evacuation based on warnings and metrological information is highly effective.

In Japan, several disaster information based on observed rainfall is issued by JMA. In addition, administrators of infrastructures (road administrator, railway company, etc.) also judge risk of sediment disasters and take actions based on their criteria. In Sri Lanka, NBRO issues Landslide Early Warning, and DMC and/or media disseminate it to public.

In Sri Lanka, however, the rainfall criterion of the warning is uniform in the whole country. Local sediment disaster characteristics were not reflected on the criterion. Therefore, NBRO plans to install 160 rainfall gauging stations by May 2017 in 10 districts where is designated as landslide prone area, and NBRO considers setting criteria for each districts by using rainfall data observed by the gauging stations.

1) Effective Rainfall/Snake Curve and Warnings

Concept of criteria setting and snake curve operated in Japan based on effective rainfall is shown in Figure6.1.2. Snake curve is a method to indicate sediment disaster risk by using short term and long-term rainfall. Comparing with warning based on daily or hourly rainfall only which is issued by NBRO, effect of long-term rainfall is considered into the warning. Therefore, accuracy of the warning should be improved. The data processing of the snake curve method is simple, but improvement of the warning is expected. Thus, adequacy to introduce the snake curve method in Sri Lanka should be high. It seems that Japanese considerable experiences on criteria settings and operation are valuable to introduce the snake curve method Sri Lanka.

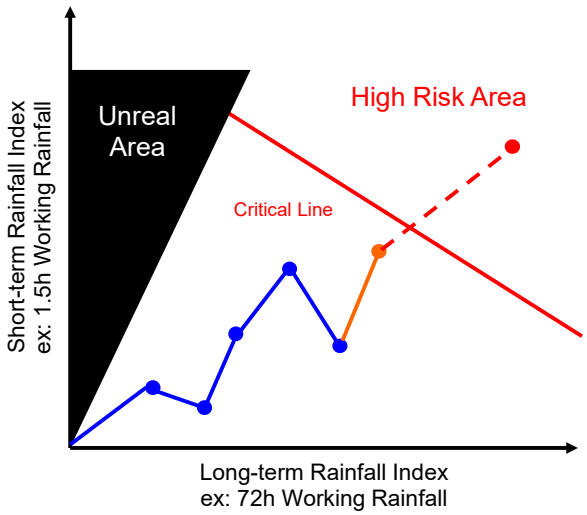


Figure6.1.2 Concept of criteria setting and snake curve based on effective rainfall
Source: Prepared by JICA Survey Team

2) Landslide Alert Information/Soil Water Index and Cooperation with Local Administration

JMA issues Heavy Rain Warning, Landslide Alert Information and other risk information in each risk stages to disseminate increase of disaster risk. Table 6.1.3 is a list of sediment disaster warnings/advisories issued by JMA. These warnings/advisories are utilized to encourage local people to evacuate as well as local administrations to establish temporary organization for disaster preparation and response. The linkage between disaster warnings/advisories and actions of local administration contributes effective preparedness for disasters. In addition, local meteorological observatories function as an advisory authority for local administrations in Japan. For example, Landslide Alert Information is jointly issued by JMA and prefectures in Japan. Collaboration of technical agencies and local agencies is one of weak points of disaster management in Sri Lanka. Thus, the administrative mechanism for disaster management in Japan should be a good sample.

The Landslide Alert Information and mesh information are judged and issued based on Soil Water Index. The Soil Water Index is calculated by using rainfall data and tank model to estimate soil water content. The amount of soil water content strongly affects occurrence of sediment disasters. A resolution of the mesh data of Landslide Alert Information is 5km x 5km. Local people and local administrations can hence recognize real-time distribution of high sediment disaster risk area. It is pointed out that the unit area of landslide alert in Sri Lanka is too wide to encourage local people to evacuate. Therefore, the Soil Water Index and the mesh information of Landslide Alert are effective to improve the landslide alert in Sri Lanka. To introduce those indexes, utilization of rainfall data obtained by Doppler Rader, calibration of model parameters and criteria considering characteristics of Sri Lankan topography/geology and disaster records are necessary. Thus, it is expected to utilize Japanese abundant experience and technologies.

In case that the Landslide Alert Information and/or Soil Water Index are introduced in Sri Lanka, it is recommended that DOM who provides Doppler Rader data and NBRO who issues landslide alert and has field information collaborate well.

Table 6.1.3 List of sediment disaster warnings/advisories issued by JMA

Name	Actions taken by local administrations
Heavy Rain Advisory (Landslide)	Establishment of temporal organization for disaster response Basis of decision to issue evacuation preparation information
Heavy Rain Warning (landslide)	Basis of decision to issue evacuation preparation information
Landslide Alert Information	Basis of decision to issue evacuation advisory
Information about a record-breaking deluge in a short period	Basis of decision to issue evacuation advisory/directive
Heavy Rain Emergency Warning (Landslide)	Triger to revise target area of evacuation advisory/directive
Mesh Information of Landslide Alert	Basis of decision to issue evacuation advisory/directive

Source: Guideline of manual preparation for decision and dissemination of evacuation advisory and directive, 2015 (Cabinet Office, Japan)

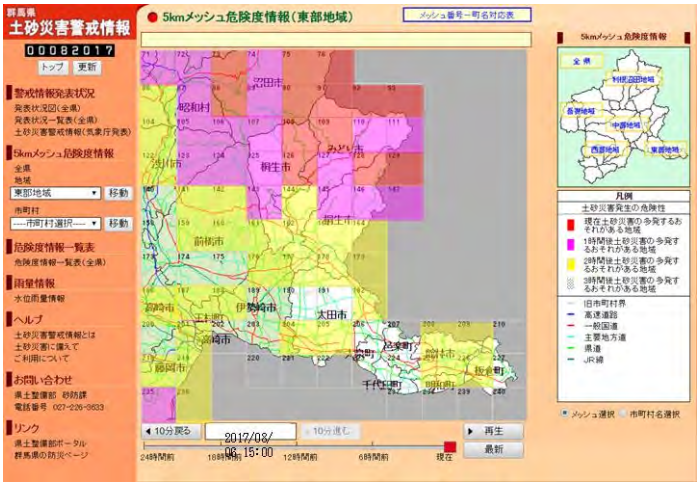


Figure6.1.3 Example of Mesh Information of Landslide Alert

Source: modified after HP of Gunma Prefecture
http://www.dosya-keikai-gunma.jp/cgi-bin/index.cgi?gmNum=116040&kbNum=01

(3) Structural Measures for Important Infrastructures

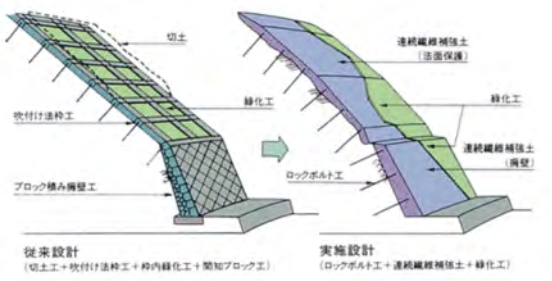
1) Green Slope Stabilization

Steep-cutting slopes are main causes of slope erosion and failure in the mountain area. However, it is difficult to make it with stable gradient by extensive slope cutting due to not only limitation of land acquisition and budget but also environmental and landscape perspective.

Recently, many new technologies of slope stabilization considering green conservation have been developed and applied in Japan. Some of these technologies were introduced and evaluated the feasibility in Sri Lanka through JICA studies. These countermeasures are so-called “Reinforced Earth Method”, which prevents slope failure by establishing unified soil body using both surface protection and soil nailing. Such countermeasures are low-cost and high applicable without extent slope cutting. Hence, those technology could be applied in Sri Lanka.

Geo-fiber Method

Geo-fiber method is to build soil structure on the slope surface by spraying reinforced soil mixed with continuous polyester fiber. Contrary to concrete structure, it can be applied keeping existing vegetation and trees in the slope. It is also able to plant by mixing seeds in the reinforced soil. JICA is carrying out a “Feasibility Survey for Environmental-sound Slope Protection Technology” with NBRO to study the applicability of the method.



Left: Conventional / Right: Geo-fiber Method
Source: Geo-fiber Association HP

Construction keeping existing trees
Source: Nittoc Construction Co., Ltd. HP

Non-frame Method

Non-frame method is a kind of soil-nailing technology keeping existing vegetation and tress in the slope. Rock-bolts of 3-5m length are driven into the slope by regular intervals. The rock-bolts are connected each other by wire ropes, so that slope are unified and stabilized. It does not require reshaping and cutting the slope. Landscape is retained after construction.

This technology has been applied in the countries of Taiwan and Bhutan where the governments are embracing environmental conservation in the national policies. Regarding JICA assistant, this technology will be applied in the south American countries.


Example (Left: before construction / Right: after 4 months)
Source: Toyota City, Aichi Prefecture, Japan

PDR Method

Permanent Drain Reinforcement (PDR) method is a soil-nailing technology with surface drainage function. Instead of rock-bolts, steel-piles with strainers (drain holes) are used for nailing, so that it can reinforce soil and drain surface ground water at the same time. Since the PDR method can be implemented by manual driving, pre-drilling is not required. However, the applicable condition is limited in soil sediments and highly weathered rocks. Besides, due to the nailing depth of 1.8m + 1.8m in maximum, it can be applied only for small-medium scale slope protection. In Japan, it is popularly used for embankment foundation of railways.

The construction is easy without any specific tools. It is suitable for small-scale slope protection at important public facilities that are carried out by NBRO.


Construction can be done
by standard driving mount

Left: no slope failure in PDR applied slope /
Right / slope failure in PDR unapplied slope
Source: Ohta Geo Research Co., Ltd. HP

2) Sabo Dam

Sabo Dam has two principle functions that are to physically trap sediments and boulders by concrete dam and to reduce river erosion and affected area of debris flow by making riverbed slope gentle. Even if the dam is filled-up by full of sediments, it can capture sediments of

10-15 % of total dam capacity because the riverbed is already gentle by filled sediments.

JICA has been supporting RDA and NBRO on sediment disaster prevention countermeasures for landslide and slope failure. Regarding debris flow, however, no structural measures and its designing capacity development were not included excepting introduction of hazard zonation methodology.

In the sediment disasters at Meeriyabedda in October 2014 and Aranayake in May 2016, the large volume of water-contained sediments generated by landslide became debris flows affecting downstream residential area. In fact, most of sediment disasters causing serious damages in recent years are debris flow type. However, there is no experience and know-how on debris flow prevention measures in Sri Lanka.

Sediment disaster prevention technology especially in debris flow has been implemented in the long history of Japan. Now the name of Sabo-Dam became an international terminology. JICA is supporting Sabo-Dam construction in many countries, for instance in Philippine, Indonesia and Nepal. Such experience and technology could be applied to mitigate debris flow disaster in Sri Lanka.

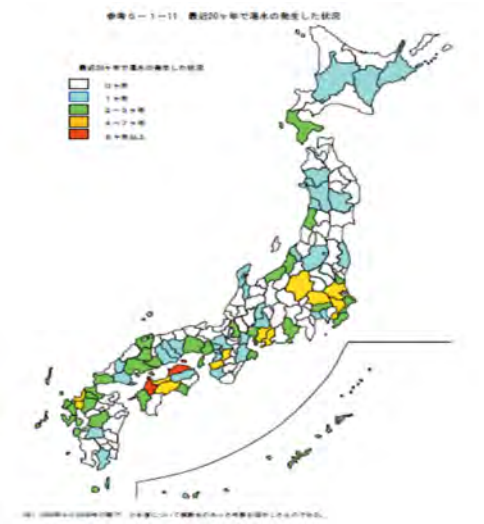
Trapped sediments by Sabo-Dam at Nigata Prefecture, Japan Source: TCLMP

6.1.4 Drought Risk Reduction

(1) Collaborated Efforts by Public and Private Sectors in Japan

A map of the distribution of droughts that occurred in the past 30 year (1989-2009) in Japan is shown in the right figure. Severe droughts have taken place in 1964, 1978-1979, 1981-1982, 1994, 2002 droughts have occurred repeatedly all over Japan. The droughts in 1994 and 2002 affected nationwide, brought huge damage to agriculture and water supply.

Droughts are particularly serious in the western Japan region. During the drought in 2002, water intake control to save water in the dam was conducted for up to 287 days in the Shikoku region. As the main cause of such droughts, unstable



Drought in the past 30 years in Japan (1989-2008)
Source: MLIT
http://www.mlit.go.jp/tochimizushigen/mizsei/c_actual/actual05.html

precipitation can be considered. In Japan, since nationwide droughts are occurring at a cycle of about once every ten years, advance measures to prepare for risk of drought is being implemented together with the public and private sectors in corporation based on the following policy.

In Sri Lanka NDRSC, DDMCU are working as coordination organizations for relief during drought. However, both the national and local governments have not experienced yet the implementation of comprehensive drought risk reduction. Drought risk reduction should be considered together with water resources management and the Japanese experience described in next section will be helpful in Sri Lanka as well.

1) Pre-Adjustment with Related Organizations to Reduce Water Shortage Risk

In Japan, in the case that the severe drought is expected, "Drought Adjustment Council" will be immediately organized in accordance with Article 53 of the River Act in participation of river administrator, each prefecture and relevant agencies. At the council meeting, principal allocation and procedures concerning water use can be determined. In this respect, the coordination with related organizations is significantly important in view of drought risk reduction. If Sri Lanka expects to minimize drought damage, drought adjustment council should be set up involving each relevant agency from the earliest possible stage of drought in order to take appropriate risk reduction activities in advance.

2) Drought Adjustment based on Integrated Water Resource Management

Japan's drought adjustment is based on the concept of integrated water resources management and considers cooperative water use within the river basin and sometimes between other river basins, such as water consumption for daily life, hydroelectric generation, agriculture, industry, and river maintenance flow etc. At the time of drought, it is implemented by integrally adjusting considerable water use. The water resource management facilities in the relatively large basin where the river flows into the urban area differs depending on the catchment's natural and social circumstance, but it is roughly divided into four, those are an upstream dam, a midstream retarding pond, a downstream conduit cannel, and estuary tide weir in Japan. In order to operate those facilities efficiently and effectively, wide area low water management is carried out based on collected data and information as mentioned below.

- As drought risk reduction, the release of water from dams will be restricted before drought starts for the purpose of keeping water in the dams (drought adjustment). Specifically, the water saving rate and period for each dam will be determined in consideration of the actual water demand for living, industry, hydroelectricity and agriculture, etc.
- If severe drought is expected, integrated management of dam groups and water conservation cooperation for other water users will be asked immediately after water adjustment consultation. For tap water, water supply restrictions such as decompression and water cut-off will be requested.

In Sri Lanka, by understanding drought risk reduction as "drought adjustment based on integrated water resources management", drought risk management will become possible to realize comprehensively.

3) Long-term Water Resource Conservation Measures

Forest in the water source area has the function of recharging the water source and reducing the

sediment inflow into the dam reservoir. Therefore, maintenance of the water source recharge function of the forest is extremely important for long term water resource conservation. In Japan, for that purpose, reforestation, improvement and maintenance of forest road, and landslide prevention and restoration works are being executed under the initiative of the relevant government agencies. Even in Sri Lanka, forest conservation aiming at long term securing water resources is definitely necessary, and Japan's experience in this field can be applied in Sri Lanka.

(2) Creating a Water Saving Society

In Japan, many attempts to create a water-saving society are being implemented by the central government, local governments, and industry and individuals. Specifically, reuse of sewage treatment water, recycling waste water of industrial water, and prevention of water leakage, and using rainwater are applied as various available countermeasures for water saving. At the same time, aiming to create a water-saving society, awareness and PR activities of water conservation, water-saving equipment promotion, etc. are being undertaken. Especially for rainwater use, it is progressing at large public facilities. To promote the use of rainwater in homes and enterprises, some local governments provide subsidies for introduction of storage tanks of rainwater and pump distribution systems.

In Sri Lanka, should a large-scale rainwater storage facility be installed at public facilities, risk reduction both in flood and drought can be simultaneously achieved.

6.1.5 Hydro Meteorological Observation and Information Sharing

(1) Integrated Operation and Application of Weather Observation Network

In addition to existing ground and aerological observation network, DOM proceeds to install new instruments and systems for weather observation and forecasting. After all installation plans will be completed, ground observation (AWS, Doppler Radars, Lightning Detection System), satellite observation (satellite image receiver: HimawariCast) and NWP model (ECMWF) will be drastically enhanced. On the other hand, there is a concern on integrated operation and application of those instruments because donners of the instruments are different. JMA has enough experience about the total management and integrated operation of the observation systems. Thus, JMA has a strong point to propose concept of the total system and to draw grand design of the observation system. In addition, JMA has long experience on synthetic application of the weather observation data. Therefore, the Japanese know-how must be useful to improve weather forecasting in Sri Lanka.

(2) Analyzed Rainfall and Precipitation Nowcast

JMA issues analyzed rainfall calculated from Doppler Radar data, ground rainfall observation and other information to public. Further, precipitation nowcast which is calculated based on the analyzed rainfall is also released to public. If these technics are innovated to Sri Lanka, temporal and spatial resolution of weather forecasting must be improved drastically. In addition, the Landslide Alert Information, Soil Water Index and Basin Rainfall Index are useful index to

improve weather warning in Sri Lanka.

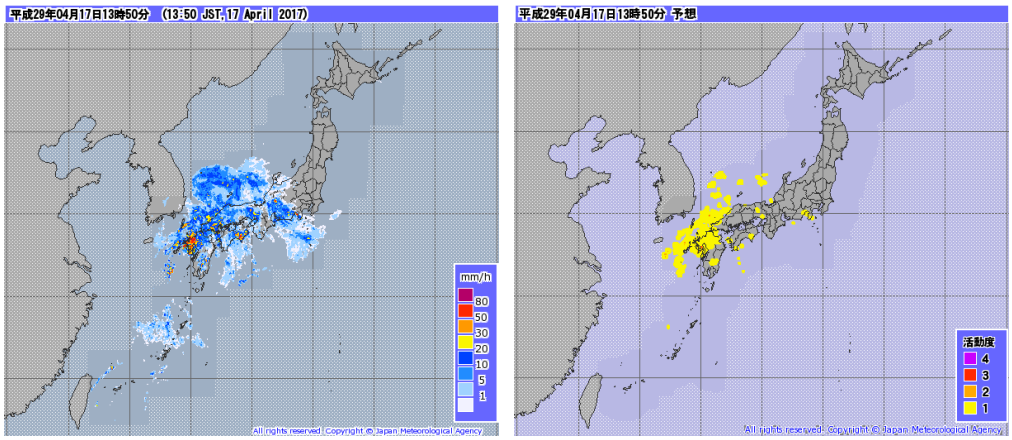


Figure6.1.4 Rainfall Nowcast and Lightning Nowcast
Source: JMA HP http://www.jma.go.jp/jp/radnowc/

(3) SATAID

SATAID which have been installed into NMC server is also helpful tool to improve weather forecasting. SATAID is developed by JMA. Satellite images, NWP, ground observation data and other meteorological data can be overlaid and analyzed on SATAID. If Lightning Detection System data, which is considered to introduce by CRIP2, will be overlaid to Doppler Radar data and Himawari satellite image, detection of rapid raincloud development becomes easy and precise. Combination of SATAID and observation network should contribute to issue effective rainfall/lightning forecasting and warning.

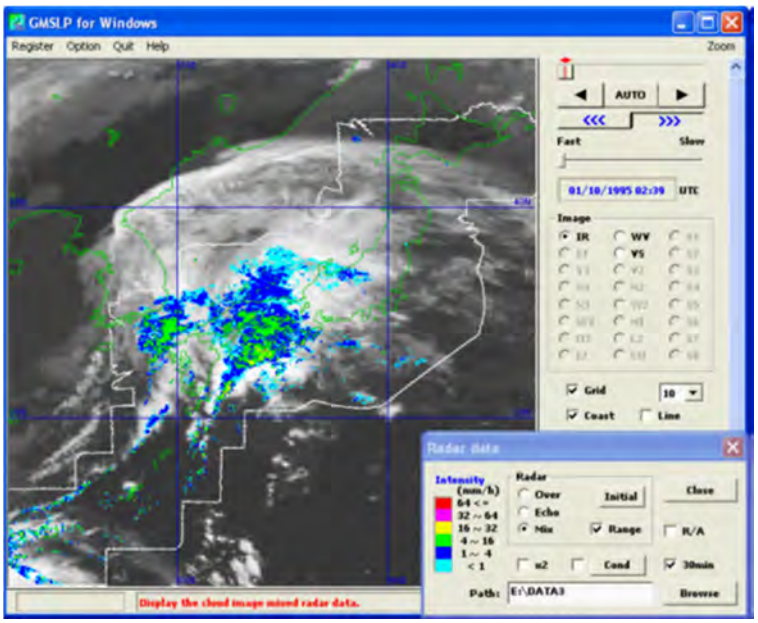


Figure6.1.5 Satellite image and Doppler radar data on STAID
Source: SATAID operation manual

6.2 Direction of Future JICA Supports in Priority Actions

Regarding the "Priority Actions" of the Roadmap for DRR in Chapter 5, the Survey suggests the possible areas of future supports by JICA in consideration of applicability of Japanese technologies and experiences described in the Session 6.1, are summarized as bellow. It is expected that the possible support areas shall be discussed between Governments of Sri Lanka and Japan on its feasibility and concrete content.

6.2.1 Comprehensive Disaster Management

(1) National Disaster Management Plan

National Disaster Management Plan (NDMP) 2013-2017 will be reviewed and updated for the next period of 2018-2022. NDMP is fundamental plan to implement the four (4) Priority Actions and to achieve the Global Targets of Sendai Framework for DRR.

JICA and MDM agreed to dispatch a DRR Advisor for the project titled "Disaster Risk Reduction Advisor for Sri Lank" on January 2017, to strengthen the institutional and operational capacity of MDM and the agencies under its purview. The Advisor shall be dispatched on July 2017.

(2) Local DRR Plan in Basin-based DRR Strategy

Developing local DRR plans which target year is set by 2020 is an urgent task to implement Sendai Framework. In order to promote holistic investment for DRR, the local DRR plans by districts and DS divisions should be based on appropriate risk profiling in consideration of Basin-based DRR Strategy.

Responsibility on river management in Japan is clearly designated according to the importance of the target rivers based on "River Act". Investment in river infrastructures and flood control facilities have been done according to the "Comprehensive Flood Management Plan" that are prepared in each river basin. Moreover, JICA has experiences to support developing Integrated Flood Management Plans in several countries to promote basin-based DRR strategy.

Such Japanese flood risk reduction mechanism and JICA's experiences could be applied to Sri Lanka. JICA would supports to formulate local DRR plans in consideration of comprehensive Basin-based DLL Strategy though the pilot activities in the important river basins. The local DRR plan shall be comprehensive plans that include not only prevention and mitigation but also response and recovery.

(3) Development Policy Loan (DPL) to promote Roadmap for DRR

For promotion and implementation of National Disaster Management Plan 2018-2022 including new SLCDMP and Local DRR Plans based on the Basin DRR Strategy, to secure financing and monitoring structure are crucial issues in Sri Lanka. In order to support this in the long-term, "Development Policy Loan" shall be considered.

The Development Policy Loan (DPL) assists recipient countries seeking to improve policy, institutional reforms and implementation of strategies in the long time spans. The recipient country and JICA shall formulate Policy Matrix based on the policy priorities. The funds shall be disbursed in phases, when the both parties confirm achievements of actions listed in Policy

Matrix. By this loan, the recipient countries are able to promote DRR policy formulation and implementation and to secure stable funds for priority projects in the long term. It also contributes to assure implementation of the projects based on regular monitoring system under both countries.

To apply the Development Policy Loan, it is important to select higher priority projects in DRR and Build Back Better in-line with Sendai Framework and Roadmap for DRR. The selected projects should be referred to the Policy Matrix. When several sub-projects are expected to implement a certain development plan, sector loan scheme to support the sub-projects can also be considered instead of DPI.

6.2.2 Flood Risk Reduction

(1) Basin Investment Plan for Important River Basin

Although the investment plans to mitigate flood and drought will be developed in 10 basins under CRIP, there remain many important river basins where no integrated and updated investment plans have been formulated. Irrigation Department recognizes other 12 important basins in addition to the basins selected by CRIP. It is necessary to prepare basin plans for these basins, in order to promote further investment.

Among the important river basins, Kalu Ganga river basins is the most flood affected basin and one of high potential basins for future water resources development for Western Province. In order to promote investment to mitigate flood and drought in and around the basin, an integrated water resources management (IWRM) plan in Kalu Ganga river basin should be formulated by reviewing existing plans and preparation of flood and water balance modelling, with enhancing involvement of stakeholders in the basin.

(2) Flood Control Advisor for MIWRM

In order to promote formulation and implementation of basin investment plans including CRIP target rivers as well as to support Basin-based DRR Strategy and Local DRR planning, a flood control advisor shall be dispatched to the Ministry of Irrigation and Water Resources Management (MIWRM).

The advisor shall also corporate with the DRR advisor to the Ministry of Disaster Management (MDM) to accelerate efficient collaboration between MDM and MIWRM to promote basin-based DRR.

(3) Master Plan for Storm Water Drainage in Colombo Metropolitan

The flood mitigation measures in Greater Colombo basin have been implemented by Metro Colombo Urban Development Project (MCUDP) supported by World Bank. However, many proposed projects in drainage master plan for Metropolitan Colombo area in the JICA Master Pan in 2003 have not yet been implemented except for Greater Colombo basin and Weras basin (part of Bolgoda basin). Meanwhile, the natural conditions such as rainfall and socio-economic situation and urban development scenario have already changed after the JICA Master Plan. It

is, therefore, necessary to review and renew the Master Plan to reflect such changes. The comprehensive storm water drainage investment plan for Colombo Metropolitan region and surrounding areas should be formulated to promote further investment for flood mitigation measures.

6.2.3 Sediment Disaster Risk Reduction

(1) Comprehensive Landslide Disaster Management

After catastrophic landslide disasters in 2014 and 2016, more investment to prevent landslide disaster becomes urgent task in Sri Lanka. Currently, JICA is supporting "Landslide Disaster Prevention Project (LDPP)" by Yen loan and "Technical Cooperation for Landslide Mitigation Project (TCLMP)" by technical cooperation.

However, since landslide does not repeatedly occur at same location, it is not realistic approach to apply structural measures for all landslide risk area by limited financial resources. In view of cost effectiveness, therefore, JICA's cooperation for landslide mitigation shall be mainly focusing on non-structural measures. For the structural measures the priority shall be given to important facilities, transportation networks such as national road.

As non-structural measures, land regulation to prevent land development and settlement into landslide risk area is primitive but most important. For that purpose, update landslide hazard zonation map and legal arrangement based on consensus among relevant agencies should accelerated under initiative of NBRO, MDM. Additionally, it is also important to strengthen early warning and evacuation system in the high-risk area.

In Japan, Sediment-related Disaster Prevention Law was enforced in 2000. Based on the law, methodology to designate landslide risk area and administrative responsibility of local governments such as establishment of early warning and evacuation system were stipulated. JICA would supports comprehensive landslide disaster management especially targeting NBRO in consideration of application of Japanese technology and experience on legal institution.

(2) Strengthening Important Infrastructures

During disaster, traffic shutdown of important road section causes serious problem in mobilization of rescue team and relief materials. It also makes state economic damage lager. Strong traffic network against landslide disaster is a key objective in DRR.

Government of Japan is supporting RDA as an implementation agency to strengthen road network from landslide disaster in mountainous area under a Yen loan project "Landslide Disaster Prevention Project (LDPP)". Through the project, slope stabilization and landslide prevention works will be done using Japanese technology and experiences for prioritized 16 sites along the Class-A national road. However, there still are many high-risk unstable slopes and road sections out of LDPP target sites along Class-A and Class-B national roads. Moreover, railway system should also be protected from viewpoint of strong transportation network.

Support to prioritize unstable sites in transportation and important public facilities (schools, hospitals) in the country can be considered to facilitate further investment to realize strong traffic network.

6.2.4 Drought Risk Reduction

(1) Formulation of National Strategy on Drought Risk Reduction

Drought in Sri Lank usually brings big economic loss and damages to not only living water supply but also agriculture, hydropower generation and other water related activities. Although NDRSC carries out mainly relief activity, such as drinking water distribution by bowsers and provision of living necessities to drought scarcity communities, drought risk reduction, as one of basic concepts of Sendai Framework, has not been realized yet.

Under this condition, it is urgently required that National Strategy on Drought Risk Reduction be formulated integrating all kind of drought risks. Prior to commencement of strategy planning, a drought risk assessment recommends detailed analysis and evaluation on the past, present and future possible drought impact on the scientific basis. Based on the risk assessment, target areas and sectors for drought risk reduction programmes are prioritized, and each programmes shall be strategically implemented in consistency with Roadmap for DRR.

Drought risk reduction should be implemented under multispectral efforts of water supply, irrigation, power, livestock, environment, etc.. The target areas are extensive from national programme by the central government to basic life security by the local authorities. For the effective and efficient implementation, it is essential to coordinated between relevant stakeholders to formulate effective strategy. Therefore, it is proposed that National Drought Risk Reduction Committee (NDRRC) and Technical Working Grope of Drought Risk Reduction (TWGDRR) consisting of scientists and professional experts shall be newly established under the initiative of MDM and DMC. Close cooperation is also required for implementation of this strategy setting up from policy and technological aspect.

As flood and drought take place repeatedly in Japan as well as in Sri Lanka, Japan's long time experiences and know-how in terms of drought risk reduction might be applicable and contributable to Sri Lankan government from institutional and technical points of views.

(2) Water Securing Programme at Drought Affected Areas

In Sri Lanka, due to recent prolong drought, water shortage in agriculture and domestic use become serious problem, especially in North-western, North-central, Uva and Southern provinces of serious drought affected areas. Specially, small scale communities without piped water supply facilities are depended on drinking and domestic water from dug wells. However, the obtainment of drinking water becomes gradually worse. The people live in the small communities vulnerable to drought should understand that there are few water sources, therefore, they should pay attention to how to use and save water. There are small communities of which dwellers are using water of tanks for domestic and agriculture purposes. In such communities, the damage by deterioration of water quality and impact on agriculture may differs from the communities depending on shallow dug wells.

Considering above mentioned condition, it is recommended that "Water Securing Programme at Drought Affected Area" be formulated aiming at forming "Drought Resilient Society" even in serious drought under the initiatives of central and local Governments.

The programme is composed of following four (4) components. It is implemented at the several pilot DS Divisions under provinces where drought situations are getting severe. According to the activities and target countermeasures, it shall be divided into, projects implemented by District Secretary and DDMCU in cooperation with national authorities, efforts by local administrations as improvement of public services, and community self-responding activities. Each activities should be collaborated to implement the programme. In this programme, many organizations and agencies are complicatedly involved, therefore, it is necessary to make each mission and role clear among the relevant agencies at the planning stage of the programme for smoothly implementation.

- Component-1: Awareness of water use and water saving ay community level
- Component-2: Promotion of Rainwater Use
- Component-3: Repair and improvement of small scale Cascade system
- Component-4: Introduction of environmentally adaptive agriculture (e.g. Water saving irrigation, shift of agricultural production)

At this moment, one of JICA projects "The Project for Formulating Cascade System Development Plan under North Central Province Canal (2016-2018)" is ongoing with objectives of "Social Infrastructure for Vulnerability Reduction". It is possible to make use of outcome of the project for the component 3.

(3) Establishment of Drinking Water Supply System and Preparation of Proper Distribution Plan

In the case that drought is lasting for long time, scarcity of drinking water supply become major problem. In the drought prone areas, piped water, reservoir water, river water and groundwater are identified as available water sources, however, the water level of these water sources are drawing down at the same times as well as shallow dug wells. Considering water sources available in the drinking water scarcity areas, finally, it can be clarified that the stable water resource is deep groundwater existing in the fissure zone of the bed rock formation.

According to the investigation result provided by WRB and NWSDB, it might be possible to develop new ground water sources applying the combination of the latest technology of satellite image interpretation, elect-magnetic and high density 2D-elect-resisitivity explorations. In the areas, there are many abandoned deep wells. If rehabilitation of those wells is conducted in a proper way, some wells can be given to new life as good yield productive tube wells. The deep ground water is characterized by high contents of hardness, iron, and fluorite, however, the distribution of high content of those minerals depend on the location even in the limited areas. It is recommended that preparation of well inventory and geophysical exploration be conducted before the establishment drinking water system.

Considering the above situation, it can be possible to construct a new drinking water supply network for emergency purpose by appropriately combining existing tube wells and new deep tube wells. If this system can be established, the cost of water distribution which had been relied on water bowsers until now can be drastically reduced. This support can provide Japan's latest technology on ground water investigation in hard rock distribution areas, drilling technology of deep well of more than 200m deep, and rehabilitation of abandoned tube wells as a life time expansion.

6.2.5 Hydro-Meteorological Observation and Information Dissemination

(1) Modernization of Meteorological Observation Network and Regime Shift

Modernization of the meteorological observation network (i.e. shift from manual observation to automatic observation) is required in Sri Lanka. The automated observation network is necessary for meteorological services for disaster risk reduction because real-time observation and short-term forecasting are important for disaster response.

Taking into account the background mentioned above, installation of AWS/Doppler Radars and related technical transfer are on-going or planned by JICA. Contributions by these JICA projects are expected for modernization of observation network. Especially, supports for operation/calibration of the Doppler Radars and Quantitative Precipitation Estimation (QPE) are the areas to be focused on, since these supports must promote applications of the instruments installed by JICA to meteorological services for disaster risk reduction. In addition, installation of the lightning detection system, enhancement of upper air observation, ensuring proper maintenance and calibration and establishment of traceability of observation instruments are also important points to strengthen meteorological services.

The modernization of observation network based on a total plan taking into account human and financial resources of DOM enables to save the resources. If DOM can shift the resources utilized for manual observation to AWS/Radar operation and advisory/warning services for central and local agencies relating to disaster risk reduction, more contributions by DOM for disaster risk reduction are expected. Japanese supports for the modernization and regime shift are desirable.

(2) Technical supports for improvement of forecast/warning capacities and information dissemination

The environment regarding the observation network is improving through international supports and efforts of the Sri Lankan Government. Further, improvement of forecast/warning capacities and information dissemination is also required to enhance meteorological services for disaster risk reduction. Improvement of forecast and introducing Precipitation Nowcast by using meteorological data of AWS, Radar and others, quantification of weather forecasting by introducing mesoscale NWP model and using guidance, revision of warning criteria (considering local disaster characteristics and more detailed warning) and improvement of long-term forecast are the major needs for technical supports. In order to provide efficient supports by JICA, it is necessary to provide technical supports and human resource development for utilization of AWS/Radar, which were installed by JICA supports, on forecast and warning services.

For mid-long term target, introduction of warning indices (e.g. soil water index and basin rainfall index) based on the radar observation must effectively contribute to improve meteorological services for disaster risk reduction.

Improvement of forecast/warning dissemination to public and relevant agencies and disaster awareness activities are conducted by the relevant agencies and projects, but it is not enough. Especially, hydro-met observation data sharing among technical agencies (e.g. DOM, ID and

NBRO) and DRR agencies (e.g. DMC, local authorities and forces) is not enough for smooth disaster response. Thus, support to improve data sharing is important.

Human capacity development and research in cooperation with DRR agencies and research institutes in Japan are the key to improve observation, forecasting/warning and information dissemination. Human capacity development for utilizing radar observation data based on Japanese DRR knowledge is a vital activity.

Appendix 1

Issues and Solutions in DRR Agencies

Image of Action Plans – Comprehensive DRR

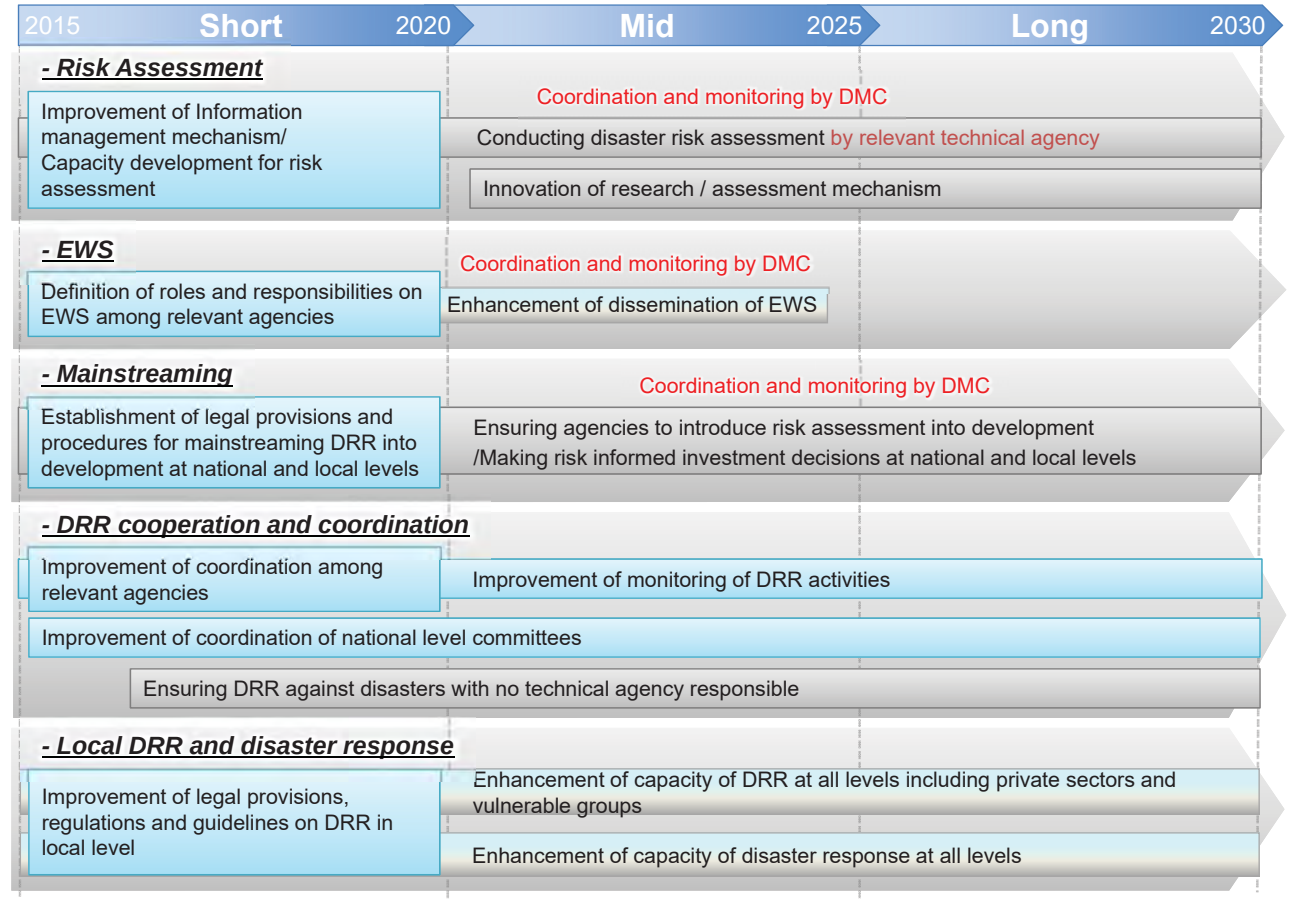
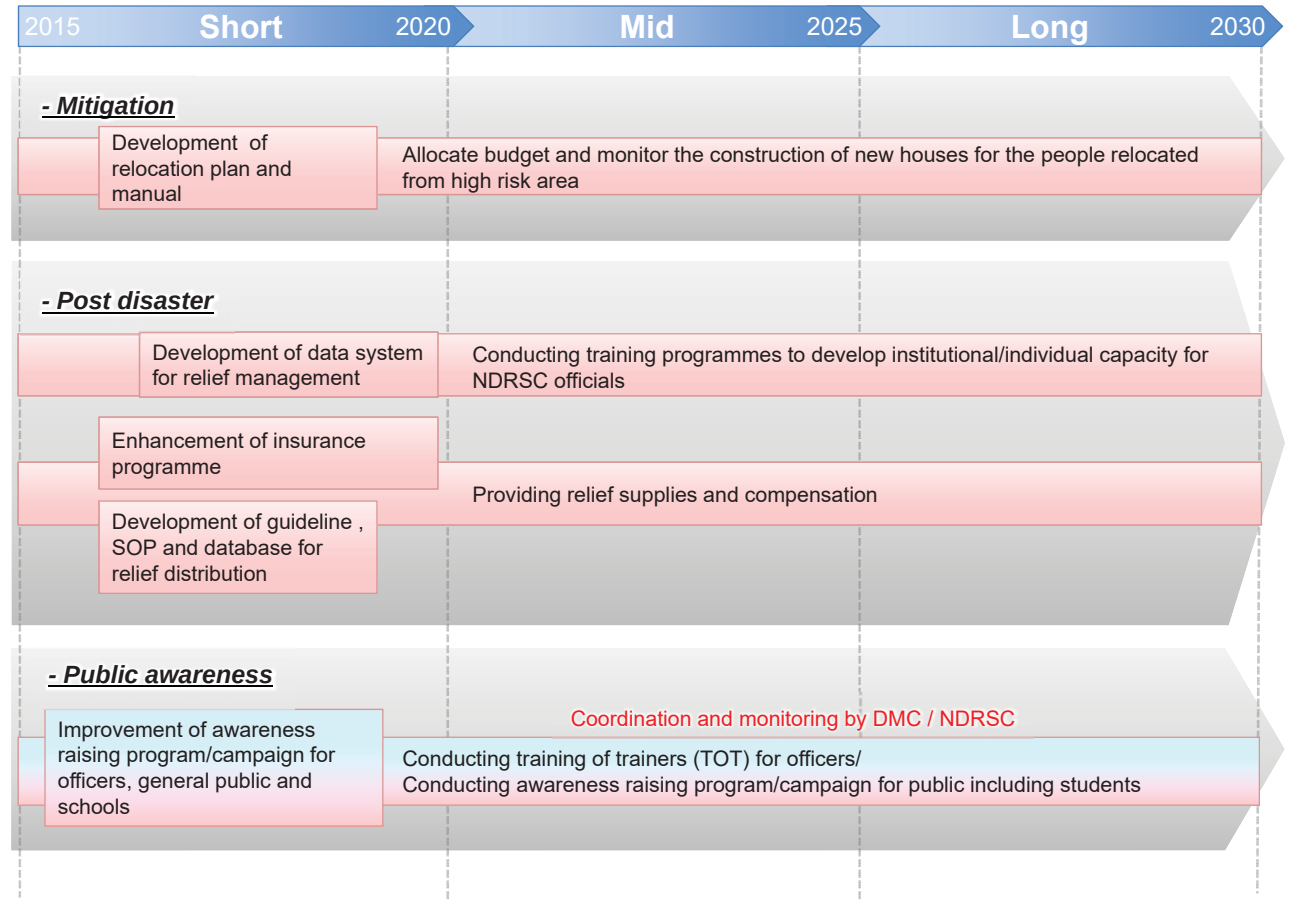


Image of Action Plans – Comprehensive DRR



Direction / Actions of DMC 2016-2030 <DRAFT for Discussion>

in line with SFDRR, Sri Lanka Comprehensive Disaster Risk Management Program(SLCDMP) and National Action Plan

	Direction / Actions on Disaster Management	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Remarks
	1- To assess disaster risk and prepare disaster risk profiles including maps at national level and high risk major urban centers (PA1)																		Mitigation, Research & Development Division, Preparedness Planning Division
1.1	Improvement of Information Management Mechanism and Capacity Development for Disaster Risk Assessment																		
	Building capacity of the Disaster Management Centre (DMC) to conduct risk assessments and to assist other agencies to conduct risk assessments																		
	Strengthen data collection mechanisms to ensure all required data collected from local level																		
1.2	Conducting Disaster Risk Assessment																		
	Conducting risk assessments for key hazards (Drought, Flood, Landslide, Tsunami, Storm surge)																		
	Preparation of disaster risk profiles at national level to capture the elements at risk and assess damage to capital assets and economic losses																		
	Preparation of detailed risk profiles are available for high risk major urban centers prone to floods and landslides																		
	Preparation of hazard maps for selected hazard prone local authority areas																		
	Preparation of vulnerability and risk maps based on the hazard maps of flood, landslide, cyclone, coastal hazards, drought																		
1.3	Innovation of Research / Assessment Mechanism																		
	Promote innovations on disaster risk assessment with institutes and universities																		
	Development / Improvement of DRM information system including web database																		
	2-To enhance mechanisms to disseminate EW messages (PA4)																		Emergency Operations & Early Warning Dissemination Division
2.1	Definition of roles and responsibilities of different stakeholders in EWS																		
2.2	Enhancement of dissemination of EWS																		
2.3	Conducting full scale study based on the risk profiles and improvement of the EWS based on the results of the study																		
	3- To accelerate mainstreaming of DRR (PA2, PA3, PA4)																		Mitigation, Research & Development Division, Preparedness Planning
3.1	Establishment of legal provisions and procedures mainstreaming of DRR into the development process																		
3.2	Ensuring national agencies use risk assessment in development planning and making risk informed investment decisions																		
3.3	Establishment of legal provisions and community capacity for the preparation of GN level development plans incorporating																		
3.4	Incorporating disaster risk reduction into development planning in all levels																		
	4-To strengthen cooperation and coordination framework on DRR among relevant agencies including development/update of policy and legal provision (PA2, PA3, PA4)																		Mitigation, Research & Development Division, Preparedness Planning Division
4.1	Improvement of Coordination among relevant agencies																		
	Development of Research Policy and strategy for DRR and CCA research																		
	Development of data sharing policy and mechanism for disaster and environmental data (including risk profiles)																		
	Improvement and strengthening of the coordination among agencies in post disaster response and recovery with building back better concept																		
	Conducting a donor forum to build the awareness of the donor agencies and development partners to implement DRR activities																		
	Review and strengthening of procedures on obtaining international cooperation during emergencies																		
4.2	Improvement of arrangement of National level committees																		
	Continuous strengthening of National DM Coordination Committee (NDMCC)																		
4.3	Improvement of monitoring of DRR activities																		
	Development / Strengthening of the monitoring and evaluation system for DM related Programmes / Plans to monitor the progress of the implementation																		
	Review and strengthening of comprehensive Monitoring and evaluation system to monitor the disaster risk sensitive investment																		

Direction / Actions of DMC 2016-2030 <DRAFT for Discussion>

in line with SFDRR, Sri Lanka Comprehensive Disaster Risk Management Program(SLCDMP) and National Action Plan

	Direction / Actions on Disaster Management	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Remarks
4.4	Improvement of Drought risk reduction																		
	Development and implementation of drought risk reduction strategy and plan with the support of all relevant stakeholders and technical agencies																		
5- To enhance the DRR and disaster response capacity of District, DS Division and GN Levels and private sectors including Planning (PA2, PA3, PA4)																			Preparedness Planning Division, Emergency Operations Centre
5.1	Improvement of legal provisions, regulations and guidelines on DRR in local level																		
	Strengthening of legal framework for disaster risk reduction at local level (including developing By-Laws for Local Authority and allocating budget for disaster risk reduction)																		
5.2	Enhancement of capacity of Disaster Risk Reduction in all levels including private sectors and vulnerable groups																		
	Enhancement of Institutional capacity for developing human resources for DRM																		
	Preparation of disaster Management Plans for National and Sub-national level state sector organisations in high and moderate risk areas developed and in operation																		
	Mitigation of flood impacts in selected Urban Local Authorities																		
	Development of resilient village concept																		
	Integration of concept of resilience to multiple disaster into village development programmes																		
	Strengthening of human and other resources for disaster risk management at provincial, district and divisional levels including vulnerable groups and students																		
	Establishment of a strategy to develop, implement and monitor school safety plans and incorporate such strategy to the national framework on school safety																		
	Preparation of Service Continuity Plans for key sectors such as electricity and supply chain																		
	Preparation of Business Continuity Plans for key SME sectors																		
5.3	Enhancement of capacity of Disaster Response in all levels																		
	Improvement of the National EOC at DMC and EOCs at sub-national levels																		
	Deployment of well capacitated Search and Rescue (SAR) teams and Rapid Response Teams and further enhancement of their capacities																		
	Strengthening & Capacity Building of Local Authorities for Emergency Response																		
	Strengthening and sensitization of CBOs and village groups for disaster preparedness and response plus steps of building back better																		
5.4	Enhancement of capacity of Post Disaster Activities in all levels including Post Disaster Needs Assessment (PDNA)																		
	Development of a mechanism to collect disaster damage and loss data and formulate Post Disaster Needs Assessment (PDNA) based on sectoral needs																		
	Establishment of a mechanism to ensure timely and immediate recovery of essential services and livlihoods with building back better concept																		
5.5	Improvement of insurance scheme for better rehabilitation																		
	Develop and implement an insurance scheme to cover lives and properties (focusing on houses, small businesses) (i.e. through National Insurance Trust Fund)																		
	Development and Implementation of Micro Finance Schemes																		
6-To improve public awareness on DRR (PA1, PA2, PA3, PA4)																			Awareness Division, Preparedness Planning Division
6.1	Development/Improvement of awareness raising program/campaign for public including students																		
6.2	Conducting awareness raising program/campaign for public including students																		
6.3	Development/Improvement of specific awareness raising program for government staff of relevant agencies																		
6.4	Incorporate disaster risk reduction into curricular of schools, training institutes and universities																		

Direction/ Actions of NDRSC 2016-2030 (Ver. 4)

(in line with the Priority Actions (PA) of SFDRR, National Action Plan (MoDM) and SLCDMP)

Direction / Actions on Relief Services	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Remarks
To enhance relief management capacity (PA1)																
Develop a database for relief management (SLCDMP 1.9)																JICA TCP
Carry out training programmes for officers at divisional level (SLCDMP 3.7)																JICA TCP
To enhance institutional capacity for relief services (PA2)																
Legislation of Amended Disaster Management (DM) Act																submitted to cabinet
Formulate legal and institutional framework and comprehensive strategic plan																by MoDM
Strengthen institutional capacity under above-mentioned actions																JICA TCP
To conduct awareness raising activities for relief services (PA2)																
Enlighten communities and public officers to face post-disaster situations																
Conduct training of trainers (TOT) and awareness programmes for officers engaged in post-disaster services including camp management																
To invest for resettlement from high risk area (PA3)																
Develop relocation plan and manual																
Allocate budget and monitor the construction of new houses for the people relocated from high risk area																
To develop and implement insurance scheme (PA3)																
Establish National Natural Disaster Insurance Policy Programme (NNDIPP)																from April 1, 2016
Enhance insurance program																JICA TCP
Build a capacity of officers at divisional level to assess loss and damage for post disaster needs assessment (PDNA)																JICA TCP
Analyze the housing assistance provided and identify households receiving financial assistance due to floods (SLCDMP 3.4)																
Develop guideline and database for providing compensation based on the budget circular and NNDIPP (SLCDMP 3.4)																
Provide relief supplies																
Grant compensation for death, houses, small and medium scale enterprises																
To operate relief mechanism at natural disaster (PA4)																
Equip the welfare centers prior to disasters with required cooking utensils and equipment (SLCDMP 3.7)																
Develop SOPs for management of relief distribution (SLCDMP 3.7)																
Provide relief supplies																
Update community based relief service preparatory and response plan																
Prepare disaster incident report and provision it to required parties																
Provide relief for rehabilitation of houses damaged by disasters not covered from insurance scheme																
Allocate budget and monitor the construction of new houses to replace damaged houses																
To distribute foreign relief donations among the deserved beneficiaries (PA4)																
Receive, store and distribute foreign relief donations																
To enhance technical capacity for relief services (PA4)																
Develop a data system to standardize receipt and distribution of foreign and local aid (SLCDMP 1.9)																JICA TCP
Build a capacity of officers at divisional level for GIS for incident reporting and relief management (SLCDMP 3.7)																JICA TCP

Objective & Strategy – Flood/Drought Management

Objectives
1- Damage and loss by urban flood in critical urban areas are reduced
2- Flood and drought hazard in important river basins are mitigated
3- Well-coordinated flood and drought operation including EWS is established

Strategies	Related Priority Action in Sendai Framework	Main Responsible Agencies
1- To prepare detailed flood and drought risk information	PA1	ID, SD, DMC, DOA, DAD, NWSDB, SLLRDC, LAs
2- To enhance legal and institutional arrangement on flood mitigation	PA2	MIWRM, ID, SLLRDC
3- To promote basin investment with IWRM concept	PA3	ID, NPC
4- To promote investment in storm water drainage improvement	PA3	SLLRDC, LAs
5- To ensure "Well managed urban development " considering flood disaster risk	PA3	MMWD, UDA, NBRO
6- To strengthen flood and drought operation	PA4	ID, DOM, DAD,MASL, CEB, NWSDB, NPC, DMC, MMWD, SLLRDC

Image of Action Plans – Flood/Drought Management

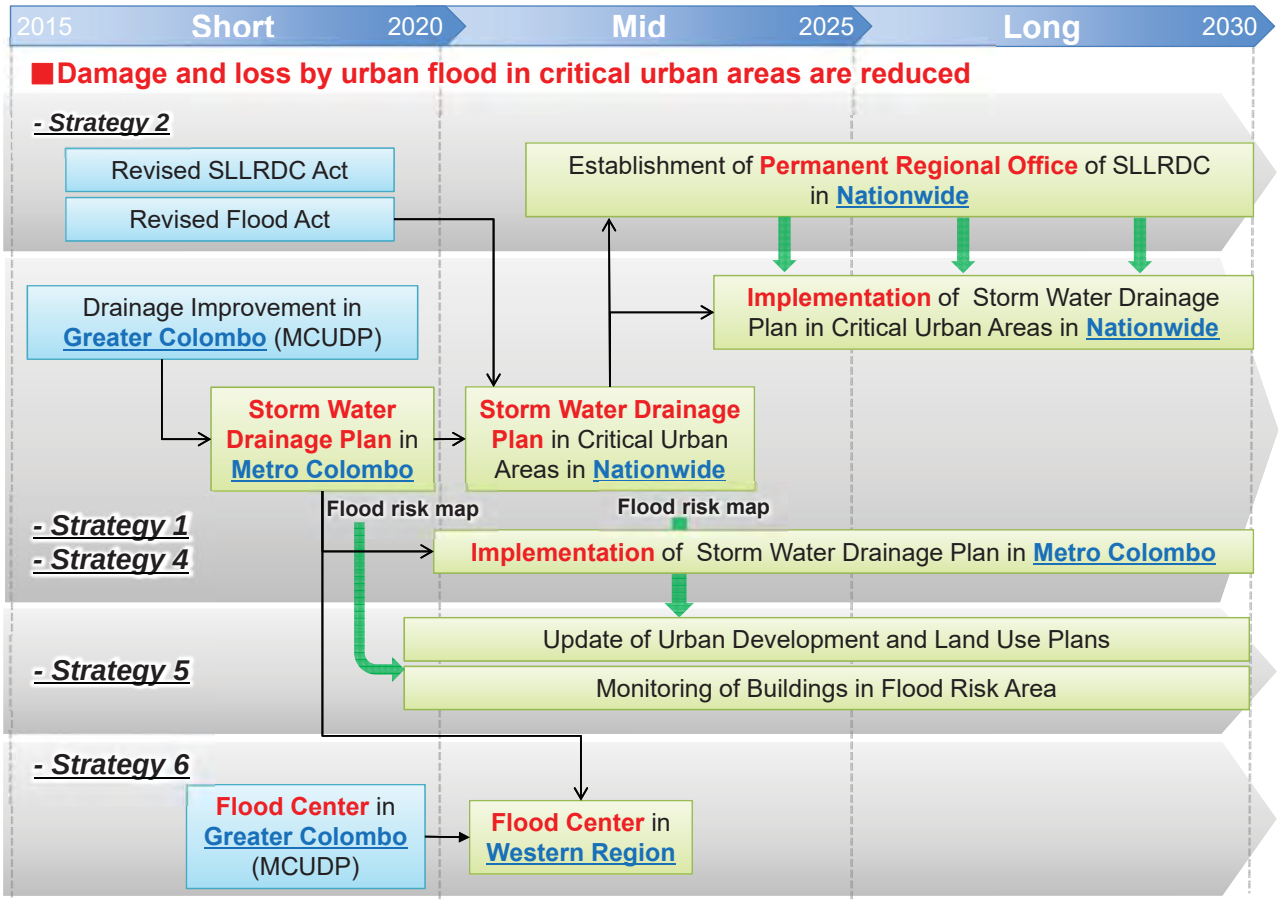


Image of Action Plans – Flood/Drought Management

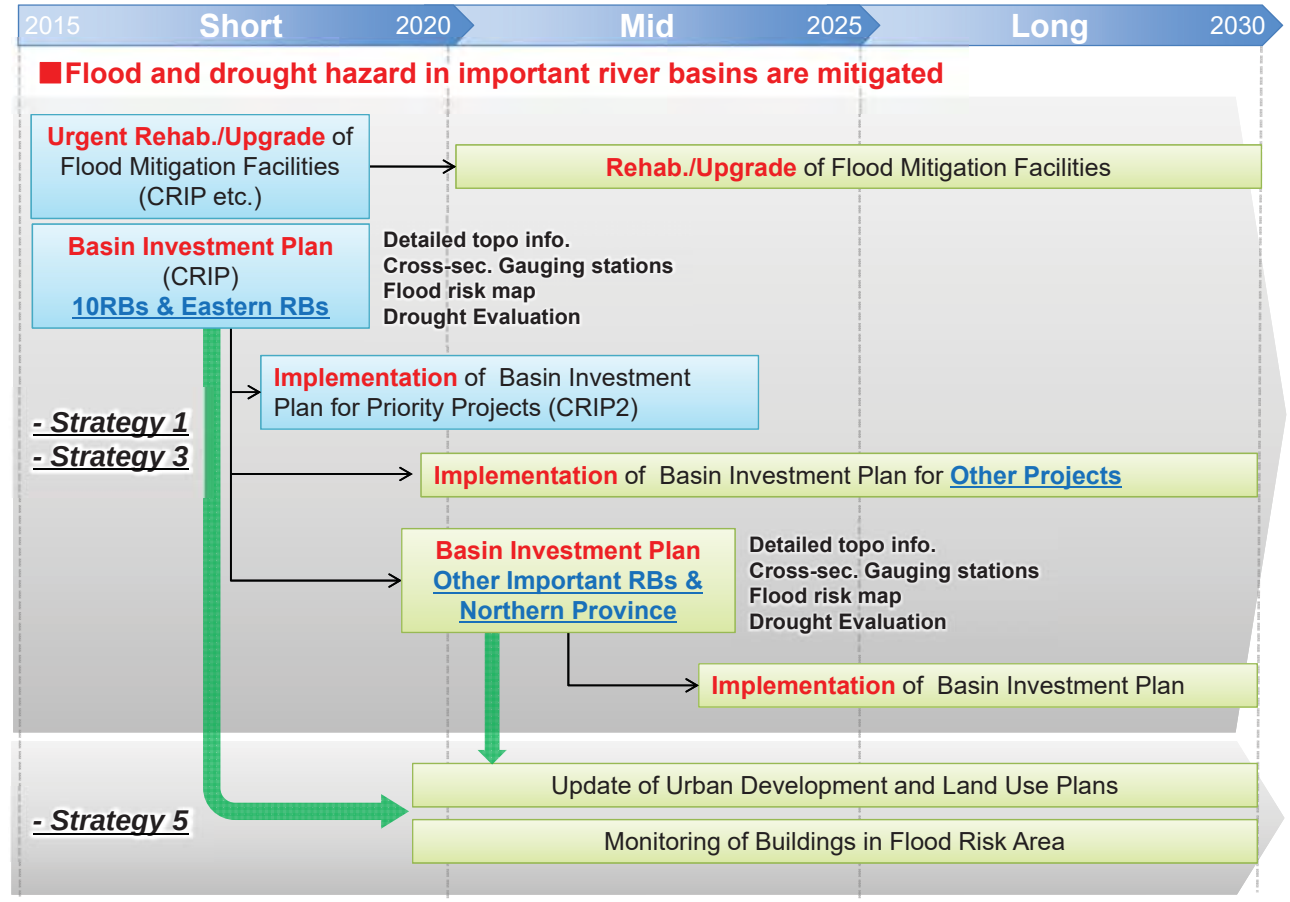
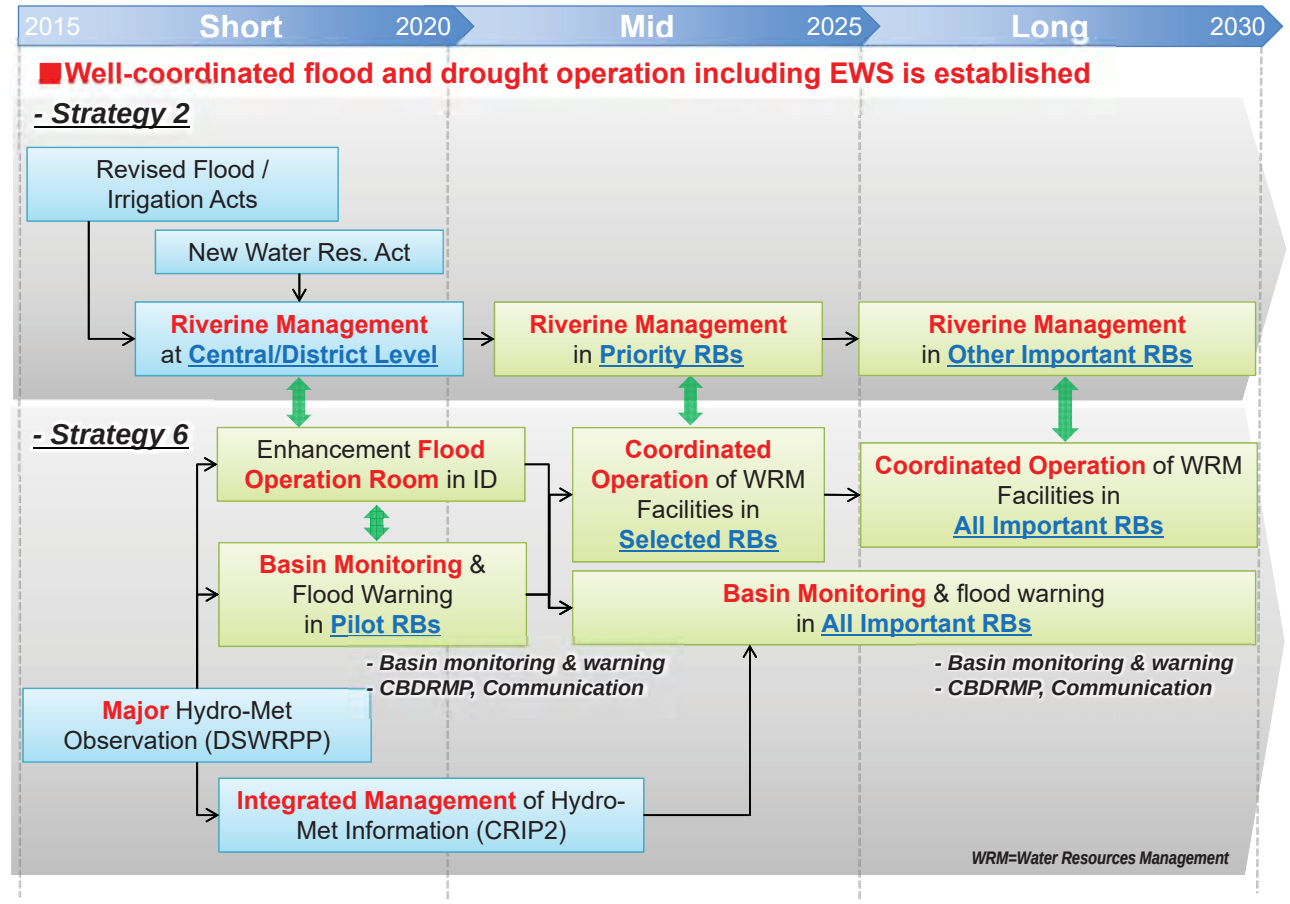


Image of Action Plans – Flood/Drought Management



		Strategies / Actions on Flood Management	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Remarks
1. To prepare detailed flood and drought risk information (PA1)																		
	1-1-1	Updating topographic map using LiDAR data in priority area																JICA-LiDAR Project
	1-1-2	Further processing of LiDAR data taken by JICA project																Follow-up of JICA -LiDAR Project
	1-1-3	Updating topographic maps in priority river basins																WB-CRIP LiDAR for 10 river basins
	1-1-4	Updating topographic maps in other important river basins and Northern Province																*together with Basin Investment Plans*
	1-2-1	Updating river cross-section and establishment of new gauging stations with rating curves in priority river basins																*together with Basin Investment Plans*
	1-2-2	Updating river cross-section and establishment of new guaging stations with rating curves in other important river basins and Northern Province																*together with Basin Investment Plans*
	1-2-3	Regular update of rating curve																
	1-3-1	Preparation of detailed flood hazard and risk map in priority river basins																WB-CRIP (10RBs) & WB (Eastern Basin)
	1-3-2	Preparation of detailed flood hazard and risk map in other important river basins and Northern Province																*together with Basin Investment Plans*
	1-4-1	Preparation of detailed flood hazard and risk map in priority urban areas																*in coordination with ID and SLLRDC*
	1-5-1	Evaluation of drought risk in terms of water balance in priority river basins																WB-CRIP (10RBs)
	1-5-2	Evaluation of drought risk in terms of water balance in other important river basins and Northern Province																*together with Basin Investment Plans*
	1-6-1	Updating risk profile based on the detailed flood and drought risk information																
2. To enhance legal and institutional arrangement on flood mitigation (PA2)																		
	2-1-1	Preparation of proposal of revised flood / irrigation acts																
	2-1-2	Enactment of revised flood / irigation acts																
	2-2-1	Preparation of water resources development, conservation and management act																
	2-2-2	Enactment of water resources development, conservation and management act																
	2-3-1	Establishment of riverine management division in MIWRM																
	2-3-2	Establishment of riverine management framework at district level																
	2-3-3	Enhancemnet of coordination frameworks for riverine management for priority basins																
	2-3-4	Enhancement of coordination frameworks for riverine management for other important basins																
	2-3-1	Preparation of proposal of revised SLLRDC act																
	2-3-2	Enactment of revised SLLRDC act																
	2-4-1	Establishment of permanent regional offices of SLLRDC outside Western Region																

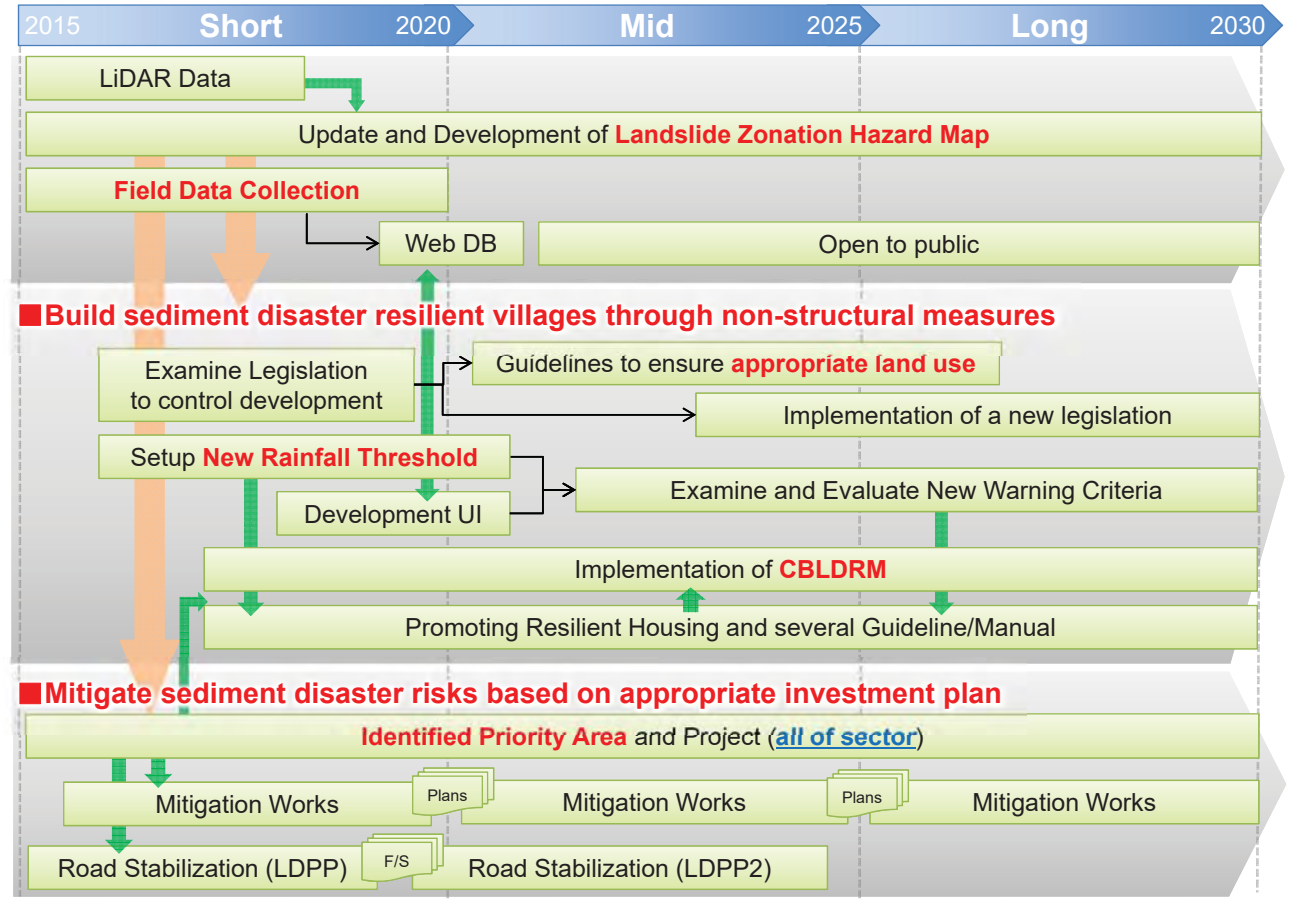
3. To promote basin investment with IWRM concept (PA3)			
	3-1-1	Preparation of basin investment plans for priority river basins	WB-CRIP (10RBs) & WB (Eastern Basin)
	3-1-2	Preparation of basin investment plans for other river important basins and Northern Province	12RBs identified by ID and RBs in Northern Province
	3-2-1	Urgent rehabilitation and upgrade of aged main flood mitigation facilities	WB-CRIP, Kelani, Gin
	3-2-2	Rehabilitation and upgrade of aged main flood mitigation facilities	
	3-3-1	Implementation of priority projects in priority river basins	WB-CRIP2(4basins) & AFD for Mundeni Aru
	3-3-2	Implementation of other projects in priority river basins	WB-CRIP (10RBs)
	3-3-3	Implementation of projects in other important river basins and Northern Province	12RBs identified by ID and RBs in Northern Province
4. To promote investment in storm water drainage improvement (PA3)			
	4-1-1	Preparation of storm water drainage investment plan for Metro Colombo Region and Surrounding Area	
	4-1-2	Preparation of storm water drainage investment plan for critical urban areas in nationwide	
	4-2-1	Implementation of storm water drainage improvement in Metro Colombo Region (ongoing)	WB-MCUDP & others
	4-2-2	Implementation of storm water drainage improvement in Metro Colombo Region (others)	
	4-2-3	Implementation of storm water drainage improvement in critical urban areas in nationwide	
5. To ensure "Well managed urban development " considering flood disaster risk (PA3)			
	5-1-1	Update of urban development and land use plans in accordance with the formulated basin investment plans and drainage investment plans	
	5-2-1	Preparation of database for buildings in flood risk area in priority river basins and critical urban areas	
	5-2-2	Preparation of database for buildings in flood risk area in other important river basins and Northern Province	
	5-2-3	Monitoring of buildings in flood risk area using the database for buildings in flood risk area	
6. To strengthen flood and drought operation (PA4)			
	6-1-1	Improvement of major hydro-met observation system	WB DSWRPP
	6-1-2	Improvement of integrated management of hydro-met information	WB-CRIP2
	6-1-3	Maintenance and replacement of hydro-met observation equipment	
	6-2-1	Enhancement of flood operation room of Irrigation Department	
	6-3-1	Enhancement of basin monitoring and flood warning system in pilot river basins	
	6-3-2	Establishment of basin monitoring and flood warning system in all important river basins	
	6-4-1	Enhancemnet of coordinated operation of river management facilities such as tanks and gates in selected river basins	
	6-4-2	Enhancement of coordinated operation of river management facilities such as tanks and gates in all important river basins	
	6-5-1	Promotion of CBDRMPs to selected river basins	
	6-5-2	Promotion of CBDRMPs to the all flood prone areas	
	6-6-1	Establishment of flood control and water management center in Greater Colombo Basin	WB-MCUDP
	6-6-2	Expansion of the flood control and water management center for Western Region	

SD: Survey Department, ID: Irrigation Department, NPC: Northern Provincila Council, DMC: Disaster Management Center, SLLRDC:Sri Lanka Land Reclamation and Development Corporation, NWSDB: National Water Supply and Drainage B

DAD: Department of Agrarian Development, MIWRM: Ministry of Irrigation and Water Resources Management, MMWD: Ministry of Metroporis and Westren Development, UDA: Urban Development Authority, NBRO: National Building Resear

Completed On-going / planned Proposed

Image of Action Plans - Landslide Management

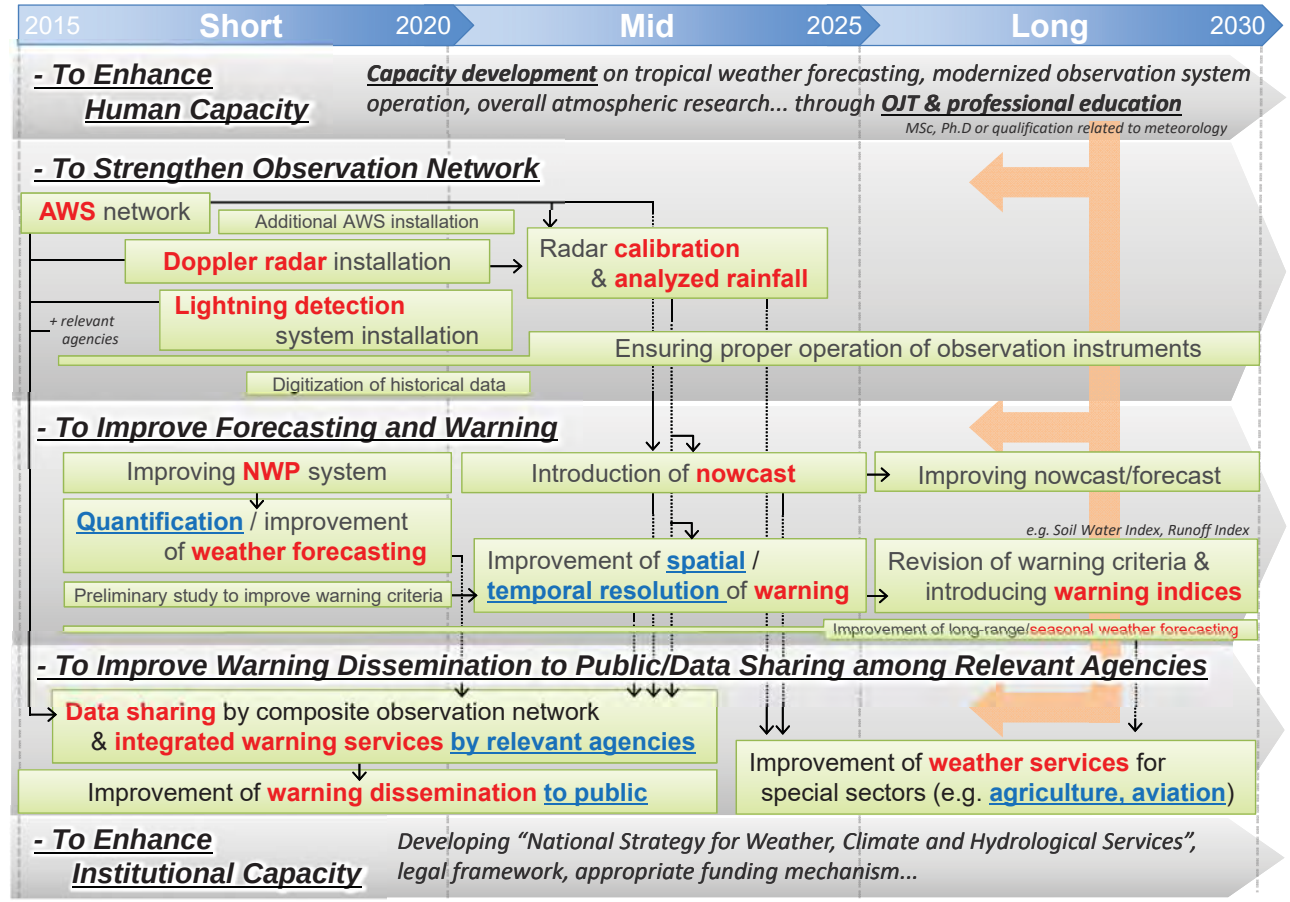


Direction / Actions on Landslide Management	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Remarks
To develop and update landslide hazard zonation maps (PA1)																
Prepare detailed base maps in landslide prone area (ex: LiDAR survey)																Survey Department implemented
																Survey Department (Phase-2 project)
Update existing 10,000 landslide hazard zonation maps using detailed base map																
Preparation of more detail maps (1:5000) specially in town centers and newly developing areas.																LRRMD
Prepared guideline to ensure appropriate land use planning based on the hazard maps.																preparing guidelines
																implementation in Local Authority
Development of community level maps and integrated with the present landslide hazard zonation																LRRMD
Distribution of hazard zonation map among relevant planning agencies																HSPTD
Setup web-based database system for landslide hazard zonation maps and update prepared hazard maps																10 district up to 2020
																will be updating
To strengthen legal framework and institutional capacity for landslide risk reduction (PA2)																
NBRI Act is taken effect																submitted to cabinet
Formulate Landslide Risk Management Plan (2017-2021) and implemented																under preparation
Revise and implement Landslide Risk Management Plan into 2022-2025																
Revise and implement Landslide Risk Management Plan into 2026-2030																
Strengthen institutional capacity under Landslide Risk Management Plan																
Development of Landslide Policy																HSPTD
Prepare legislation on control development in landslide prone area																
Implement a new legislation																
Introduce legal framework for safer construction and developments better land use practices.																LRRMD
Development of institutional linkage																HSPTD
To formulate priority projects based on the risk assessment (PA3)																
Identify mitigation projects and formulate investment plans (NBRO) for all type of vulnerable areas for landslide																
																Identified priority project
-Identify priority projects for national roads (RDA)																LDPP is on-going
-Identify priority projects for national railway lines and provincial roads																primary survey was conducted by NBRO
Establishment of Disaster Resilient City Rating System																HSPTD
Development of Disaster Resilient City Guide Plan for high/medium risk																HSPTD

Direction / Actions on Landslide Management	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Remarks
To implement priority projects especially for priority area and infrastructure (PA3)																
Implement priority mitigation projects (NBRO)	■	■	■													on going (by GoSL, TCLMP, LDPP and etc.)
				▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	several project conducted by NBRO and other agencies
Implement priority projects for national roads (RDA)	■	■	■													LDPP is on-going (16 sites)
				□	□	□	□	□								LDPP-2 implement based on F/S result
Implement priority projects for national railway lines and provincial roads			□	□	□	□	□	□								LRRMD
To strengthen rainfall observation networks and optimize warning criteria (PA4)																
Install rainfall observation stations (Increase the present distribution and the density of automated rain gauges to cover up all landslide prone areas)	■	■	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	160 stations were installed
Examine working rainfall applying to the current observation system	■	■	■	■	■											on going
Update user interface for rainfall observation system				▩	▩	▩										
Evaluate warning criteria						□	□	□	□	□	□	□	□	□	□	evaluate based on actual
Examine employing soil water index with other research agencies											□	□	□	□	□	Collaboration with Met Department
Develop new warning mechanism in cooperation with other agencies						□	□	□								
To strengthen local resilience under concept of Disaster Resilient Village (PA4)																
Formulate implementation programme for CBLDRM		▩	▩													
Conduct CBLDRM programme in collaboration with DDMC			□	□	□	□	□	□	□	□	□	□	□	□	□	based on LRMP 2017-2021
																based on LRMP 2022-2025
																based on LRMP 2026-2030
Promote Hazard Resilient Housing Construction Manual	■	■	■													
Prepare guideline for disaster resilient housing concept and conduct promotion campaign for the implement		▩	▩													preparing guidelines
				▩	▩	▩	▩	▩	▩	▩	▩					implementation
Awareness and training for the vulnerable communities in a understanding manner for decision making	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	
Determination of the suitability of disaster resilient construction	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	BMTD
To enhance technical capacity and R&D for landslide mitigation (Cross-cutting)																
Effect science technology exchange agreement with international institutes			□	□												
Develop new warning mechanism in cooperation with other agencies						□	□	□								
Strengthen laboratory testing capacities for materials quality control in landslide mitigation works	▩	▩	▩	▩	▩	▩										
Preparation of materials handbook for disaster resilient housing, mitigation and reconstruction works for different climatic zones	▩	▩	▩	▩	▩	▩	▩	▩	▩	▩						
Cost effective construction materials/methods and reconstruction	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	
Introduce of practical researches for landslide management and cost effective construction materials/method with collaboration with the local institutes, universities and international research agencies.	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	LRRMD and BMTD

■ on-going ▩ planned ▨ proposed □

Image of Action Plans - Weather Forecasting



Direction / Actions on Weather Forecasting and Warning	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Remarks
To strengthen observation network (PA4)																
Enhancement of weather observation system focusing on nowcasting for disasterous weathers																
Capacity development on proper operation of modernized observation system																CRIP2, JICA,...
Establishment of stable AWS data communication																JICA project
Updating AWS network including replacement of manual weather station																including replacement of mercury thermometer, CRI
Installation of Doppler radars																JICA project
Installation of lightning detection system																CRIP2
Developing a composite network on meteorological and hydrological observation																DOM, ID, NBRO... (specialized agencies) + DMC... (
Calibration of Doppler radars with AWS and provision of analyzed rainfall data																JICA+DOM
Ensuring proper operation of rainfall and other observation instruments																DOM, ID, NBRO... (specialized agencies)
Digitization of historical weather data and enhancement of data management system																CRIP & CRIP2
To improve forecasting and warning (PA4)																
Providing nowcast and improving forecast for disastrous weathers																
Capacity development on tropical weather forecasting																JICA, CRIP2,...
Improving NWP system and introducing short-range forecasting and verification methods																Including access to ECMWF, CRIP2
Quantification and improvement of weather forecasting																CRIP2
Introduction of nowcasting by utilizing automated observation system (Doppler radars, AWS and others)																
Improving nowcast/forecast based on accumulated Doppler radar/AWS data																
Building seasonal forecasting capacity and improvement of long-range weather forecasting																SLCDMP/RIMES/JMA/IRI/IMD/WMO/GCF
Developing climate change scenarios for 2050 and 2100																RIMES
Introducing new warning indices (ex. Soil Water Index) for earlier and higher spatial/temporal resolution warning																
Capacity development on early warning for disastrous weathers																JICA, CRIP2,...
Preliminary study to improve warning criteria and development of impact-based warning system																CRIP2
Improvement of spatial/temporal resolution of warning based on Doppler radar products																
Revision of warning criteria and introducing warning indices (e.g. Soil Water Index, Runoff Index)																
To improve dissemination of weather nowcast/forecast/warning to relevant agencies and public (PA4)																
Providing nowcast to public and disseminating early warnings for disastrous weathers																
Development of data sharing and communication system among relevant agencies																DOM, ID, NBRO... (specialized agencies) + DMC... (
Developing and implementing integrated nowcast/forecast/warning services by relevant agencies																DOM, ID, NBRO... (specialized agencies) + DMC... (
Improvement of nowcast/forecast/warning dissemination to public through media unit, web and others																JICA, CRIP2
Improvement of weather services for special sectors (e.g. agriculture, aviation) by utilizing																CRIP2
To enhance institutional capacity (PA2)																
Develop and update National Strategy for Weather,Climate and Hydrological Services																1st (CRIP2) 2nd phase 3rd phase
Review/re-formulation of legal framework related to the weather services																
Preparation of appropriate funding mechanism to operate/maintain systems for weather observation and nowcast/forecast/warning																DOM, Ministry of Finance (Teasury)
To enhance technical capacity for weather forecasting (Cross-cutting)																
Capacity development through professional education in graduate school or research institution																WMO, KOICA,...
Enhancement of overall atmospheric research capacity																

Appendix 2

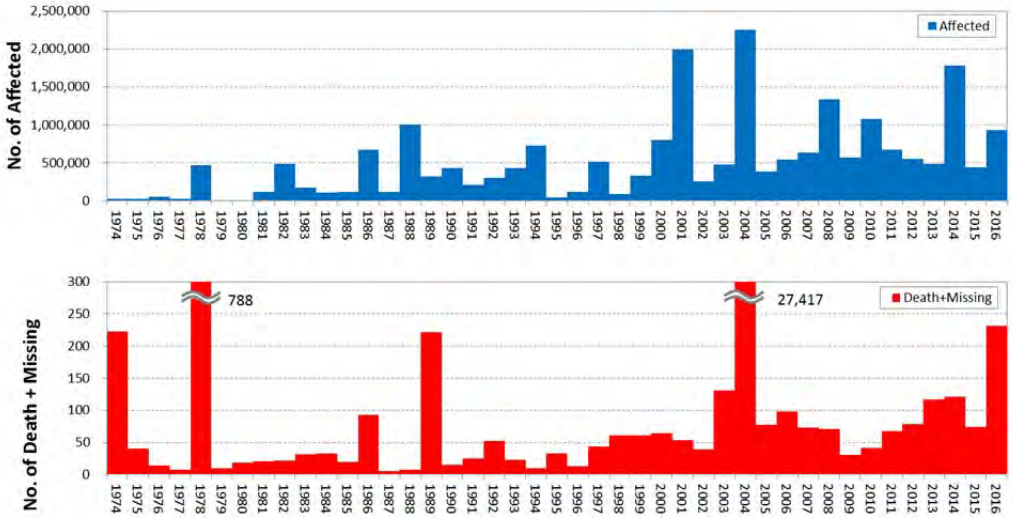
Roadmap for DRR
- Safe and Resilient -

Roadmap for DRR
~ Safe and Resilient Sri Lanka ~

Disaster Risk in Sri Lanka

Disaster victims are increasing in recent years

After the tsunami attack by the Sumatra Earthquake in 2004, the Government of Sri Lanka (GoSL) has been strengthening Disaster Risk Reduction (DRR) institutions in national and local levels under enforcement of Disaster Management Act (2005). However, the number of disaster affected people and death/missing seem to be increasing because of global climate change and population growth.

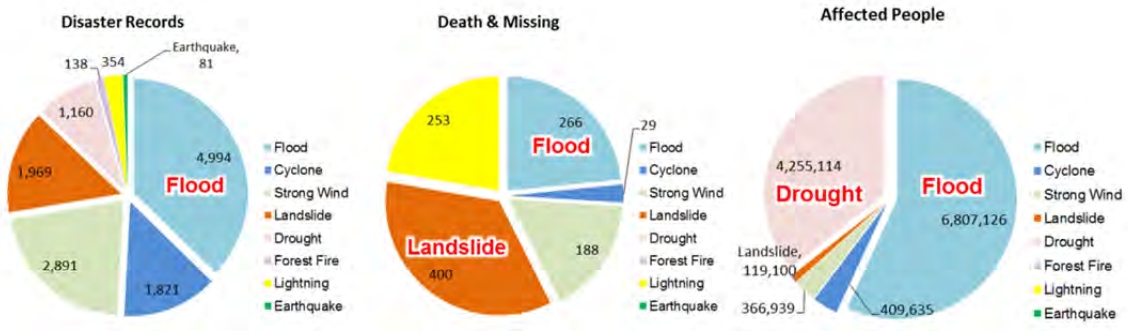


Source: DesInventar (1974-2015)

Flood, landslide and drought are the main disaster in Sri Lanka

"Flood" is the most frequent disaster in Sri Lanka in recent decades. It brings damages in vast geographical areas, accounting for high percentages in death/missing and affected people. On the other hand, "Landslide" causes a large number of death/missing despite its relatively limited geographical effects, as observed upon the disasters in 2014 and 2016. "Drought" also accounts for high percentages in affected people following "Flood".

These 3 types of disaster are critical in Sri Lanka.

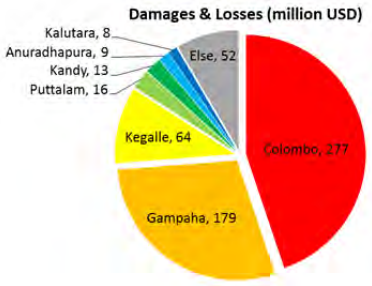


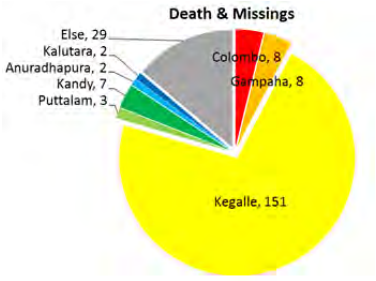
Source: DesInventar (2007-2016)

Economic damage by flood / human damage by landslide

According to Post Disaster Needs Assessment (PDNA) for May 2016 disaster, the total damage and losses by the disaster was estimated at US$ 689 million (0.8% of GDP). 74% of the total damage and losses were from Colombo and Gampaha districts where the damages are mainly caused by “Flood”.

Total number of death/missing people in May 2016 disaster was 210. Of them, 151 people (70% of total) were due to “Landslide” in Kegalle district.

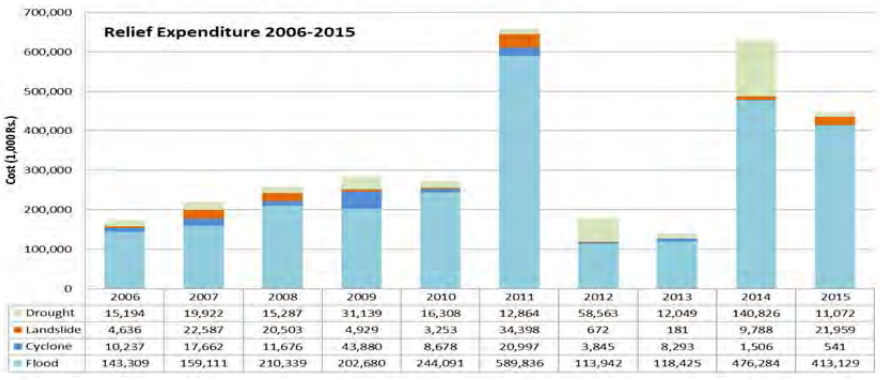




Source: PDNA

80% of relief expenditure has been made against flood

80-90% of annual disaster relief expenditure by Ministry of Disaster Management (MoDM) are made against “Flood”. Victims who live in flood prone area are repeatedly provided with compensation. “Flood” has been a financial encumbrance in Sri Lanka.



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Drought	15,194	19,922	15,287	31,139	16,308	12,864	58,563	12,049	140,826	11,072
Landslide	4,636	22,587	20,503	4,929	3,253	34,398	672	181	9,788	21,959
Cyclone	10,237	17,662	11,676	43,880	8,678	20,997	3,845	8,293	1,506	541
Flood	143,309	159,111	210,339	202,680	244,091	589,836	113,942	118,425	476,284	413,129

Source NDRSC

Flood risk has been increasing with population growth & urbanization

General population growth rate in Sri Lanka from 2001 to 2012 is +8.3% whereas affected people by “Flood” have drastically been increasing, in comparison to the population growth. This indicates that these flood-prone areas tend to attract population, leaving more and more people vulnerable to flood.

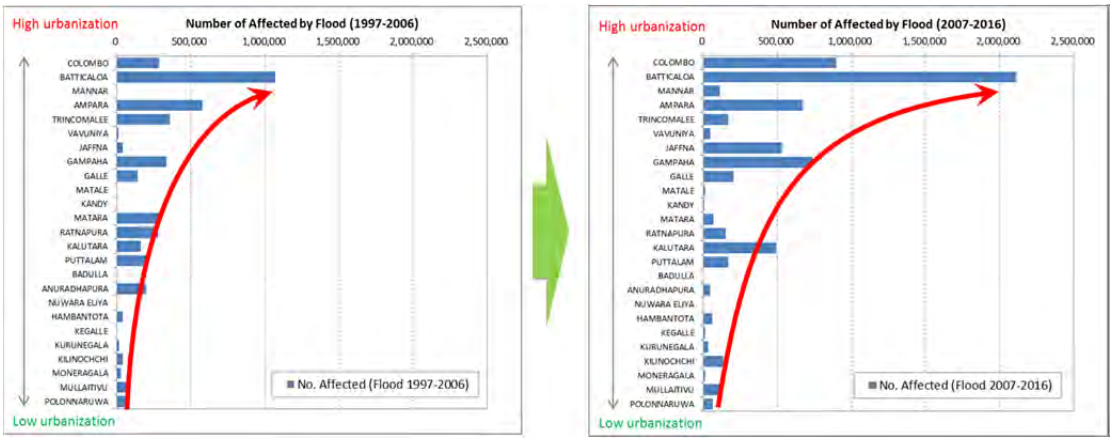
Year		1998-2004	2009-2015	Increase Rate
Population		18,797,257 (2001)	20,359,439 (2012)	+8.3%
Total number of affected	Flood	3,030,348	4,370,001	**+44.2%**
	Landslide	29,181	31,633	+8.4%
	Drought	6,267,968	3,040,677	-51.5%

Source: National census in 2001 and 2012, and DesInventar

Flood / Drought DRR

Flood victims have been increasing by urbanization

In Sri Lanka, urbanization and population growth have been accelerating in Colombo Metropolitan area within Kelani River basin, as well as neighboring districts in such as Attanugalu, Kalu and Bolgoda basins. The urbanized districts in the East and North, such as Batticaloa, are also frequently affected by flood. By comparison between 1997-2006 and 2007-2016, the number of affected people is increasing in high urbanized districts more rapidly than low urbanized districts.

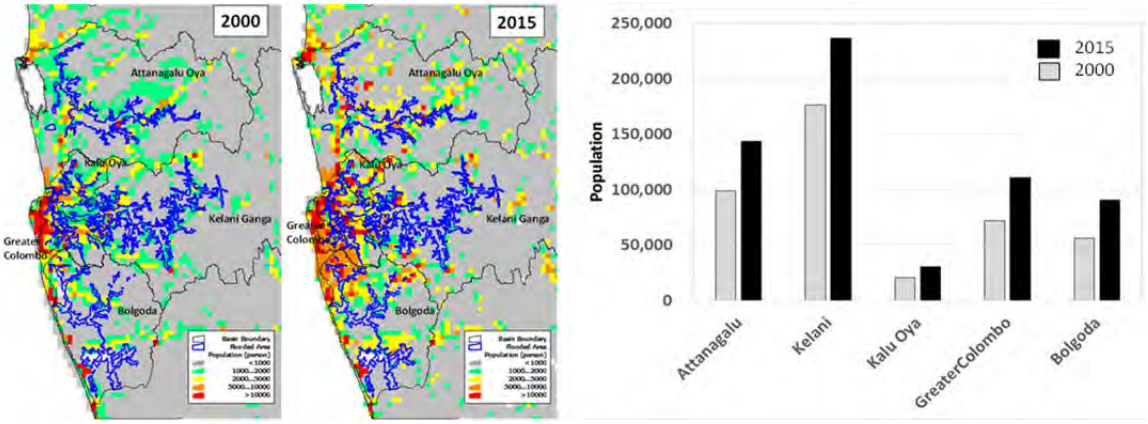


Source: National census in 2001 and 2012, and DesInventar

Population in flood prone areas is rapidly increasing

Especially in Colombo Metropolitan area, the population in flood prone area is rapidly increasing, not only in Kalani Ganga basin but also in the small and medium size river basins such as Attanugalu, Kalu Oya and Bolgoda basins. It means that the exposure to flood risk is increasing.

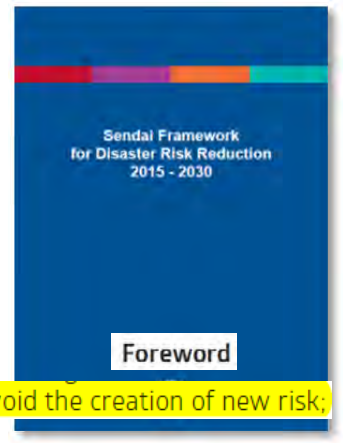
In Western Region Megapolis Planning Project (WRMPP), there are development plans of “Science and Technology City” and “Industrial City” in such basins. Possible increase in run-off and flood hazard due to the developments should be considered for the future city planning to prevent “New Risk”.



Source: flood prone area from IWMI and Survey Dept. / population from LandScan

Non-“Risk-Sensitive Development” creates “New Risk”

The Sendai Framework for Disaster Risk Reduction 2015-2030 highlights the importance of “Reducing Existing Risk” and “Preventing New Risk”.



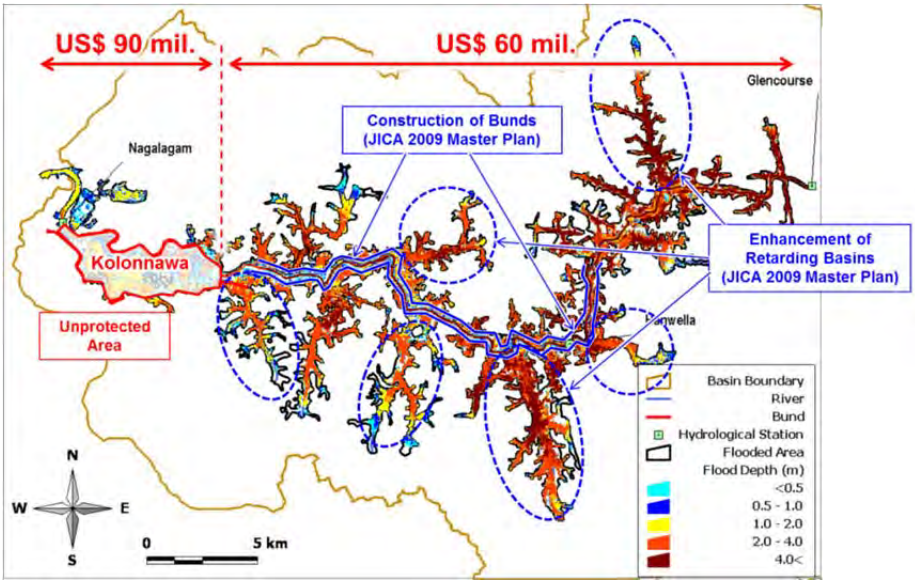
In Sri Lanka, most of traditional villages are located on hill side, while flood plains have been utilized as paddy fields that naturally retard flood during heavy rainfall. However, urbanized housing developments has intruded into the flood prone area without appropriate land use plans. This process creates “new risk” with government regulation and/or land use plan can prevent.

Traditionally villages located on hill side

Recent urbanization produces new risk

Kolonnawa area, which was severely affected by flood in May 2016, is basically inappropriate land for settlement. It is not protected by bunds and any flood mitigation measures have not been applied. Despite such condition, the population in Kolonnawa increased 3 times in recent 15 years according to LandScan data.

In May 2016 flood, about 60% of the direct damage of housing sector was from Kolonnawa area. It is strongly required to update the master plan to cope with actual situation and to restrict new settlement to prevent new risk.

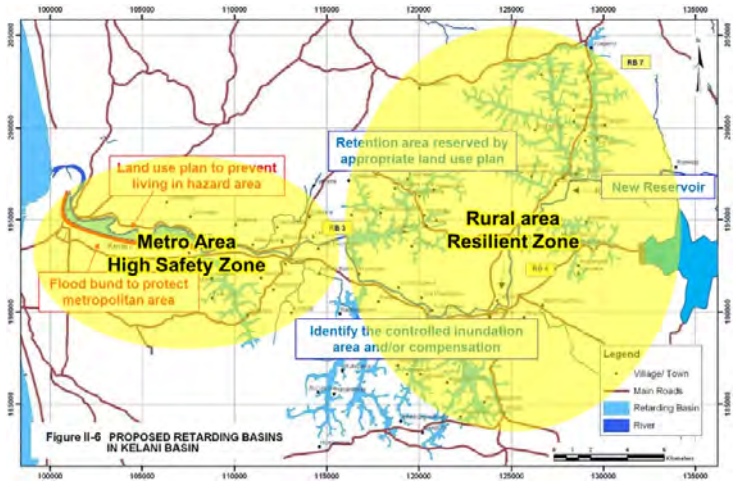


Source: flood depth prepared from Survey Dept. data

“Safety” in urban area and “Resilient” in rural area should be ensured

To protect Colombo Metropolitan area from flood is an urgent issue to minimize national economic losses for sustainable development. However it is not realistic to secure “Safety” for entire river basin by flood control measures due to limited financial resources and/or social environmental impact.

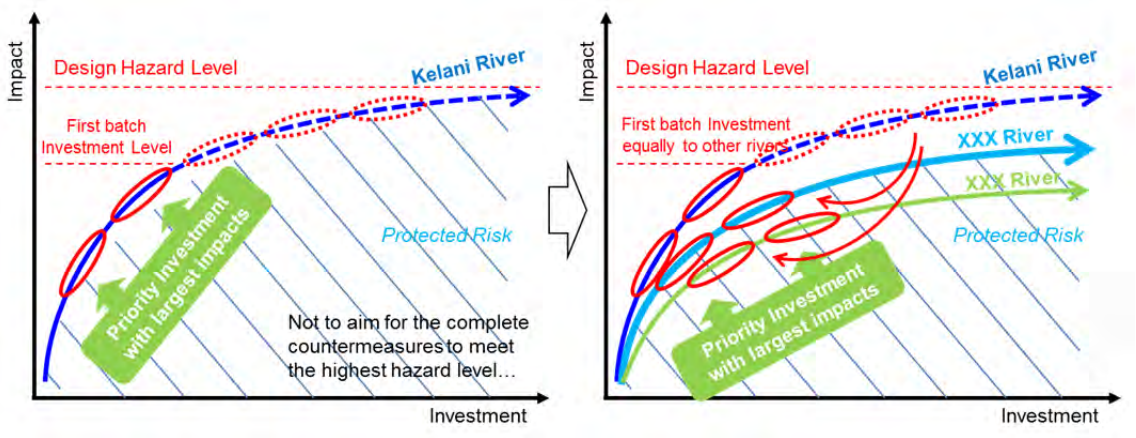
GoSL should make efforts to secure “Safety” to protect central urban area, and to strengthen local “Resilience” in rural area even in the same river basin, so that the financial resources can be utilized more effectively.



Investments should be focused on higher Impact

In DRR countermeasures, the impact of initial investment is relatively high, but the effectiveness curve gradually flattens as the investment accumulates. Investment should thus aim to meet a certain level with maximum investment effectiveness.

Meanwhile, there are numerous flood-prone rivers of various scales in Sri Lanka, which cause constant human and economic losses. Instead of focusing on DRR investment to a single river basin, which flooded recently, it is important to make balanced allocation of investment among other important basins as well simultaneously, in the sense of wise and well-balanced DRR investment which is essential for steady development of Sri Lanka..

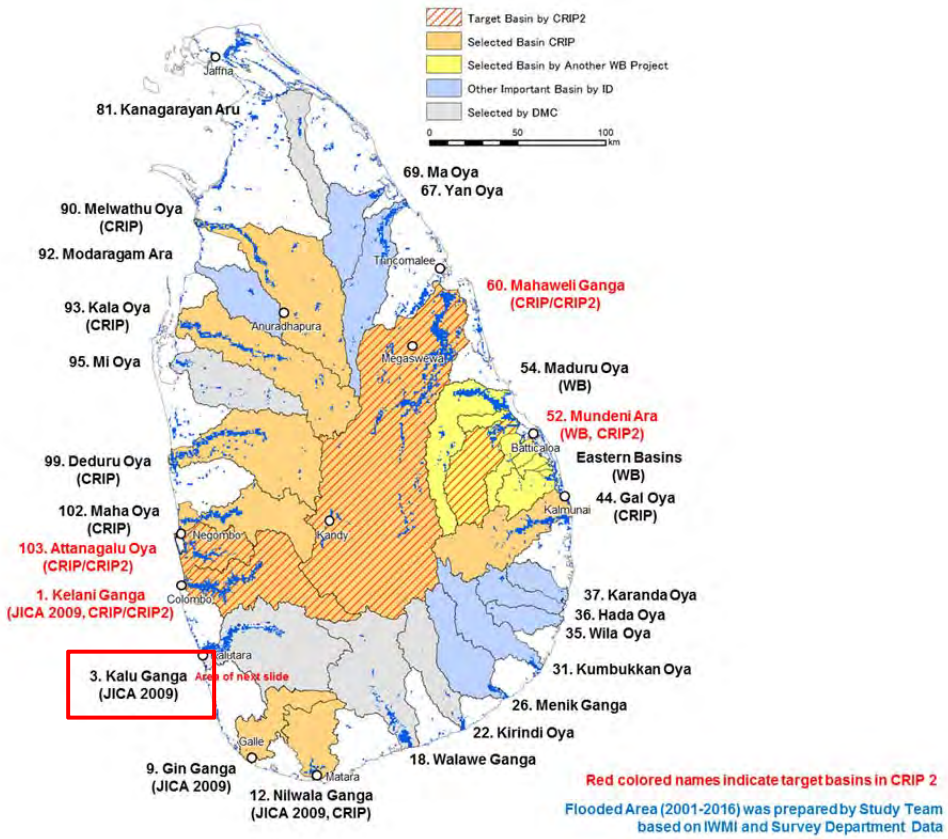


Basin investment plans should be prepared considering overall balance

Population in flood prone area of Kelani Ganga is about 395,000, equivalent to 24.2% of total population in flood prone area in Sri Lanka. Thus, it has highest priority in the country.

GoSL (Disaster Management Centre / Irrigation Department) selected the following important basins. Of them, 10 basins and 2 basins were selected by CRIP and the other project in which basin investment plans will be formulated.

Kalu Ganga, having 4th largest number of population in its flood prone area, was not selected by the above projects. Basin investment plan of the other basins should be prepared considering overall investment balance.



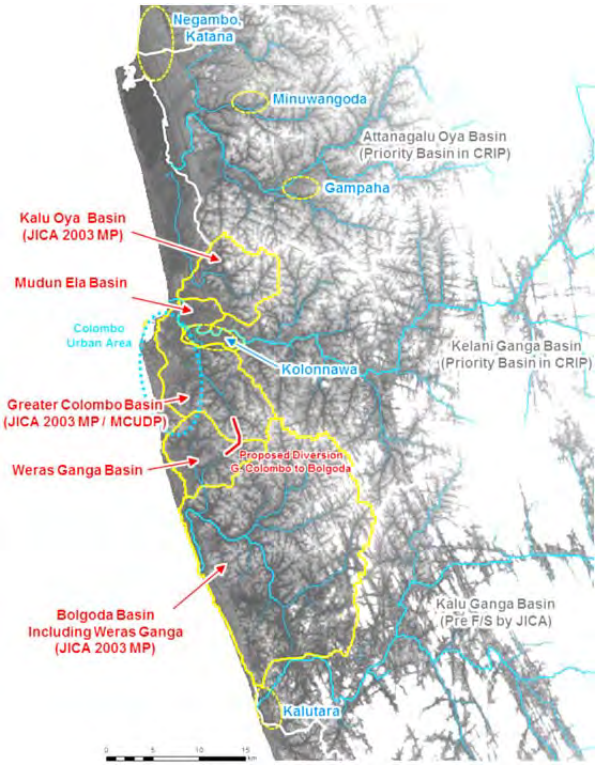
ID	Basin Name	Pop. (2015)	Area (km^2)	% of total pop. in flood area	Important Basin	CRIP 10+2 Basin	CRIP2 4 Basin
1	Kalani Ganga	394,975	2,314	24.16	○	○	○
103	Attanagaru Oya	182,653	854	11.17	○	○	○
60	Mahaweli Ganaga	171,947	10,268	10.52	○	○	○
3	**Kalu Ganga**	**123,275**	**2,816**	**7.54**	○	Out of Target	
99	Deduru Oya	83,786	2,682	5.12	○	○	
102	Maha Oya	76,291	1,553	4.67	○	○	
44	Gal Oya	46,446	1,872	2.84	○	○	
12	Niwala Ganga	32,766	1,034	2.00	○	○	
18	Walawe Ganga	30,553	2,478	1.87	○		
104	Jaffna Area	23,447	1,260	1.43			
5	Madu Ganga	21,715	73	1.33			
93	Kala Oya	20,433	2,860	1.25	○	○	
100	Karambalan Oya	15,016	777	0.92			
52	Mundeni Ara	11,284	1,352	0.69	○	○	○
90	Malwath Ara	10,264	3,187	0.63	○	○	

Master Plan for Urban Drainage in Colombo should be reviewed

Actual central urban area of Colombo Metropolitan is located in the small and medium size river basins in Colombo, Gampaha and Kalutala districts. Thus, it is essential for flood mitigation of Colombo Metropolitan to improve urban drainage system in these river basins in addition to flood management of major river basins of Kelani Ganga and Attanagalu Oya.

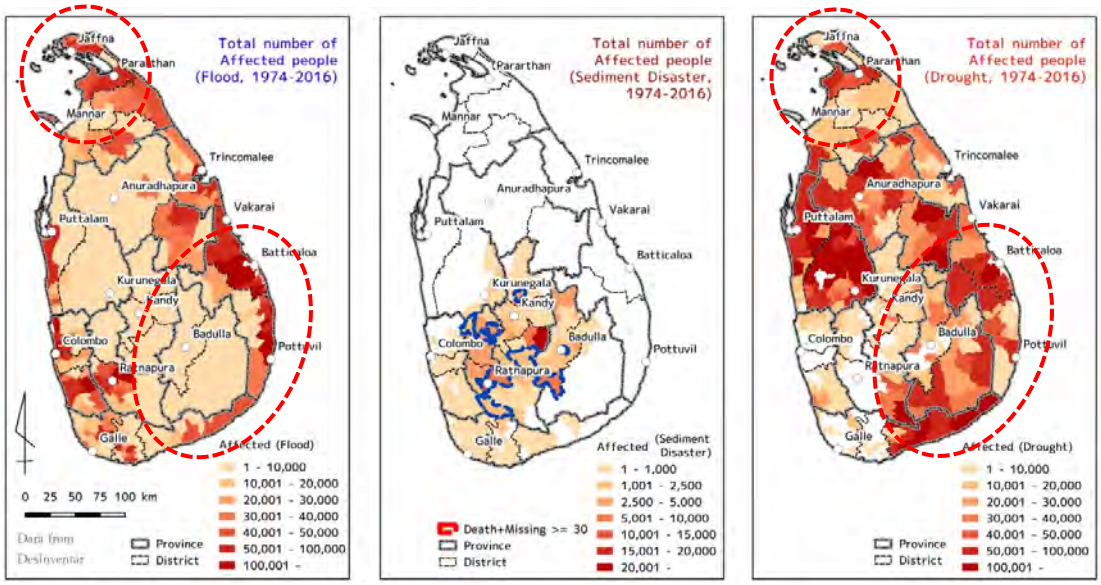
Urban drainage system in Colombo Metropolitan has been improved based on a Master Plan formulated in 2003 (JICA 2003 MP). However, after 13 years from JICA 2003 MP, the social and climate conditions have been changed.

After severe flood in May 2016, GoSL is facing necessity to revise JICA 2003 MP and develop comprehensive flood management system in this area.



Drought DRR should be discussed in IWRM concept

According to the records of disaster-affected people in each district, the northern and southeastern districts are affected by both flood and drought. Therefore, flood risk and drought reduction should always be considered together with water resources development, including ground water monitoring and management, from a viewpoint of Integrated Water Resources Management (IWRM).



Source: DesInventar (1974-2016)

After May 2016 heavy rainfall, Sri Lanka is experiencing extremely severe drought in the entire country. As of Jan. 2017, total water storage of 73 major reservoirs was at only 29% (vs 80-90% last year) out of total capacity, less than 50% of water required for Maha cultivation.

Following are incorporated into actions to be taken for drought and flood risk reduction.

- Evaluation of drought risk in terms of water balance for river basins
- Water resources development to mitigate drought according to basin investment plan
- Improvement of coordinated operation of reservoirs based on proper monitoring system

Landslide DRR

Land regulation is fundamental solution in landslide DRR

Most fundamental countermeasure for landslide is to prevent land development and new settlement in landslide risk area. To achieve this, 1) accurate hazard zonation and 2) legal arrangement for land regulation are the must.

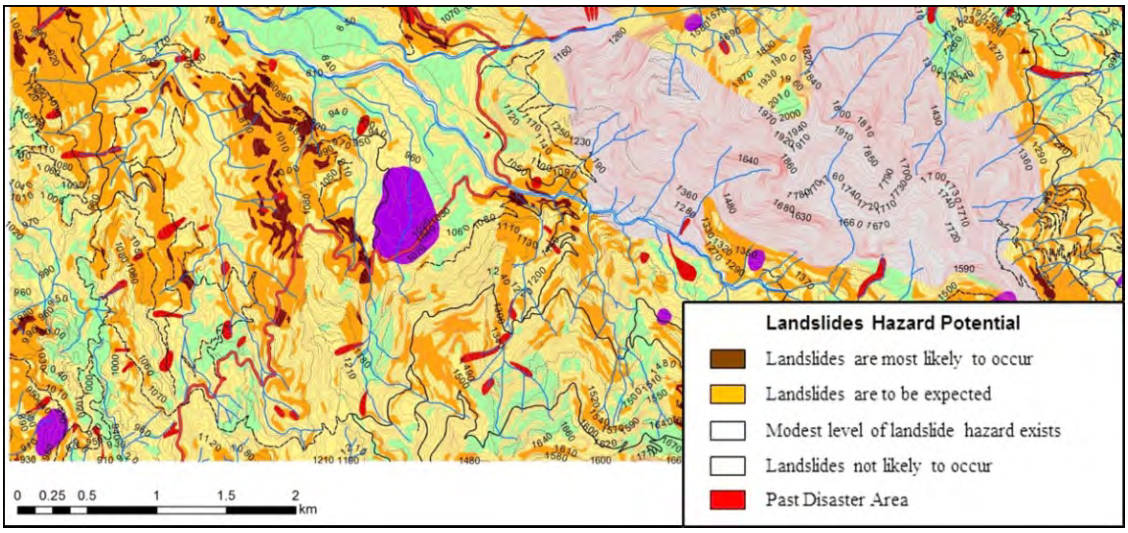
1) Accurate hazard zonation

NBRO is preparing several scales of landslide hazard zonation map. For land regulation purpose, following action should be taken:

- To upgrade hazard zonation map evaluating not only in-situ slope stability but also affected zone in downstream area
- To generalize the methodology of zonation, and prepare guidelines in cooperation with Urban Development Authority (UDA) and other concerned agencies

2) Legal arrangement

GoSL should prepare regulations not only for permission of land development, but also for obligation of the central and local Governments on necessary structural and non-structural measures.



Example of 1:10,000 Scale Landslide Zonation Map by NBRO

Investment in transportation and other important infrastructures

During disaster, traffic shutdown of important road section causes serious problem in mobilization of rescue team and relief materials. It also makes state economic damage lager. Strong traffic network against landslide disaster is a key objective in DRR.

GoJ is supporting to strengthen road network from landslide disaster in mountainous area under a loan project “Landslide Disaster Prevention Project (LDPP)”. Through the project, slope stabilization and landslide prevention works will be done using Japanese technology and experiences for 16 sites along the Class-A national road. The construction will start on April 2017 and completed on 2019.

Many unstable slopes remain out of LDDP targets

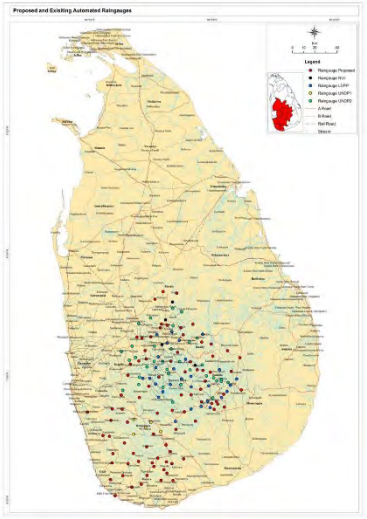
However, there remain a number of unstable slopes and road sections out of LDPP target sites along Class-A and B national roads. Moreover, railway system should also be protected from viewpoint of strong transportation network.

Road Development Authority (RDA) and NBRO should prioritize critical national road sections and important public facilities (such as school and hospital) to ensure future investment.

Landslide early warning should be improved and regulated

Landslide is local event that occurs in particular weather conditions. Therefore, landslide early warning should be localized by high-density rainfall observation. NBRO established landslide early warning system in 2007 using cylinder-type rainfall gauges. It has been effective for landslide early warning that can be maintained by community people.

Recently, NBRO is developing and upgrading 160 sets of automatic rainfall gauges. All the rainfall records are transmitted to NBRO in real time. Besides, NBRO started to examine a new warning criteria using a Japanese standard “Working Rainfall”. It is expected to improve the warning criteria and regulation to issue more accurate and high-resolution landslide waning, so that people in landslide risk area could have enough time for safety evacuation.



Distribution of automatic rain gauges by NBRO

Principle of landslide disaster management

Since landslide disaster mostly occurred in rural area, cost-benefit of the mitigation measures is comparatively low unlike flood and drought. However, landslide is one of the most serious disasters, causing many deaths and catastrophic impact to rural economy. It should be tackled by the GoSL from humanitarian perspective.

The principle of landslide disaster management is summarized as follows:

- In rural area, non-structural measures (risk assessment, land regulation and early warning) are practical approaches.
- Structural measures should be applied for only important public facilities, transportation networks and recovery of affected area.
- These structural and non-structural measures should be prioritized based on proper investment plan by the central Government and local authorities.

Early Warning Mechanism

Lessons learnt from May 2016 Flood

May 2016 disasters are a valuable experience for GoSL to review present Early Warning (EW) and emergency response mechanism among relevant agencies. Based on timeline in May 2016, following issues are revealed.

- Department of Meteorology (DOM): *Weather forecasting and waning*
  "Special Warning Bulletin" was issued by DOM in the south-western region two days before the peak rainfall. However the warned area was too large for people to recognize their imminent risk.
- Irrigation Department (ID): *Flood Warning*
  "Major Flood Warning" was not issued until water level reached the critical level at the most downstream water level station near Colombo city. Accordingly, people could not have enough lead-time for evacuation.
- National Building Research Organization (NBRO): *Landslide Warning*
  "Level 3" Warning" (most critical landslide warning) was not issued at any location. There is no localized warning regulation to issue reliable warning.
- Disaster Management Centre (DMC): *Comprehensive Disaster Warning to Public*
  Real-time and visualized information was not gathered at EOC. It was difficult to identify accurate risk area for warning. Role and responsibility among agencies are not clearly regulated.

Well-coordinated EW institution should be setup among agencies

Considering lessons learnt, following countermeasures are required;

- Provision of real-time rainfall data utilizing two Doppler Radars to improve weather forecasting and waning
- Development of flood forecasting and warning in important river basins
- Improvement of landslide warning criteria and regulation
- Integrated information and visualization for emergency operation

All the above efforts should be well-coordinated under initiative of MDM. Warning and decision making for evacuation should be discussed involving Districts and DS Division as well as local authorities.

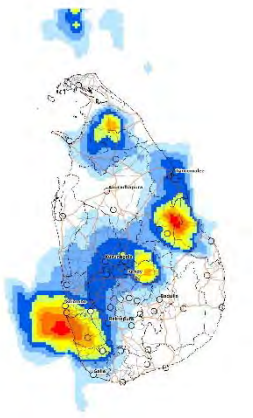


Image of Doppler Radar

DRR Governance

Logical Structure of 7 Global Targets in Sendai Framework 2015-2030

The Sendai Framework 2015-2030 sets seven (7) Global Targets, which will be achieved by the efforts of each state. These targets categorized to 3 “Input Targets” and 4 “Outcome Targets”.

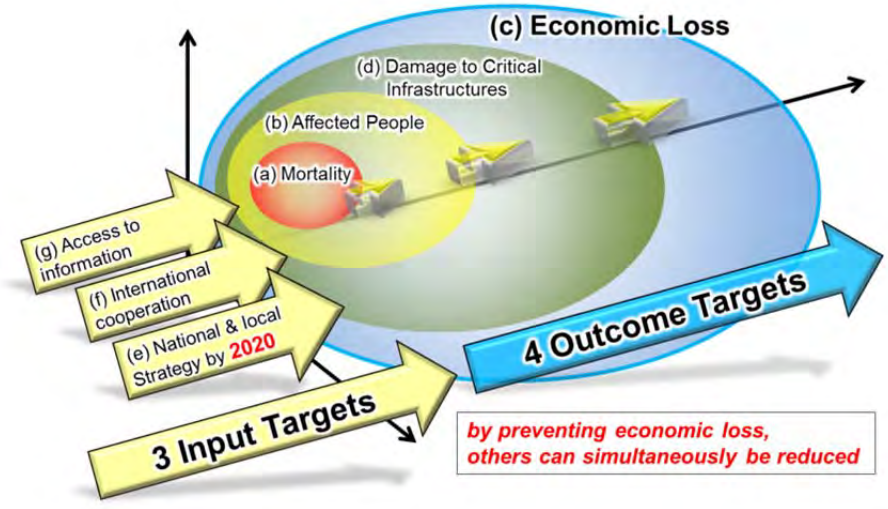
Output Targets:
(a) Substantially reduce global disaster mortality by 2030
(b) Substantially reduce the number of affected people globally by 2030
(c) Reduce direct disaster economic loss in relation to global GDP by 2030
(d) Substantially reduce disaster damage to critical infrastructure by 2030
Input Targets:
(e) Substantially increase countries with national and local DRR strategies **by 2020**;
(f) Substantially enhance international cooperation for Sendai Framework by 2030;
(g) Substantially increase availability of access to EWS and risk information by 2030.

In addition, all countries adopted the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs). Following Goals are closely related to the Global Targets of Sendai Framework 2015-2030. Especially in Goal 9, the SDGs clearly indicate to make efforts reducing disaster economic loss (Target (c)) by building resilient infrastructure and sustainable industrialization.

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable

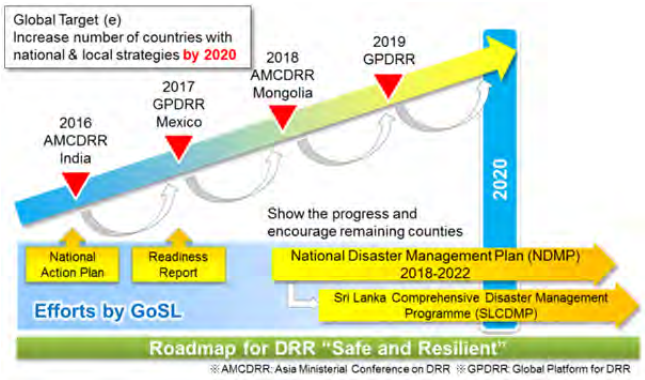
Generally, by investing countermeasures for “Reduce Economic Loss”, simultaneously other 3 outcome targets “Mortality, Affected People and Damage to Critical Infrastructure” can be reduced.

For the countries’ economic growth which align to SDGs Sustainable Development Goals, the targets “Reduce the Economic Loss” is the most important target among 7 targets.



Establishment of Local DRR Strategy as the Primary Task by 2020

Target year of the “Global Target (e): national and local DRR strategies” is set as 2020, while the other Targets are due in 2030.



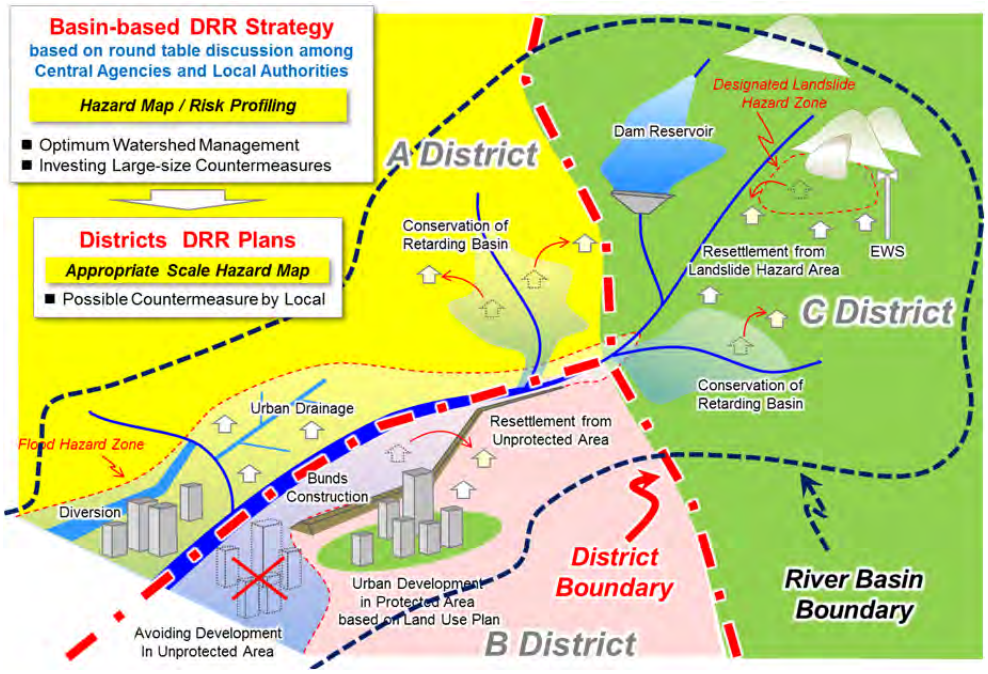
In Sri Lanka, National Disaster Management Plan (NDMP) 2018-2022 is now under preparation by MDM, followed by preparation of local DRR Plans in line with NDMP. Considering the Global Target (e), districts with high risk of disaster may need be prioritized for local DRR planning by 2020. MDM shall take the lead in this process, in coordination with concerned agencies, and monitor the progress in line with the international monitoring mechanism of the Sendai Framework.

Practical Local DRR Plan in Line with “Basin-based DRR Strategy”

Disaster, particularly flood which is the most critical disaster in Sri Lanka, often occurs beyond administration boundary, and it is difficult to develop practical Local DRR Plans by individual districts and DS divisions. Consequently, development of “Basin-based DRR Strategy” with basin-wide risk profiling, under the initiative of the concerned national agencies is essential for practical Local DRR plan.

With appropriate scale hazard map, Basin-based DRR Strategy should be developed including structural and non-structural countermeasures. Local DRR Plans are to be formulated based on the Basin-based DRR Strategy.

In case there are already residents in a high-risk area, it should be assessed as “existing risks” and appropriate measures including resettlement may need to be examined.



Roadmap for DRR in Sri Lanka

Principle for Implementation of Sendai Framework

Consequently, the principle for implementation of Sendai Framework is summarized as follows;

- Each projects has its own purpose but must be prioritized from the damage potential and effectiveness fit to the country's holistic growth
- The central Government's leadership, by not only MoDM but including National Planning Department (NPD) and other relevant agencies, is essential to take a holistic approach
- Sendai Framework Target (e), national & local DRR strategy by 2020 is urgent task
- In order to make local DRR strategy, appropriate scale of hazard map is essential to make land use regulation and practical counter measures.
- Institutional consensus for role allocation for central local DRR strategy and implementation must be formulated

Utilization of Roadmap

Proposed Priority Actions in DRR governance, flood / drought DRR, landslide DRR and early warning mechanism toward 2030 are attached. Priority projects by 2020 are indicated. Some activities have been implemented by GoSL and international donors (blue) and some have not been started yet (yellow).

A new National Disaster Management Plan (NDMP) 2018-2022 is under preparation by MoDM. Based on the NDMP 2018-2012, Sri Lanka Comprehensive Disaster Management Programme (SLCDMP) will also be updated. Although the proposed Roadmap covers few disaster types in which the actions should be taken in highest priority, it is expected to be referred for NDMP formulation.

As described previously, combination of "Safe" and "Resilient" shall be a keyword to promote DRR investment effectively and efficiency in Sri Lanka.

Roadmap for Disaster Risk Reduction ~ Safe and Resilient Sri Lanka ~

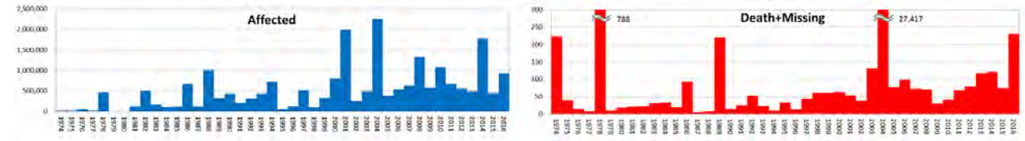
As of May 16, 2017

Ministry of Disaster Management, in cooperation with: Japan International Cooperation Agency (JICA)

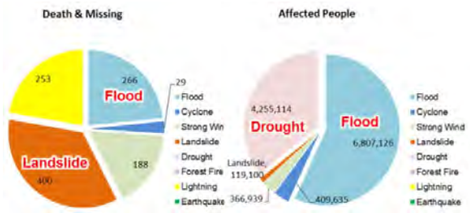
Disaster Risks in Sri Lanka

Disaster victims are increasing in recent years.

After the tsunami attack by the Sumatra Earthquake in 2004, the Government of Sri Lanka has been strengthening Disaster Risk Reduction (DRR) institutions in national and local levels such as establishment of Ministry of Disaster Management (MDM) under enforcement of Disaster Management Act (2005). However, the number of disaster affected people and death/missing seem to be increasing.



Flood, landslide and drought are the critical disaster types in Sri Lanka.



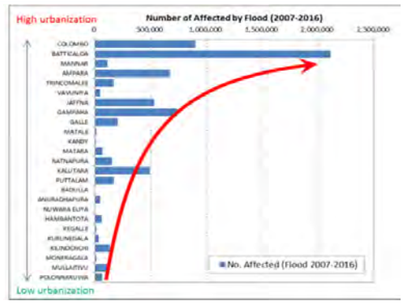
"Flood" is the most frequent disaster in Sri Lanka in recent decades. It brings damages in vast geographical areas, accounting for high percentages in death/missing and affected population. On the other hand, "Landslide" causes a large number of death/missing despite its relatively limited geographical effect, as observed upon the disasters in 2014 and 2016. "Drought" also accounts for high percentages in affected people following "Flood". These 3 types of disaster are critical in Sri Lanka.

Flood victims have been increasing by urbanization.

In Sri Lanka, urbanization and population growth have been accelerating in Colombo Metropolitan area within Kelani River basin, as well as neighboring Districts in such as Attanugalu, Kalu and Bolgoda basins. The urbanized Districts in the East and North, such as Batticaloa, are also frequently affected by flood.

The number of affected population by flood has drastically been increasing, in comparison to the general population growth.

	1998-2004	2009-2015	Increase (%)
Population	18,797,257 (2001)	20,359,439 (2012)	+8.3%
Number of affected by flood	3,030,348	4,370,001	**+44.2%**



Non- "Risk-Sensitive Development" creates "New Risk", causing more damage.

The Sendai Framework for Disaster Risk Reduction 2015-2030 highlights the importance of "Reducing Existing Risk" and "Prevent Creating New Risk". In Sri Lanka, most of traditional villages are located on hill side, while flood plains have been utilized as paddy fields that naturally retard flood during heavy rainfall. However, urbanized housing development has intruded into the flood-prone areas without appropriate land use plans. This process creates "new risk" which Government regulation and/or land use plan can prevent.

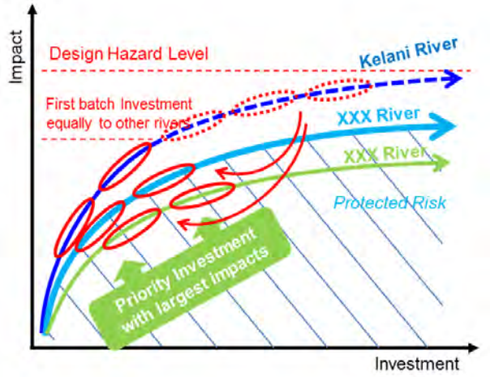
To prevent creating "new risk" and avoid consequent damages from disaster, urban development process should consider disaster risk of the area and reflect it in appropriate preventive measures, including resettlement from existing risk area and restriction of new settlement.

Principles of Disaster Risk Reduction in Sri Lanka

FLOOD: Well-balanced DRR investment among important river basins

In DRR countermeasures, the impact of initial investment is relatively high, but the effectiveness curve gradually flattens as the investment accumulates.

Meanwhile, there are numerous flood-prone rivers of various scale in Sri Lanka, which cause constant human and economic losses. Instead of focusing on DRR investment to a single river basin which flooded recently, it is important to make simultaneous and balanced allocation of investment among other important basins as well, in the sense of wise and well-balanced DRR investment which is essential for steady development of Sri Lanka.

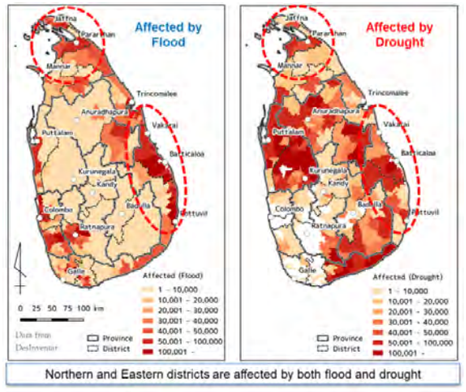


DROUGHT: DRR in the context of Integrated Water Resource Management

Flood risk reduction should always be considered together with the issue of water resources development, including ground water monitoring and management, from a viewpoint of Integrated Water Resources Management (IWRM).

Following should be incorporated in IWRM, contributing to drought and flood risk reduction:

- Evaluation of drought risk in terms of water balance for river basins
- Water resources development to mitigate drought according to basin investment plan
- Improvement of coordinated operation of reservoirs based on proper monitoring system



Northern and Eastern districts are affected by both flood and drought

LANDSLIDE: Efficient investment and prioritization on landslide DRR

Landslide is one of the most serious disasters, causing many deaths and catastrophic impact on rural economy.

The principles of landslide DRR are summarized as follows:

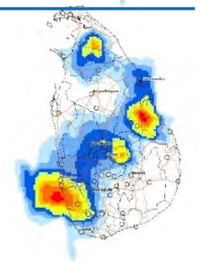
- In rural area, non-structural measures (risk assessment, land regulation and early warning) are practical approaches.
- Structural measures should be focused on important public facilities and transportation networks.
- These structural and non-structural measures should be prioritized based on proper investment plan.

EARLY WARNING: Mechanism under Inter-Agency Coordination

Early Waning (EW) Mechanism should be well-coordinated among the central agencies under initiative of MDM. Decision making for evacuation should be discussed involving Districts and DS Division.

Following countermeasures are considered:

- Real-time rainfall data utilizing two Doppler Radars to improve weather forecasting
- Development of flood forecasting and warning in important river basins
- Improvement of landslide warning criteria and regulation

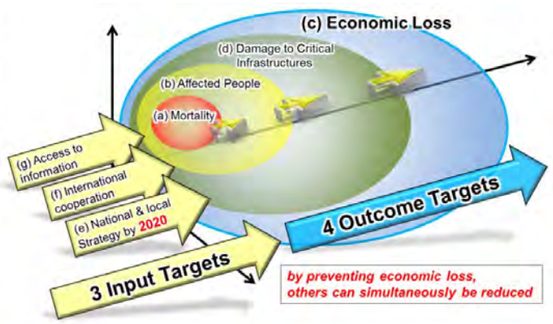


Roadmap for Disaster Risk Reduction ~ Safe and Resilient Sri Lanka ~

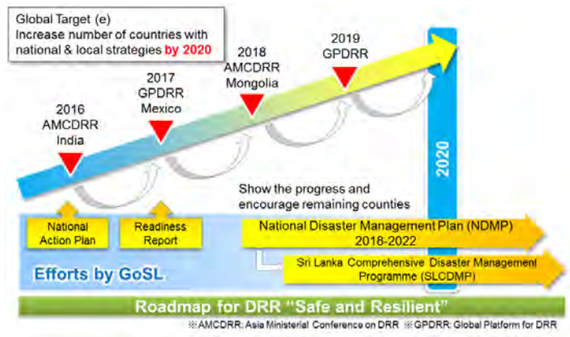
Logical Structure of 7 Global Targets in the Sendai Framework for DRR 2015-2030

The Sendai Framework sets 7 Global Targets which will be achieved by the efforts of each state. These Targets are categorized into 3 “Input Targets and 4 “Outcome Targets”.

Generally, by investing countermeasures for “Reduce Economic Loss”, other 3 outcome targets “Mortality, Affected People and Damage to Critical Infrastructures” can simultaneously be reduced.
For the countries’ economical growth which align with Sustainable Development Goals (SDGs), the Target “Reduce the Economic Loss” is the most important target among the 7 Targets.



Establishment of Local DRR Strategy in Line with NDMP as the Primary Task by 2020



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Practical Local DRR Plan in Line with Basin-based DRR Strategy

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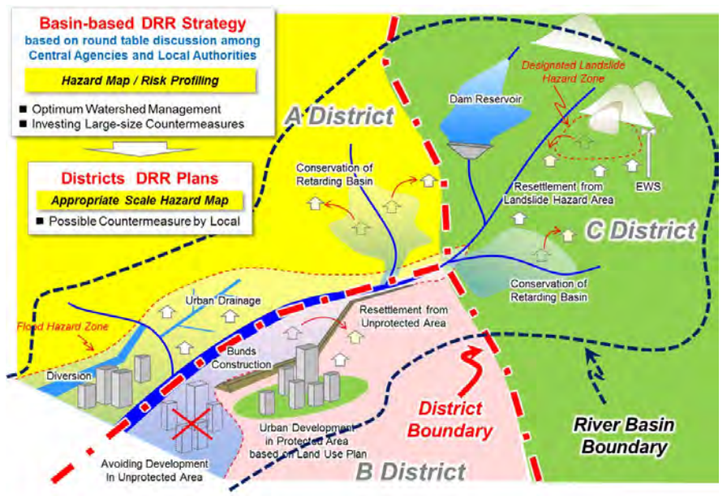
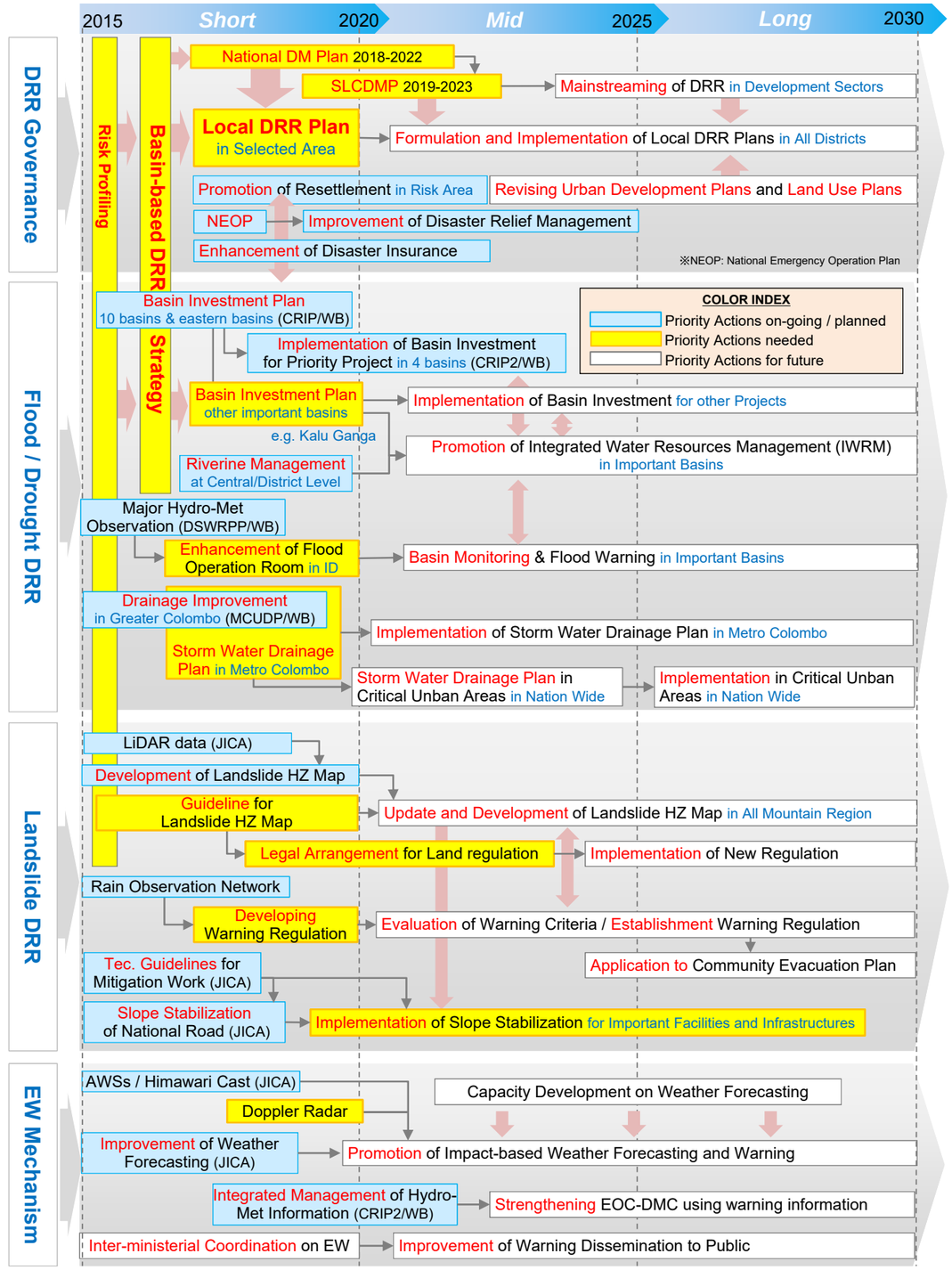


Priority Actions



※Priority actions only for main disasters are indicated. The other shall be considered as needed.

Appendix 3

List of Collected Data and Information

No.	Title	Language	Date of Issue	Publisher	Place of Obtain	Form/Style
■01 Ministry of Disaster Management (MoDM) / Disaster Mangement Centre (DMC)						
01-01	Sri Lanka Disaster Management Act	English	May 2005	GoSL	Web Site	Document
01-02	National Policy on Disaster Management	English	May 2005	NCDM	Web Site	Document
01-03	Towards a Safer Sri Lanka - Road Map for Disaster Risk Management Volume 1	English	Dec 2005	DMC	Web Site	Document
01-04	Towards a Safer Sri Lanka - Road Map for Disaster Risk Management Volume 2	English	Dec 2005	DMC	Web Site	Document
01-05	National Disaster Management Plan 2013-2017	English	N/A	N/A	DMC	Document
01-06	National Disaster Management Plan	English	N/A	N/A	DMC	Document
01-07	Sri Lanka Comprehensive Disaster Management Programme 2014-2018	English	Mar 2014	MoDM	MoDM	Document
01-08	National Emergency Operation Plan 2015-2019 (Draft)	English	May 2015	DMC and UNDP	DMC	Document
01-09	Sri Lanka- National progress report on the implementation of the Hyogo Framework for Action (2007-2009)	English	Jun 2009	DMC	Web Site	Document
01-10	Sri Lanka- National progress report on the implementation of the Hyogo Framework for Action (2009-2011)	English	Apr 2011	DMC	Web Site	Document
01-11	Sri Lanka- National progress report on the implementation of the Hyogo Framework for Action (2011-2013)	English	Apr 2011	DMC	Web Site	Document
01-12	Sri Lanka- National progress report on the implementation of the Hyogo Framework for Action (2013-2015) -	English	Jan 2009	DMC	Web Site	Document
01-13	Safer Sri Lanka Progress Report 2013	English	N/A	MoDM	MoDM	Document
01-14	Annual Performance Report 2014	English	N/A	MoDM	MoDM	Document
01-15	Annual Performance Report 2015	English	N/A	MoDM	MoDM	Document
01-16	Progress Report - 2016	English	N/A	MoDM	MoDM	Document
01-17	The Gazette of the Democratic Socialist Republic of Sri Lanka Extraordinary	English	Sep 2005	President Office	MoDM	Document
01-18	Provincial Councils Act No.42 of 1987	English	1987	GoSL	DMC	Document
01-19	Disaster Management Plan (DMP) Template for District	English	2012	DMC	DMC	Document
01-20	National Action Plan Final Draft	English	March 2016	MoDM	MoDM	Document
01-21	AMCDRR-OIEWG Commitments, Progress, and Way forward	English	N/A	MoDM	MoDM	Power Point
01-22	Recommendations of the OIEWG on Indicators and Terminology relating to Disaster Risk Reduction	English	Nov 2016	UN	MoDM	Document
01-23	Report of the Chair of the OIEWG on Indicators and Terminology relating to Disaster Risk Reduction	English	Nov 2016	UN	MoDM	Document
01-24	Asia Regional Plan for Implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030	English	Nov 2016	AMCDRR	MoDM	Document
01-25	Results of the informal consultations of the Chair on indicators for global targets of the Sendai Framework for DRR	English	Nov 2016	UNISDR	MoDM	Document
01-26	Situation Report – Special Issue on 18th May 2016	English	May 2016	DMC	DMC	Document
01-27	Situation Report – Special Issue on 18th May 2016	English	May 2016	DMC	DMC	Document
01-28	Situation Report – Special Issue on 18th May 2016	English	May 2016	DMC	DMC	Document
01-29	Sri Lanka Flood Monitoring Bulletin	English	May 2016	IWMI	DMC	Power Point
01-30	Sri Lanka Flood Monitoring Bulletin 12 May 2016	English	May 2016	IWMI	DMC	Power Point
01-31	Information Management Initiatives during the Floods and Landslide	English	May 2016	DMC	DMC	Power Point
01-32	Effective Information Management For Disaster Management from the past 10 years' experience of DMC	English	N/A	DMC	DMC	Power Point
01-33	Terms of Reference Preparation of Urban Flood Maps for 10 Cities in Sri	English	2015	DMC	DMC	Document
01-34	Technical Working Group on Development of National Risk Profiles for	English	N/A	DMC	DMC	Document
01-35	Data Operation Book from 9-27 May	Sinhala	N/A	MoDM	DMC	Record
01-36	Report on Early Warning and Emergency Response Activities on Recent Floods and Landslides Situation in the Country	English	May 2016	DMC	DMC	Document
■02 Department of Meteorology (DOM), MoDM						
02-01	DOM Annual Report 2015	English	2015	DOM	DOM	Document
02-02	Communication List for Weather	English	N/A	DOM	DOM	List

No.	Title	Language	Date of Issue	Publisher	Place of Obtain	Form/Style
02-03	Baseline Survey Report under Technical Cooperation Project for Improvement of Meteorological Observation, Weather Forecasting and Dissemination	English	Dec 2014	JICA	DOM	Document
02-04	Location Map of Rainfall Gauge	English	N/A	DOM	DOM	Power Point
02-05	All Station List with Details (Latitude and Longitude)	English	N/A	DOM	DOM	List
■03 National Building Research Institute (NBRO), MoDM						
03-01	Landslide Risk Management Plan (2017-2021) Draft	English	Aug 2016	MoDM	NBRO	Document
03-02	The study of threshold limits on lope disaster events in Sri Lanka – Case study on Kegalla district Landslides during May-July 2016	English	N/A	NBRO	NBRO	Power Point
03-03	Land Acquisition and Implementation of the National Involuntary Resettlement Policy – A Guide for Public Officials on Good Practices –	English	2013	Ministry of Land and Land Development	NBRO	Document
03-04	Guideline for Construction in Landslide Prone Areas	English	Mar 2003	Ministry of Housing and Plantation Infrastructure	NBRO	Document
03-05	2015 Annual Report of National Building Research Institute	English	2015	NBRO	NBRO	Document
03-06	Copy of NBRI Draft Act	English	Jun 2014	N/A	NBRO	Document
03-07	Hazard Resilient Housing Construction Manual - Resilient Construction Series	English	Aug 2015	NBRO	NBRO	Document
03-08	Area Where Landslide Hazard Zonation Mapping is Implemented	English	Sep 2016	NBRO	NBRO	Figure
03-09	Current Trend of landslides, National Level Landslide Detection, Early Warning and Notification	English	N/A	NBRO	NBRO	Power Point
03-10	Updated Situation on Landslide Risk Reduction in Sri Lanka	English	N/A	NBRO	NBRO	Power Point
03-11	Implementation Guideline – For Home Owner Driven Housing Construction Programme for Landslide Victims – Kegalle District -	English	N/A	NBRO	NBRO	Document
■04 Irrigation Department (ID), Ministry of Irrigation and Water Resources Management						
04-01	Scheme of Organization and Standing Orders – To Safeguard City of Colombo From Floods in Kelani Ganga	English	Apr 1993	ID	ID	Document
04-02	Climate Resilience Improvement Project (CRIP) Overview	English	Nov 2016	CRIP	ID	Power Point
04-03	Current system of Hydro-Meteorological Data Collection and Flood Forecasting	English	N/A	ID	ID	Power Point
04-04	Future River Basin Planning	English	N/A	ID	ID	Power Point
04-05	Water Resources Development Projects in the Pipeline	English	N/A	ID	ID	Power Point
04-06	An Ordinance to Amend and Consolidate the Law Relating to Irrigation	English	N/A	e-Law, Sri Lanka	ID	Document
04-07	Amending Flood Protection Act No.22 of 1955	English	Apr 2016	ID	ID	Document
04-08	An Ordinance for the Protection of Areas Subject to Damage from Floods	English	1955	ID	ID	Document
04-09	Hydrological Aspects of the Recent Flood, Kelani River	English	N/A	ID	ID	Power Point
04-10	An Introduction to Disaster Management	English	N/A	ID	ID	Power Point
04-11	Kelani River Improvement – Flood Protection (Sedawatta to Ambatale) Phase 01	English	Jun 2016	Planning & Research Unit- WRMPP	ID	Document
04-12	Major Floods in Kalani River- 2016 May	English	N/A	ID	ID	Document
04-13	Hydrological Annual 2014/15	English	N/A	ID	ID	Document
04-14	Flood Inundation Areas in Kelani Ganga Basin in 2016 Flood	English	N/A	ID	ID	Document
04-15	Study of Effects on Kelani River Floods due to Proposed Inhibition for Construction of Kelani River Crossing Bridge on Outer Circular Road	English	Jun 2012	Prof.Pathirana and Dr.Ratnayake	ID	Document
04-16	An Ordinance for the Protection of Subjects to Damage from Floods	English	1924	GoSL	ID	Document
04-17	Consultancy Services for Flood Risk Modelling and Pre-Feasibility Studies for Flood Risk Management in Mundeni Aru Basin in Sri Lanka – Inception Report	English	Jul 2016	Royal Haskoning DHV	ID	Document
04-18	Meteorological and Hydrological Services in Sri Lanka	English	2016	World Bank	ID	Document
04-19	Flood Monitoring	English	N/A	ID	ID	Power Point
04-20	Introduction of Irrigation Department	English	N/A	ID	ID	Document

No.	Title	Language	Date of Issue	Publisher	Place of Obtain	Form/Style
04-21	Flood Monitoring: Information Dissemination system ; River Floods	English	N/A	ID	ID	Document
04-22	Metorological and Hydrological Services in Sri Lanka - CRIP2 Investment Plan	English	N/A	ID	ID	Document
04-23	Expert Workshop on Vulnerability Curves Mundeni Aru Basin	English	Feb 2017	ID	ID	Power Point
04-24	Flood Mitigation in Anuradapura City	English	N/A	N/A	ID	Power Point
04-25	Master Plan for Kelani River Flood Alleviation & Mitigation	English	Dec 2016	ID	ID	Document
04-26	Rationale: Generation of, and dialogue on new climate projections for Sri Lanka	English	Aug 2016	DOM	ID	Power Point
04-27	Observed Trends and Extremes in Sri Lanaka Using Updated Historical	English	Aug 2016	DOM	ID	Power Point
04-28	Past Work on Climate Projections: Identification of suitable Downscaled Modles for Sri Lanka	English	N/A	Centre for Climate Chanage Studies (CCCS)	ID	Power Point
04-29	Future Climate Change Projections for Sri Lanka	English	N/A	Centre for Climate Chanage Studies	ID	Power Point
04-30	Potential Integration of New Climate Change Projections into Development Planning in Sri Lanka; Policy Dialogue Climate Data Access & Analysis System	English	Aug 2016	RIMES	ID	Power Point
04-31	National Policy on the Protection and conservation of Water Sources, Their Catchments and Reservations in Sri	English	Dec 2014	GoSL	ID	Document
04-32	Consultancy Services for Development of Basin Investment Plans (DBIP)	English	Oct 2016	ATKINS	ID	Document
04-33	Development of a Flood Forecasting and Data Dissemination System for Kalu River Basin in Sri Lanka	English	Aug 2016	N/A	ID	Document
04-34	Administration Reports - 2015	English	N/A	ID	ID	Document
■05 Sri Lanaka Land Reclamation and Development Corporation (SLLRDC), MMWD						
05-01	Sri Lanka Land Reclamation and Development Corporation (Amendment) Act, No.35 of 2006	English	Oct 2006	SLLRDC	SLLRDC	Document
05-02	Weras Ganga Storm Water Drainage & Environment Improvement Project	English	N/A	MMWD	SLLRDC	Power Point
05-03	Five Main Sub Basins Layout Plan Studied by JICA Proposal in 2013	English	N/A	MMWD	SLLRDC	Power Point
05-04	Kolonnawa Canal Diversion	English	N/A	N/A	SLLRDC	Power Point
05-05	Contextual Analysis of Katunayake Aero City -Draft-	English	Oct 2016	Aerocity Development	SLLRDC	Document
05-06	Avissawella Plantation City -Draft-	English	Oct 2016	MMWD	SLLRDC	Document
05-07	Horana Industrial Township	English	Oct 2016	MMWD	SLLRDC	Document
05-08	Logistic Corridor Master Plan Draft 01	English	Oct 2016	MMWD	SLLRDC	Document
05-09	Transport Master Plan for Western Region Megapolis Planning Project –	English	N/A	MMWD	SLLRDC	Document
05-10	Mirigama – Industrical Township Master Plan	English	2016	MMWD	SLLRDC	Document
05-11	Science & Technology city Mater Plan - Draft 01-	English	Oct 2016	MMWD	SLLRDC	Document
05-12	The Megapolis Western Region Master Plan- 2030 Sri Lanka From Island to Continent	English	N/A	MMWD	SLLRDC	Document
05-13	Design of Pumping Scheme for Storm Water Drainage – Mudun Ela Integrated Drainage & Rehabilitation Project	English	Jan 2012	SLLRDC	SLLRDC	Document
05-14	Design of Mudun Ela Development Project – Construction of Pumping Station at Oliyamulla	English	N/A	N/A	SLLRDC	Document
05-15	Flood Mitigation in Metro Colombo & Kolonnawa Basins	English	N/A	N/A	SLLRDC	Power Point
05-16	National Physical Planning Policy and Plan Sri Lanka - 2030	English	Apr 2010	NPPD	SLLRDC	Document
05-17	Projects Identification Report, Western Region Megapolis Planning Project	English	N/A	Ministry of Megapolis and Western	SLLRDC	Document
05-18	Sri Lanka 2011 – 2030 National Physical Plan and Project Proposal	English	Mar 2012	National Physical Planning Department	SLLRDC	Document
■06 Urban Development Authority (UDA), MMWD						
06-01	Declaration of Urban Areas and Approved Development Plans	English	N/A	N/A	UDA	Document
06-02	Integrating Hazard Risk Information into Kanthale Urban Development Plan, Sri Lanka	English	Jul 2011	DMC and UDA	UDA	Document
06-03	Guidelines for Western Province Wetlands Zoning & Relevant Regulations for Application in Urban Development Plan Preparation	English	2006	UDA	UDA	Document

No.	Title	Language	Date of Issue	Publisher	Place of Obtain	Form/Style
06-04	Annual Report 2013, Urban Development Authority	English	2007	UDA	UDA	Document
06-05	Urban Development Authrity (Amendment) Act, No.41 of 1988	English	Nov 1988	Parilament of the Democratic socialist Republic of Sri Lanka	UDA	Document
■07 Road Development Authority (RDA)						
158	Annual Report 2015, Road Development Authority	English	N/A	RDA	RDA	Document
158-1	Landslide Disaster Protection Project of the National Road Network: Loan SL-	English	N/A	PMU, LDPP	RDA	Power Point
158-3	Act to Provide for the Establishment of the Road Development Authority	English	1981	GoSL	RDA	Document
■08 Local Authorities						
08-01	Naitonal Policy on Local Government No.1632/26	English	Dec 2009	GoSL	Local Authorities	Document
08-02	Provincial Councils Act. No.42 of 1987	English	1987	GoSL	Local Authorities	Document
08-03	Organization Chart – Colombo District	English	N/A	Colombo District	Local Authorities	Figure
■09 United Nation Development Programme (UNDP) / World Bank (WB)						
09-01	Integrated Post Flood Assessment May 2010	English	Dec 2011	IPFA Team	UNDP	Document
09-02	Sri Lanka Post-Disaster Needs Assessment – May 2016 Floods and	English	Nov 2016	MoDM	UNDP	Document
09-03	Project Document: Strategic support to operationalize the Sri Lanka Comprehensive Disaster Management	English	N/A	UNDP and MoDM	UNDP	Document
09-04	Sri Lanka Floods and Landslides Mayy 2016 Post-Disaster Needs Assessment	English	N/A	UN, EU, WB and Government of Sri Lanka	UNDP	Power Point
09-05	CRIP2 Preliminary Study for Meteorology and Hydrology	English	2016	World Bank	DOM	Document
■10 Sri Lanka Red Cross Society (SLRCS)						
10-01	Sri Lanka Red Cross Society -Flood and Landslide Operation-	English	May 2016	SLRCS	SLRCS	Document
10-02	Strategic Plan 2015-2017	English	N/A	SLRCS	SLRCS	Document
■11 Central Environmental Authority (CEA)						
11-01	Medium to Long-term Multi-Stakeholder Strategy and Action Plan for Management and Conservation of the Kelani River Basin 2016-2020 – Final Report	English	Jan 2016	Central Environment Authority and International Union for the Conservation of Nature Sri Lanka	CEA	Document
11-02	Medium to Long-term Multi-Stakeholder Strategy and Action Plan for Management and Conservation of the Kelani River Basin 2016-2020 – Natural Resource Profile	English	Jan 2016	Central Environment Authority and International Union for the Conservation of Nature Sri Lanka	CEA	Document
11-03	Medium to Long-term Multi-Stakeholder Strategy and Action Plan for Management and Conservation of the Kelani River Basin 2016-2020 – Map compendium	English	Jan 2016	Central Environment Authority and International Union for the Conservation of Nature Sri Lanka	CEA	Document
11-04	Medium to Long-term Multi-Stakeholder Strategy and Action Plan for Management and Conservation of the Kelani River Basin 2016-2020 – Preliminary Perception Survey	English	Jan 2016[\	Central Environment Authority and International Union for the Conservation of Nature Sri Lanka	CEA	Document
■12 National Water Supply and Drainage Board (NWSDB)						
12-01	Corporate Plan 2016 - 2020	English		NWSDB	Web Site	Document
12-02	List of Regional Support for Drought	English		NWSDB	NWSDB	Document
12-03	List of Groundwater Development for W	English		NWSDB	NWSDB	Document
■13 Water Resources Board (WRB)						
13-01	The Gazette of the Democratic Socialist Republic of Sri Lanka Extraordinary	English		Ministry of Irrigation and Water Resources Management	WRB	Document
13-02	Annual Report 2014	English		WRB	WRB	Document
■14 Ministry of Mahaweli Development and Environment (MMDE)						
14-01	The National Climate Change Adaptation Strategy for Sri Lanka 2011 to 2016	English		MMDE	MMDE	Document
14-02	National Adaption Plan for Climate Change Impacts in Sri Lanka 2016 -			MMDE	MMDE	Document
■15 Department of National Community Water Supply (DNCWS)						
15-01	Vision & Mission	English		DNCWS	DNCWS	Power Point