COMPARATIVE STUDY ON PREPARATION OF EMERGENCY RESPONSE, RECOVERY PLAN AND STRUCTURAL COUNTER MEASURES FOR FLOOD IN JAPAN AND SRI LANKA

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DMC SRI LANKA

ASIAN DISASTER REDUCTION CENTER

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A PROJECT REPORT PRESENTED BY

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DECLARATION

I do hereby declare that the work reported in this research project report was exclusively carried out by me under the supervision of Ms. KODAMA Miki, Deputy Director, and Research Department of Asian Disaster Reduction Centre. It describes the results of my independent research except where due reference has been made in the text. No part of this research project report has been submitted earlier or concurrently for the same or any other VR course

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A.M.R.N.K. Alahakoon

In the recent past, Sri Lanka has been experiencing an increase of intensity and frequency of natural disasters. Therefore, this visiting research study was carried out to introduce the Japan flood hazard response and recovery plan activities in the pre disaster and post disaster event comparative with Sri Lanka contents and it can be included to implement in Sri Lanka. The study area was selecting the National Disaster Management Plan comparatively with Japan and Sri Lanka and went through deeply with two countries plans and compared on preparation of emergency response, recovery plan and structural counter measures for flood in Japan and Sri Lanka. The study was conducted to analysis through the secondary data collection on the focus on flood hazard. The study was identified the best practices of Japanese government currently practicing as disaster preparedness counter measures and identifying the best match technologies and other parameters which can be directly applied to Sri Lanka Disaster Management System focusing the attention to flood hazard.

The research method mainly focused on gathering information from secondary data and participatory method. Specially participating community drill at Kobe Minato shonan junior high school and Iza! Mikaeru Dai Caravan programme gave comprehensive ides on the practical intervention of the Japanese DRM system. By visiting places such as disasters museum like Great Hanshin Awaji Memorial museum, Earthquake museum in Awaji Island, Higashi Matsushima City and Disaster Recovery Memorial Museum, DM institutions such as Kobe Local Meteorological Office, Hyogo Disaster Management Center, Rokko Sabo Office, Tokyo Rinkai Park, PASCO mapping institute, Takatori Community Center and Cabinet Office etc collected more information on disaster preparedness countermeasures and overall disaster management system in the Japan. Further, during my study period participated to International forum such as International Recovery Forum 2020 and International Disaster Reduction Alliance Forum 2020.

Gathering information with secondary data was the main resource for the investigation. Based on this research, one of the objectives was to study the legal framework of the disaster and the revolutionary changes in acts and the policy document in the event of a flood disaster. After gathering the information through reference documents, the practitioner is ready to proceed with verification and additional information from a particular authority or to visit them for presentation or clarification.

Finally, the Japanese government has invested a large amount of money in disaster mitigation projects to improve civilians. Compared to other countries in the world, the highest investment per capita seems to be the case of disaster mitigation. Japan is the best example in the world that has developed all development projects taking into account disaster risk reduction measures.

ACKNOWLEDGEMENTS

First of all, I would like to express my heartiest gratitude that I had an opportunity to gain hands-on experience in Japan from many in writing this report. I must place on record my sincere gratitude both of the government of Japan and Sri Lanka.

I am sincerely grateful to the Asian Disaster Reduction Centre (ADRC), Ministry of Defense of Democratic Republic of Sri Lanka and Disaster Management Centre (DMC) for their great support and guidance to participating this program as a visiting researcher, FY 2019B

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I record with great appreciation the advice, suggestions, and encouragement provided by My supervisor Deputy Director, Research Department Ms Miki KODAMA, Our course Coordinator Senior Researcher Dr Makoto IKEDA, Asian Disaster Reduction Centre.

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I am grateful to gain the support of World Bank Consultant Mr S. Suthakaran guided me throughout the study period.

Finally, I must thank my wife, Thejavine, my sons Hasaru, Chamiru, Janiru, my daughter Danudi and my parents who had to give up all the time that I could not spend with them while I was juggling a full-time career and this course of study in Japan.

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AD	Anno Domini
ADRC	Asian Disaster Reduction Centre
BC	Before Christ
CCTV	Closed-Circuit Television
DCBA	Disaster Countermeasures Basic Act
DDMCU	District Disaster Management Coordinating Unit
DM	Disaster Management
DM	Department of Meteorology
DMAT	Disaster Medical Assistant Team
DMC	Disaster Management Center
DRM	Disaster Response Mechanism
EOC	Emergency Operation Centre
FDMA	Fire and Disaster Management Agency
FEMA	Federal Emergency management Agency
GFDRR	Global Facility for Disaster Reduction and Recovery
GN	Grama Niladhari
ID	Irrigation Department
JMA	Japan Meteorological Agency
JMAT	Japan Medical Association Team
LRRD	Linkage of Relief, Rehabilitation and Development
MDM	Ministry of Disaster Management
MIC	Ministry of Internal Affairs and Communications
MHLW	Ministry of Health, Labor and Welfare
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MOIWR	Ministry of Irrigation and water resources
NBRO	National Building Research Organization
NDRSC	National Disaster Relief Services Centre
NEOP	National Emergency Operation Plan
NFI	Non Food Items
NGO	Non-Government organizations
NMC	National Meteorological Centre
NPO	None Profit Organizations
SDF	Self Defense Force
SLCDMP	Sri Lanka Comprehensive Disaster Management Program
SLLRDC	Sri Lanka Land Reclamation and Development Cooperation
SOP	Standard Operation Procedures

Chapter1

INTRODUCTION

1.1 OVERVIEW

Emergency management is the organization and management of resources and responsibilities for addressing all aspects of an emergency, especially, Mitigation, Preparation, Response, Recovery and Rehabilitation. Emergency management includes plans, structures and arrangements which are established to include the normal efforts of governments, voluntary and private organizations in a comprehensive and coordinated manner to meet all emergency needs. This is also called disaster management.

Federal Emergency management Agency (FEMA) of the United State set eight principles of emergency management. The summary of them are provided as follows.

Emergency management must be:

01. Comprehensive – Emergency management considers and takes into account all hazards, all stakeholders and all aspects relevant to disaster.

02. Progressive – Emergency management anticipate future disasters and take preventive and preparatory measures to build disaster-resistant and resilient communities.

03. Risk Driven – Emergency management use sound risk management principles (Hazard identification, risk analysis and impact analysis) in assigning priorities and resources.

04. Integrated – Emergency management ensure unity of effort among all levels of government and all elements of a community.

05. Collaborative – Emergency management create and sustain broad and sincere relationship among individuals and organization to encouraged trust, advocate a team atmosphere, build consensus and facilitate communication.

06. Coordinated – Emergency managers synchronized activities of all relevant stakeholders to achieve a common purpose.

07. Flexible – Emergency management use creative and innovative approaches in solving disaster challengers.

08. Professional – Emergency management value a science and knowledge based approach based on education, training, experience, ethical practice, public stewardship and continuous improvement. Four stages of emergency management show in figure 1.1

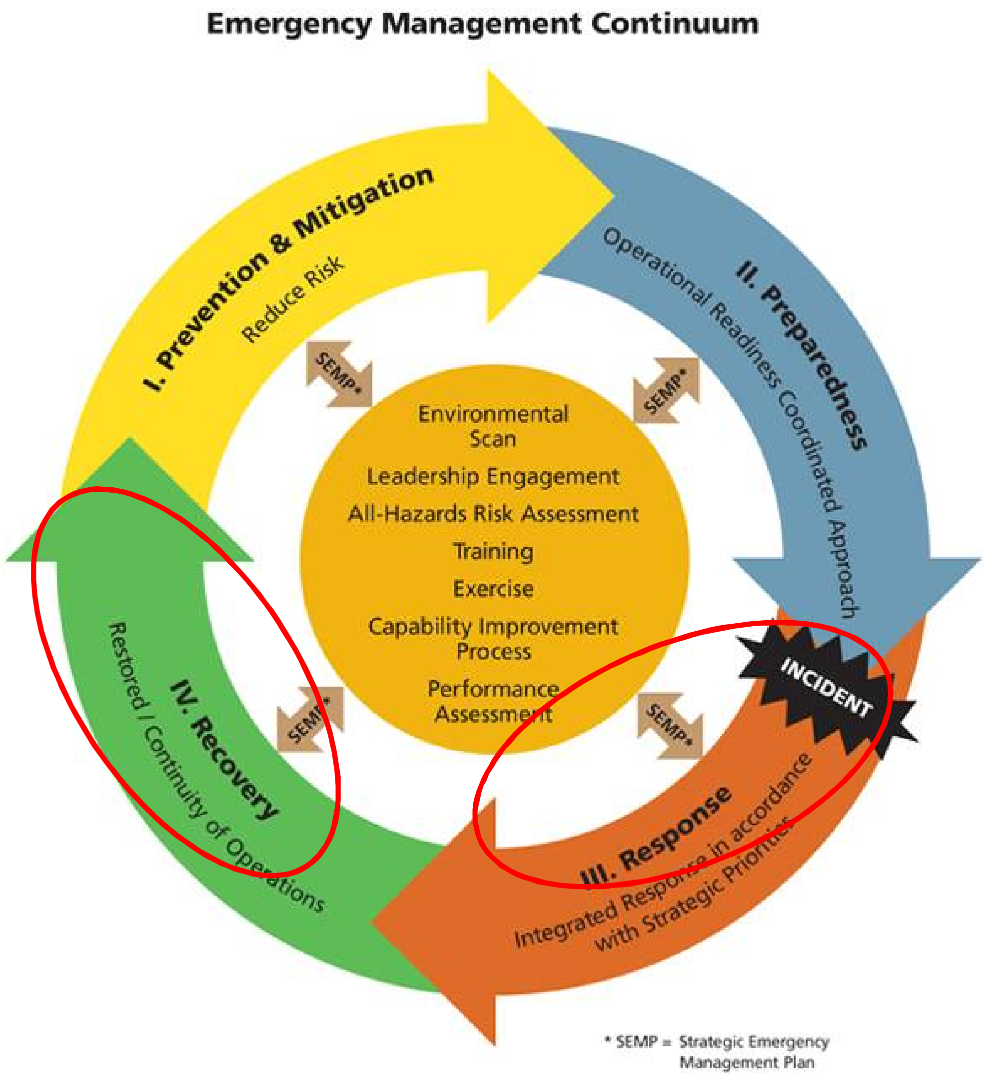


Figure 1.1: Four phases of emergency management characteristics

- **Mitigation -** Mitigation is to lessen or minimize the adverse impacts of a hazardous event. The adverse impacts of hazards, in particular natural hazards, often cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Mitigation measures include engineering techniques and hazard-resistant construction as well as improved environmental and social policies and public awareness.
- **Preparedness** – Preparedness is the knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to

effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters. Preparedness action is carried out within the context of disaster risk management and aims to build the capacities needed to efficiently manage all types of emergencies and achieve orderly transitions from response to sustained recovery.

Preparedness is based on a sound analysis of disaster risks and good linkages with early warning systems, and includes such activities as contingency planning, the stockpiling of equipment and supplies, the development of arrangements for coordination, evacuation and public information, and associated training and field exercises. These must be supported by formal institutional, legal and budgetary capacities. The related term "readiness" describes the ability to quickly and appropriately respond when required.

- **Response –** Response is the actions taken directly before, during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected. Disaster response is predominantly focused on immediate and short-term needs and is sometimes called disaster relief. Effective, efficient and timely response relies on disaster risk-informed preparedness measures, including the development of the response capacities of individuals, communities, organizations, countries and the international community.

  The institutional elements of response often include the provision of emergency services and public assistance by public and private sectors and community sectors, as well as community and volunteer participation.

- **Recovery –** Recovery is restoring or improving of livelihoods and health, as well as economic, physical, social, cultural and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and "build back better", to avoid or reduce future disaster risk.

1.2 BACKGROUND AND SIGNIFICANCE OF THE STUDY

Flooding accounts for a third of the average annual economic losses caused by natural disasters worldwide. Flood damage resulting from typhoons and torrential rainfall is increasing each year. Sri Lanka is affected by a variety of natural disasters, including climatic events such as cyclones, monsoon rains and the resulting floods and landslides (DMC, 2019). Droughts are also common due to variations in monsoons followed by lightning, coastal erosion, epidemics, and pollution. The 2004 December 26 Indian Ocean Tsunami severely hit Sri Lanka. Among these, localized and seasonal floods represent the greatest threat to populations, and the flood risk profile increases due to the expected increase in the impact and frequency of hydro-meteorological risks (GFDRR, 2017).

Natural hazards can destroy decades of effort and investment in seconds. Given that natural hazards have a significant negative impact on long-term development, they represent a threat to sustainable development. Each year, natural disasters cause serious economic and social setbacks in the country's priorities for development and poverty reduction.

When disasters strike, infrastructure such as houses, schools, hospitals, government buildings, roads, bridges, crops, and livelihoods are also destroyed. The meager resources allocated to development should be used for relief and rehabilitation activities. The amount spent on relief activities can be minimized if preparedness plans have been developed in public institutions. Similarly, development activities can sometimes lead to new risks unless disaster risk considerations are included and significantly integrated into the development planning process. (DMC, 2005; Road Map for Safer Sri Lanka).

Since the 2004 Tsunami, the government of Sri Lanka has taken significant steps towards strengthening legislative and institutional arrangements for disaster risk management. In May 2005, the Sri Lanka Disaster Management Act No.13 of 2005, which provides the legal basis for instituting a disaster risk management system in the country, was enacted. According to Sri Lanka's Disaster Management (DM) Act of May 2005, all ministries, public administrations, public corporations, government agencies, and private institutions must develop a Disaster Management Plan. DM plans were developed from the national level to sub-national levels for responding to disasters if and when they occur.

Sri Lanka has many flood-prone areas and was categorized one of the three most affected countries in the 2017 estimate in terms Climate-related losses, second in the climate risk index measures death and economic loss due to extreme weather conditions (Eckstein et al., 2019). Unusual events like the 2017 floods after a heavy monsoon, contributed to the state of emergency since the event left more than 200 dead and displaced more than 600,000 people in 12 districts (Eckstein et al., 2019). Economic losses after the 2017 floods increased by 50% compared to the previous decade between 2007 and 2016. We should be ready to reduce the impact of flood risks during and after the floods. Therefore, the development of emergency response and recovery plan for flood is an urgent task for Sri Lanka. Further, some structural measures against the flood should be considered.

Japan has been also facing a flood situation similar to that of Sri Lanka. They have developed very good emergency response and recovery plans. Flood-related projects have been very effectively implemented in Japan to reduce flood risks.

1.3 JUSTIFICATION AND SCOPE OF THE PROBLEM

Sri Lanka is a small island in the Indian Ocean in the path of two monsoons, and frequently affected by weather-related hazards. It is surrounded by 1,340 kilometers of beach frontage and with an abundance of breathtaking inland waterways, including rivers, lakes, reservoirs and tanks. Floods mostly due to monsoonal rain or effects of low-pressure systems and droughts due to failure of monsoonal rain are the most common hazards experienced in Sri Lanka. Flood is more commonly occurred in Sri Lanka than the other natural disasters. 2016 Colombo flood situation in Sri Lanka is shown in figure 1.2.1.

Figure 1.2.1: 2016 Colombo flood situation in Sri Lanka
Source:https://www.straitstimes.com/asia/south-asia/230000-displaced-by-sri-lanka-floods

The water resources map of 1959 identified 103 river basins of which about 10 rivers are considered as major. Sri Lanka Rivers map showing in figure 1.2.2.

Figure 1.2.2: River basing map of Sri Lanka

Among these major rivers Kalani, Gin, Nilwala and Mahaweli are vulnerable to floods. The increase in population and subsequent need for land have forced more and more people to live and work in these vulnerable areas, thereby intensifying the risk to life and property in the event of major floods. Heavy rainfall and run off the large volume of water from the catchment areas of rivers, deforestation, improper land use and the absence of scientific soil conservation practices could be identified as the major factors for floods in Sri Lanka. Moreover, with global heating due to the greenhouse effect, tropical countries are expected to get less annual rainfall, but increased rainfall intensities.

The average annual rainfall ranges from 550 mm to 5500 mm. The highest rainfall recorded 805 mm at Kanukken in 1897 and 508 mm at Nedunkerni in 1911. Due to the

Southwest and Northeast monsoon rains, floods occur in the Island. The districts of Kegalle, Ratnapura, Kalutara, Colombo, Gampaha and Gall are subject to floods on account of Southwest monsoon rains (figure 1.2.3) while Ampara, Trincomalee, Badulla, Polonnaniwa, Batticaloa, Matale, Anuradapura, and Monaragala suffer from the Northeast rains (figure 1.2.4).

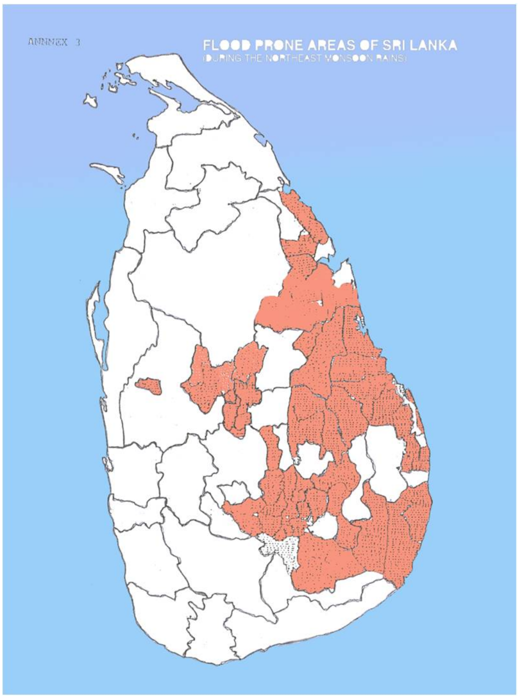


Figure 1.2.3: Flood Prone areas during South west Monsoon (May – Sep)

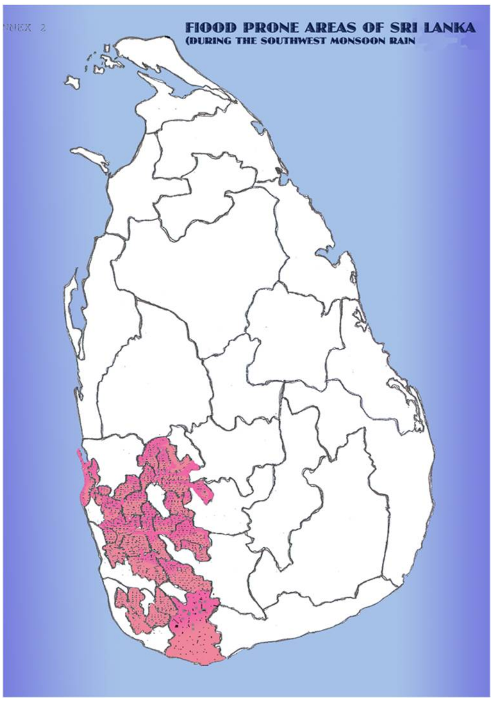


Figure 1.2.4: Flood Prone areas during North East Monsoon (Dec – Feb)

Recently, flood and flash flood phenomenon has become a serious problem in Sri Lanka. This phenomenon occurred due to rainfall intensity and uncontrolled development especially in low areas such as Kegalle, Ratnapura, Kalutara, Colombo, Gampaha, Gall, Ampara, Trincomalee, Badulla, Polonnaniwa, Batticaloa, Matale, Anuradapura, and Monaragala districts. The flood tragedies have perished many lives and also destroyed infrastructure facilities such as buildings, roads, recreational park, houses, bridges and others. This phenomenon also caused a major socio-economic impact on people and their livelihood. Most of these tragedies were triggered by the misuse of land-use practices.

Therefore, the development of emergency response and recovery plan for flood is an urgent task for Sri Lanka. Further, some structural measures against the flood should be considered. Japan has been also facing a flood situation similar to that of Sri Lanka. Japan have developed very good emergency response and recovery plans. Flood-related projects have been very effectively implemented in Japan to reduced flood risks. After this comparative study, I can identify recent gaps in the flood management system in Sri Lanka and can gain much more knowledge about Japanese flood management system. Some good practices in Japan for flood management can be recommended to Sri Lanka for improving DRR measures.

1:4 OBJECTIVES

- To Study the flood emergency and recovery plans in Japan and how to adapt them to Sri Lanka.

- To study on immediate and effective emergency response, especially considering gender-equitable and universally accessible approaches (children, women, elderly, disabled etc.)

- To study on rehabilitation & reconstruction programs incorporating Disaster Risk Reduction components.

- To study the structural counter measures for flood hazard in Japan and propose appropriate measures for Sri Lanka.

- To recommend the mitigation measures and strategies to restore the ecosystem.

Chapter 2

METHODOLOGY

2.1 DATA COLLECTION

A. Primary Data Collection

Based on the secondary data acquired, primary data is collected through lectures and field visits in Japan

B. Secondary Data

Following value is collected with secondary data:

DRR Plans in Japan and Sri Lanka

- ✓ Major disaster management laws/act, regulations and programs of Japan and Sri Lanka.
- ✓ Flood Response and recovery plan in Japan and Sri Lanka.
- ✓ Details of structural counter-measures against flood in Japan and Sri Lanka.
- ✓ Other Required data and information based on emergency response and recovery system in Japan and Sri Lanka.

C. Historical Document in Japan and Sri Lanka

Extract data on past flood management practices from some historical document in Japan and Sri Lanka, if possible. The lessons learned is referred to propose how to improve the system**.**

D. Observations

Several exploratory visits to some areas during my course duration were used to check the reality of good practices on the ground. This fieldwork also includes a discussion with three administrative level (National, Prefecture and local) stakeholders, especially on matters of flood management in Japan. Observations were made to understand the physiographic relationships of DRR Plans in Japan.

2.2 DATA ANALYSIS

The study is to compare Japan's existing flood emergency management system with ones in Sri Lanka using the collected primary and secondary data to find the gaps and consider adaptation to the Sri Lanka emergency management plan.

2.3 LIMITATION OF THE RESEARCH

Time: Three months' period is not enough to gather all the data with other works. Due to the time constraints, the number of documents reviewed is limited.

Field observation: Due to the time limitation, felid visit for direct discussion with flood affected communities and the response and recovery agencies will not be realized.

Chapter 3

STUDY AREA

The study area is Japan and Sri Lanka:

3.1 WHERE IS JAPAN LOCATED?

Japan is an island country in Asia bordering the Pacific Ocean. Just off the east of Asian continent, Japan is made up of 6,852 island in total. The latitude of Japan is 36.2048° N and the country's longitude is 138.2529° E as a part of the northern hemisphere. Figure 3.1.1 is shown the map of Japan.

Figure 3.1.1: Location Map of Japan

3.2 GEOGRAPHY OF JAPAN

Japan is an archipelago of around 6,852 islands located in the Ring of Fire of the Pacific Ocean. Almost continuous series of trenches, volcanic arches, and changing tectonic folds' account for the fact that there are 75% of active volcanoes in the world and 90% of earthquakes in the world occur along the Ring of Fire. Mountains cover more than 75% of the earth's surface in Japan. Geologically speaking, Japan is still a young area because the mountain is steep. Opposite to the north-south direction of central Honshu, there are three main mountain ranges collectively known as Japanese Alps: Hida, Kiso and Akaishi There are 23 mountains with peaks over 3,000 m (9800 ft.), and highest mountain is the magnificent Mt. Fuji, 3,776 m (12,388 feet). Japan has 111 active volcanoes including Mt. Fuji. With an average of 2,000 mild shocks per year, earthquakes of magnitude 6.0 and greater occur average 16 times in a year in Japan. One of the largest earthquakes in Japan is the Great Kanto Earthquake of 1923, when the Tokyo-Yokohama area was devastated and more than 105,000 people died. Japan Topographic map shown in figure 3.2.1.

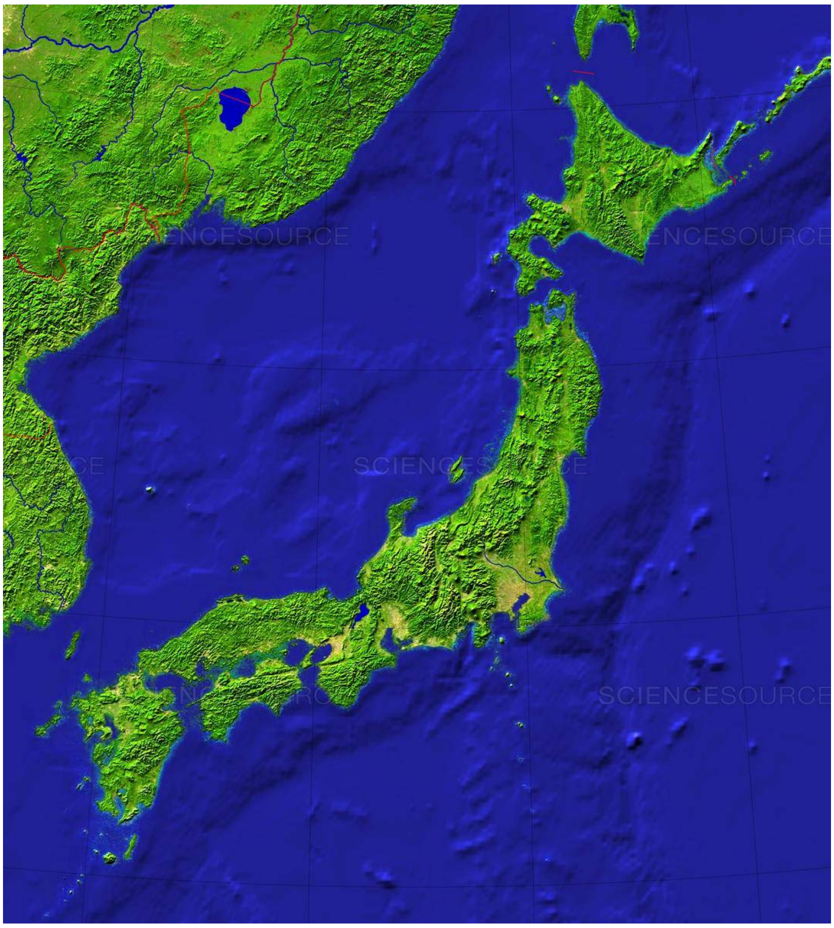


Figure .3.2.1 Topographic Map of Japan

1. https://www.data.jma.go.jp/svd/vois/data/tokyo/STOCK/souran_eng/intro/volcano_list_b.pdf
2. https://www.data.jma.go.jp/svd/eqev/data/higai/higai-1995.html

Japan has four main islands, Honshu, Hokkaido, Kyushu and Shikoku. These islands represent 97% of the total area of the country. Tokyo and many other major cities including Yokohama, Osaka, Nagoya, Kobe, Kyoto, Kawasaki, Hiroshima and Sendai, are located in Honshu in Japan,

Hokkaido, the second major island in Japan and the northernmost prefecture, occupies almost a quarter of Japan's arable land. Hokkaido leads 46 other prefectures in Japan. (Figure 3.2.2).

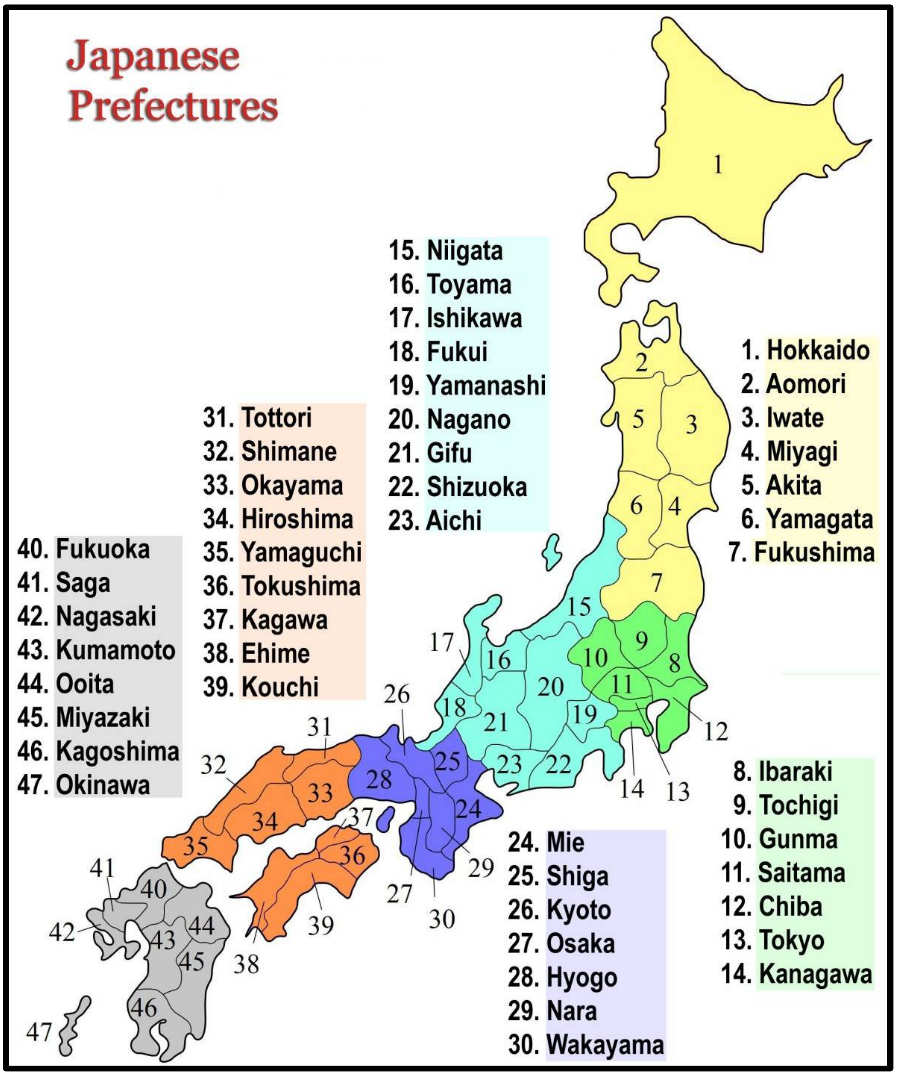


Figure 3.2.2: Prefecture Map of Japan

Hokkaido producing abundant seafood and producing various agricultural products such as soybeans (a major component of tofu and miso), wheat, corn, meat, and raw milk. Sapporo is the prefectural capital and biggest city of Hokkaido and holds the annual Sapporo Snow Festival. Kyushu is the third largest island of Japan with a lot of active volcanic mountains. Fukuoka, Kitakyushu, Kumamoto, Kagoshima and Nagasaki are the cities with historical, political, and commercial significance.

3.3 CLIMATE OF JAPAN

An important feature of Japan's climate is net temperature change between four seasons. From north to south, Japan covers a latitude range of about 25 degrees. The climate in winter is influenced by seasonal wind blowing from Siberia and for the one in summer by seasonal wind blowing from Pacific. Despite its rather small area, Japan has four characteristics weather patterns (Figure 3.3.1.).

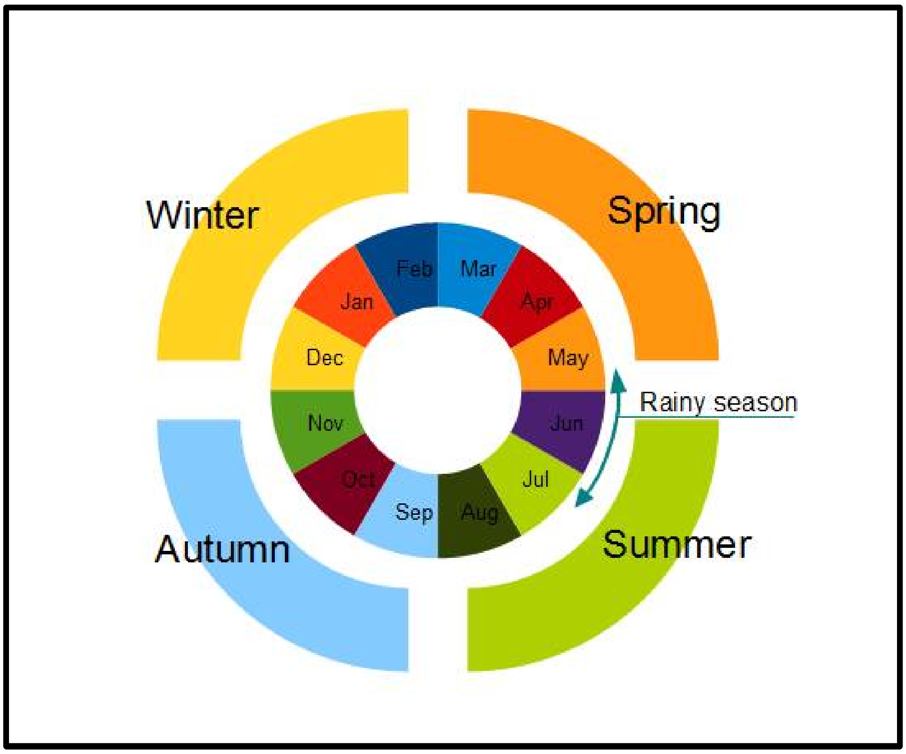


Figure .3.3.1 four characteristics weather model of Japan

Hokkaido, with a subarctic climate pattern, has an annual average temperature of 9.45 degrees centigrade, and average annual rainfall is about 1,205 mm. Pacific Ocean side of Japan, from the Tohoku region in northern Honshu to Kyushu belongs to the temperate zone, and its summer is hot influenced by seasonal Pacific wind. Side of the country facing to the Sea of Japan has a rainy and snowy weather, produced by the condition cold and wet seasonal winds from the continent are stopped by the Central Alps etc. which penetrate Central Japan like a backbone. Okinawa belongs to the subtropical region climatic zone with annual average temperature 22 degrees or more, and the reception of more than 2000mm precipitation. Figure 3.3.2 shows major climate differences and climate zones in Japan.

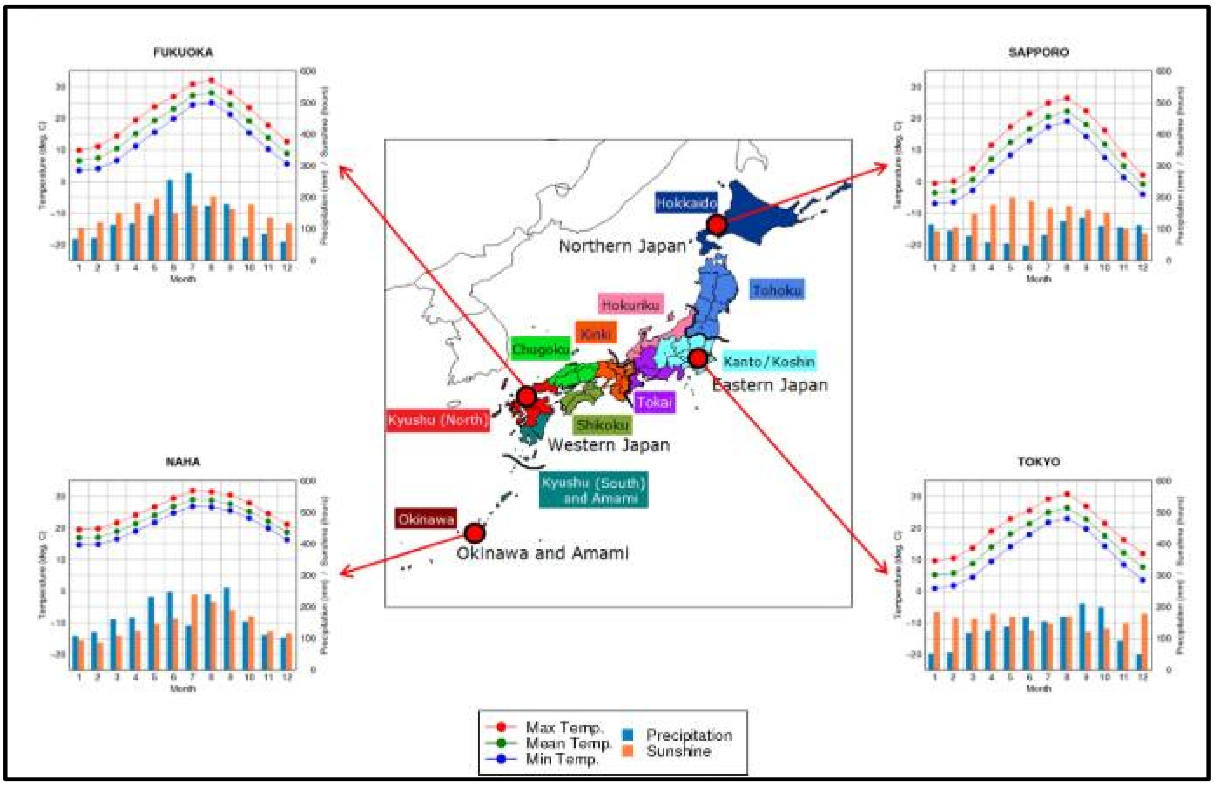


Figure .3.3.2 Climate Differences and Climate Zone of Japan

- **3.3.1 Winter Season (December, January and February):** Near the end of November, seasonal cold winds begin to blow through Japan. These northwest winds bring humidity from Sea of Japan in the form of rain and snow on the west side of Japan blocked by the ridge of mountains crossing the central part of the country. Hokuriku region (Fukui, Ishikawa, Toyama and Niigata) which faces the Sea of Japan and separate from the rest of Japan by alpine is famous for its deep snow. On the contrary, the Pacific side of the country usually has sunny weather in winter season. In Tokyo, despite the clear sky, winter average temperature is about 5 degrees, 25 degrees difference from summer temperatures. Okinawa prefecture islands located in the southwest end has a subtropical climate, the small temperature difference between the seasons. Winter temperature there much milder than elsewhere country.

- **3.3.2 Spring Season (March, April and May):** After winter, seasonal cold winds blowing from the continent become weaker and more intermittent. Low pressure air mass from China enter the Sea of Japan and strong and warm winds from south are moving to this low pressure area from Pacific Ocean. While the first of these winds is announcing the coming of Spring Season, it sometimes causes an avalanches.

Also side of the country facing to the Sea of Japan sometimes very warm and dry weather, which can even cause a big fire.

- **3.3.3 Summer Season (June, July and August):** Before the true summer weather comes, Japan has a rainy season from May to July, when there is a mass of high-pressure cold air above the Sea of Okhotsk in Northern Japan and there is a mass of high-pressure warm air over the Pacific Ocean. Along the line these hot and cold air masses meet, rainy season front known as a baiu zensen (in Japanese) often develop areas of low-pressure warm air. The baiu zensen extended from southern China the Japanese archipelago, becomes causes of long-term continuous precipitation. High-pressure air masses over the Pacific Ocean becomes dominant from mid-July, baiu zensen is pushed to the North, and the rainy season is over. Country has hot summer weather with many days when temperatures rise to more than 30 degrees centigrade.
- **3.3.4 Autumn (September, October, and November):** From late summer to September, Japan is usually affected by typhoons. Typhoons originate from massive low-pressure tropical air in the North Pacific between about 5 and 20 degrees latitude, which is a phenomenon similar to hurricanes and cyclones in other parts of the world. As the typhoon begins to take shape, it gradually moves north. Every year, about 25 typhoons occur during this period, an average of about four arrive in Japan, sometimes causing major destruction. Since mid-late October, Japan has generally enjoyed a fine weather, neither cold nor hot. It also benefits from the particularly mild climate of early November.

3.4 WHERE IS SRI LANKA LOCATED?

Sri Lanka is an Island (Figure 1) with a land area of 65,610 square kilometers. It is situated between the 5.55′and 9.51′N, 79.41 and 81.54 E. The Island is 224 Km wide and 432 Km long at its furthest point. Figure 3.4.1 showing location map of Sri Lanka.

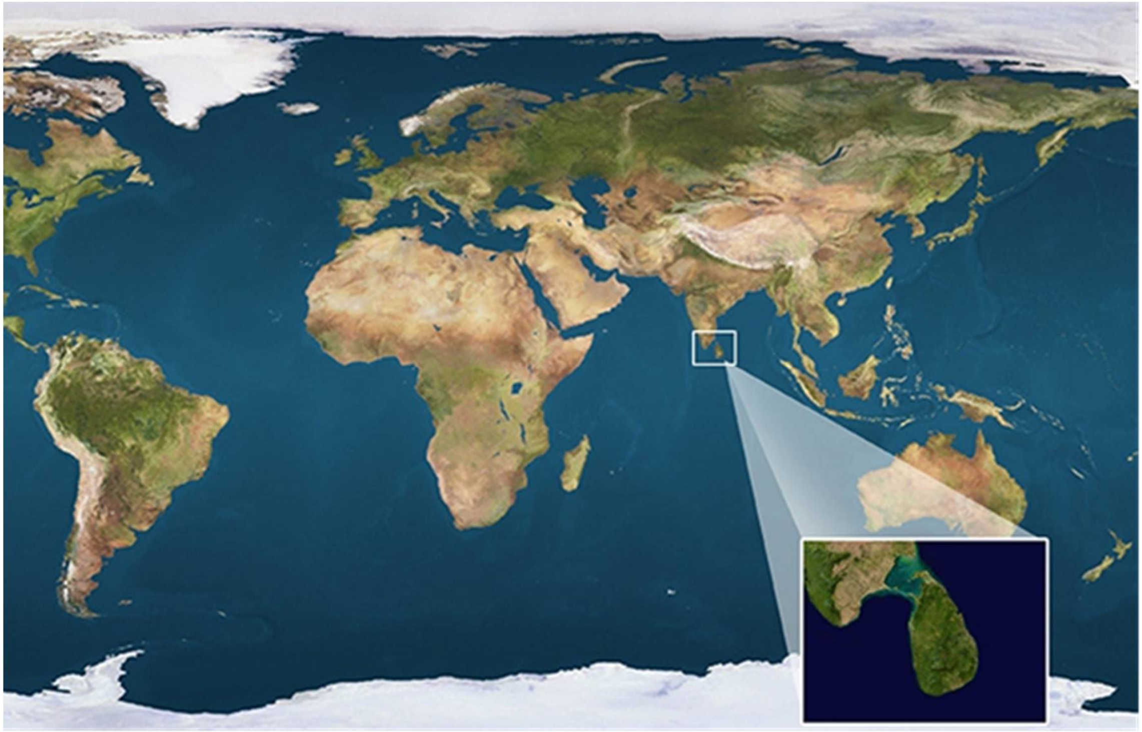


Figure .3.1.1 Location Map of Sri Lanka

3.5 GEOGRAPHY OF SRI LANKA

In generally Sri Lanka has a variety of terrain, but is mainly composed of plains. In the south central part of the country, there are mountain and river. The central part of the southern half of the island is mountainous with heights more than 2.5 Km. The core regions of the central highlands contain many complex topographical features such as ridges, peaks, plateaus, basins, valleys and escarpments. The remainder of the island is practically flat except for several small hills that rise abruptly in the lowlands. These topographical features strongly affect the spatial patterns of winds, seasonal rainfall, temperature, relative humidity and other climatic elements, particularly during the monsoon season. Topographic map shown in figure 3.5.1.

Figure 3.5.1: Topographic Map of Sri Lanka

Sri Lanka's highest Mountain is Pidurutalagala which is 2,524 meters in height and Mountain of Pidurutalagala. Figure 3.5.2 showing Pidurutalagala Mountain in Sri Lanka.

Figure 3.5.1: Pidurutalagala Mountain in Sri Lanka

Most of the island's surface consists of plains between 30 and 200 meters above sea level. Hundred and three rivers in the Central Highlands and flow in a radial pattern toward the sea. Most of these rivers are short. There are 16 principal rivers longer than 100 kilometers in length, with twelve of them carrying about 75% of the mean river discharge in the entire country. The longest rivers are the Mahaweli Ganga (335 km) and the Malwathu Oya (164 km).

In the highlands, river courses are frequently broken by discontinuities in the terrain, and where they encounter escarpments, numerous waterfalls and rapids have eroded a passage. Once they reach the plain, the rivers slow down and the waters meander across flood plains and deltas. The upper reaches of the rivers are wild and usually un-navigable, and the lower reaches are prone to seasonal flooding. Human intervention has altered the flows of some rivers in order to create hydroelectric, irrigation, and transportation projects. In the north, east, and southeast, the rivers feed numerous artificial lakes or reservoirs (tanks) that store water during the dry season. More than 90% of Sri Lanka's surface lies on Precambrian strata, some of it dating back 2 billion years.

3.6 CLIMATE OF SRI LANKA

The Climate in Sri Lanka is tropical and consists of very distinctive dry and wet seasons. The average temperature of Sri Lanka usually ranges from 28 – 32 degrees Celsius which may differ due to global weather conditions as a whole. The temperature can vary from being as low as 16 degrees Celsius in Nuwara Eliya which belongs to the central highlands and to as high as 32 degrees in Batticaloa along the Eastern coast of the island. However, there are certain areas along the coast that are cooled by the ocean breezes. The coldest months according to the mean monthly temperature are December and January while the warmest months are April and August. The Climate experienced during 12 months' period in Sri Lanka can be characterized in to four climate seasons as follows. Four climate seasons shown in figure 3.6.1.

- **First Inter-Monsoon Season (March – April)** – Typical weather conditions during this season are particularly uncomfortable with thunderstorm rains in the afternoon or evening.

- **Southwest-Monsoon Season (May – September)** – The warm season is eased away by the windy weather during this particular monsoon season. Rains can be expected during any time of the day.

- **Second Inter-Monsoon Season (October – November)** – Rains occur with thunder storms while the influence of the weather system like depression and cyclones in the Bay of Bengal is considered to be common. The whole island experiences wide spread rain with strong winds.

- **Northeast-Monsoon Season (December – February)** – Cold and dry windy weather can be expected during this season while cloud free and days filled with sunshine can be expected. Rain can be expected in several parts of the island as well.

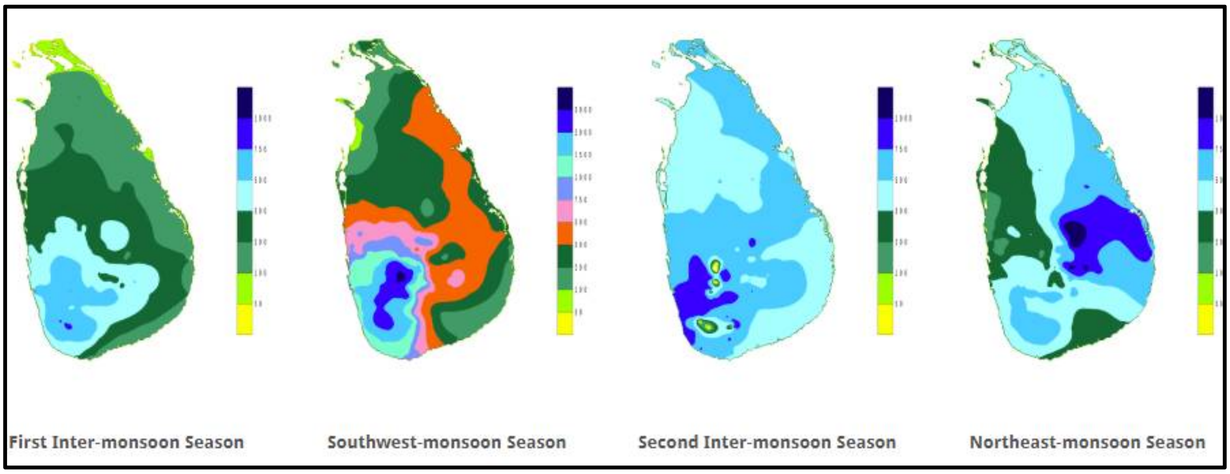


Figure .3.6.1 Four Climate Season Maps of Sri Lanka

Due to increase of global warming and climate change scenarios above mentioned time period has slightly been changed. The rainfall pattern is influenced by the monsoon winds of the Indian Ocean and Bay of Bengal and is marked by four seasons. The mean annual rainfall varies from under 900mm in the driest parts (southeastern and northwestern) to over 5000mm in the wettest parts western slopes of the central highlands. Sometimes tropical cyclones bring overcast skies and rains to the southwest, northeast, and eastern parts of the island. The average yearly temperature for the country, as a whole, ranges from 26° C to 28° C. Annual rain falls map and Annual temperature map shown in figure 3.6.2 and figure 3.6.3.

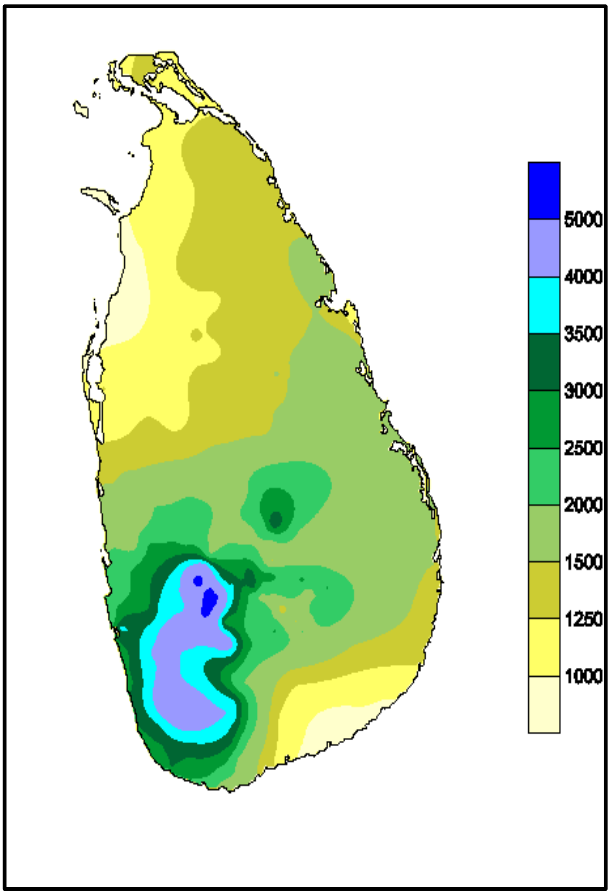


Figure 3.6.2: Annual Rainfall Map of Sri Lanka

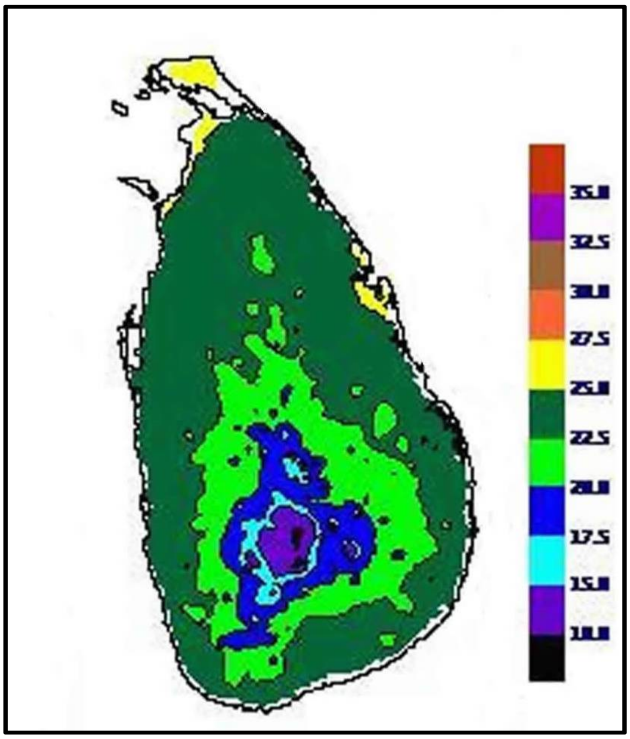


Figure 3.6.3: Annual Temperature Map of Sri Lanka

Chapter 4

DISCUSSIONS AND RESULTS

4.1 GENERAL INTRODUCTION ABOUT FLOOD IN JAPAN

Flood risks are diverse and complex in the world. In the case of Japan, the country is fairly mountainous, and rivers are relatively short and steep. Population density is very high. Most residential and industrial areas tend to be located in lowland areas, along rivers. Risk phenomena such as precipitation, runoff generation and concentration, downstream flood wave propagation, flooding and flood damage change over time and change one after another. It is influenced by the natural conditions of each region, human activities, and the Japanese disaster culture. In Japan, the loss of life and the economic loss of the nation due to floods have decreased significantly in the last 60 years. However, new flood risks are emerging in urban areas, such as increased flood potential, increased exposure to flood risk, and new forms of damage. Figure 4.1.1 showing Degree of urbanization in Japan from 2008 to 2018.

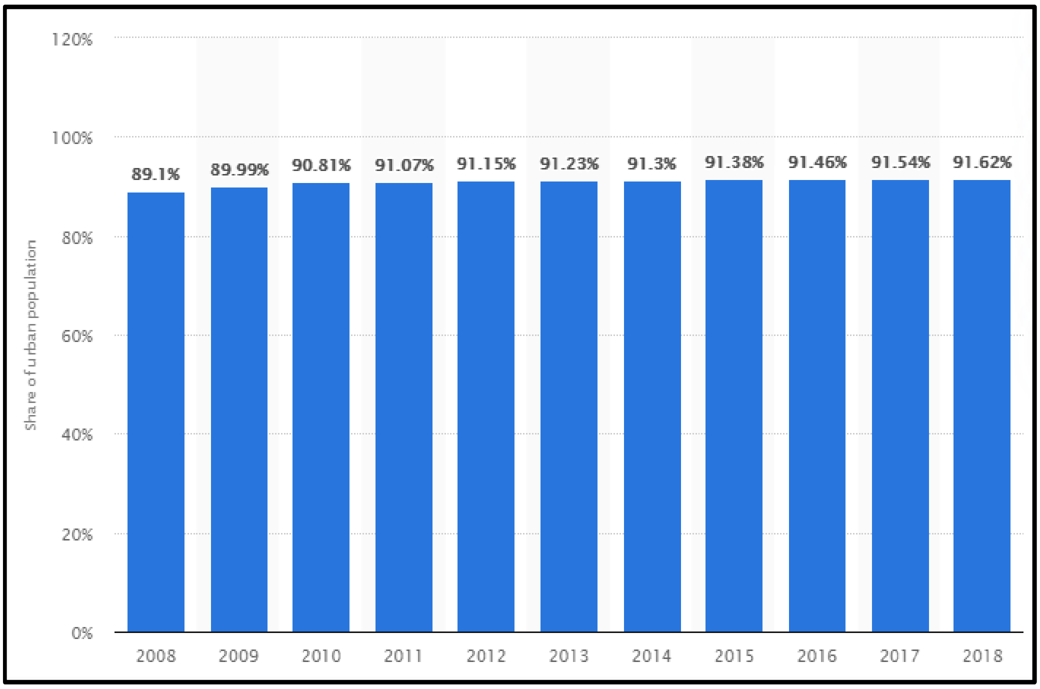


Figure .4.1.1 Degree of urbanization in Japan from 2008 to 2018
Source: https://www.statista.com/statistics/270086/urbanization-in-japan/

Japan is exposed to all types of floods, in particular

• **Storm surge:** Water pressed to shore (coast or large seas) by strong winds, which, when coinciding with tide, can create considerable rise in sea levels

• **River floods:** Such floods are the result of heavy rainfall over several days and over large area. The water level rises also when the soil is saturated

• **Flash floods:** Caused by intense rain over a small area. The soil is not saturated but the rainfall exceeds the infiltration rate and runs off the surface

• **Tsunamis:** Waves generated by large volumes of water being displaced (by earthquakes, landslides or volcanic eruptions). Tsunamis can travel through the open sea for hundreds of kilometers without losing their energy and increase in height when they reach shore – up to 10m.

In cities, rain water is released into rivers and oceans via sanitation. However, if the intensity of precipitation exceeds the design intensity of the sewer, floods will occur. In addition, if the incoming water level is higher than expected, the sewer will not be able to discharge the runoff and cause flooding. Figure 4.1.2 showing Concept of Urban Flooding.

Figure .4.1.2 Concept of Urban Flooding
Source: http://www.mlit.go.jp/river/basic_info/english/pdf/conf_01-0.pdf
https://www.japan-zone.com/news/2018/07/09/japan-flooding-update

For example, in Japan, the recent flooding of a broken embankment has had catastrophic damage and consequences. The general economic loss due to the flooding of the Nagoya metropolitan area due to the 2000 Tokai flood was the worst in 40 years. In 2004, the embankment caused serious damage to some urban areas in the region, and the death of elderly peoples in Niigata has become a serious problem. New risks have also been identified in urban areas. In 2003, the underground shopping Centre Hakata Station in Fukuoka, Japan's sixth-largest city, was flooded and lost life under the building. Figure 4.1.3 showing underground flood Hakata Station Fukuoka municipal subway of Japan, July 2003.

Figure .4.1.3 Underground flood Hakata Station Fukuoka municipal subway of Japan, July 2003
Source: http://www.qsr.mlit.go.jp/bousai/index_c19.html

The river environment has undergone dramatic changes over the last 100 years, with rivers being pushed into man-made waterways, placing them in an artificial, rather than natural environment. Also, awareness of disaster prevention and prevention activities for flood in the local community is decreasing. Mr. Takahashi (1964, 1971) investigated the floods in Japan and showed that floods were not purely natural phenomena and that social conditions played important roles in different regions and regions.

4.1.1 Natural Conditions

The steep mountain ranges that cross the central part of the long and narrow Japanese archipelago are most of their retreat. It can also be found in the summer monsoonal region of Asia. Figure 4.1.1.1 showing world map of summer monsoonal region.

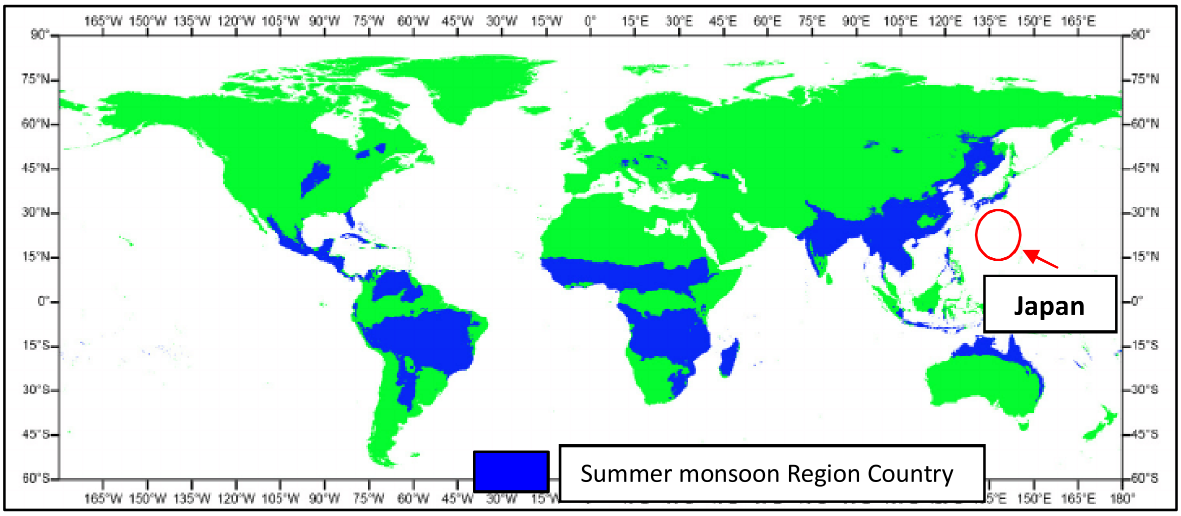


Figure 4.1.1.1: World Map of summer monsoonal regions
Source: https://www.researchgate.net/publication/259166095_A_global-scale_test_for_monsoon_indices_used_in_palaeoclimatic_reconstruction

Japan is characterized by the concentration of precipitation during the rainy and typhoon seasons. Mainland Japan enters into a typhoon season. It may have heavy rain when a strong typhoon passes near Japan when the rainy season is in an active mode. Figure 4.1.1.2 Active Typhoon Map for July in Japan.

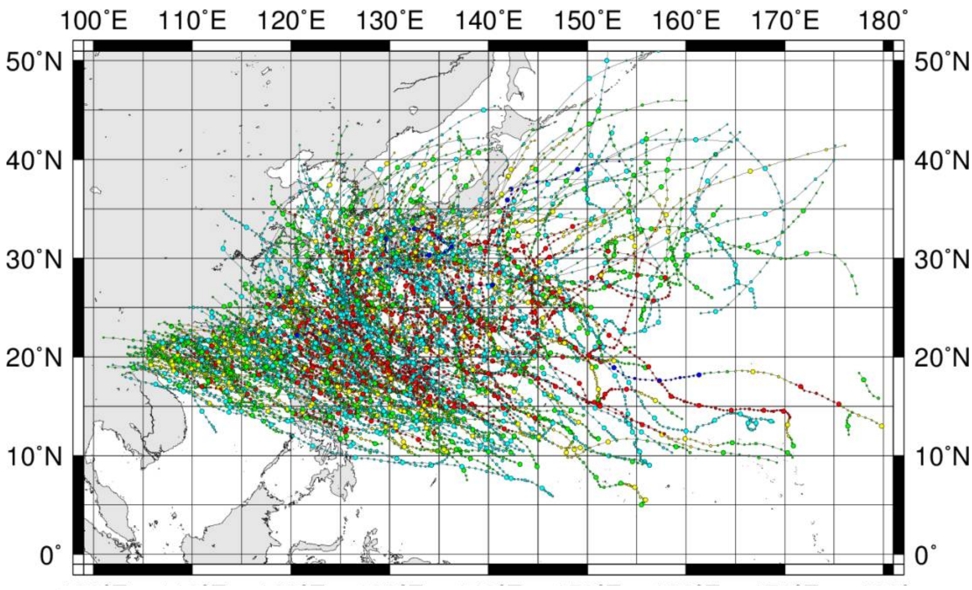


Figure 4.1.1.2: Active Typhoon Map in Japan for July
Source: http://agora.ex.nii.ac.jp/digital-typhoon/index.html.en

Due to the Typhoon, the maximum flow becomes extremely large compared to the normal flow, and the water flows downstream for a short time, and it causes flooding. But the long time without rain causes the water volume to increase significantly, as a result, water accumulates. Landslide disasters can easily occur on most of the vulnerable geology resulting from deforestation and the crust caused by many tectonic lines. For this reason, floods and landslides are very likely to occur in Japan. Its hydrological properties are more supportive for the floods.

4.1.2 Social Conditions

In parallel with urbanization, Japan's population and wealth were concentrated in specific areas. For example, about 90% of the population lives in urban areas, about 25% of the nation, about 50% of the total population, and about 75% of the nation's total assets are concentrated in urban areas. Flood plain floods, which make up about 10% of the country. Therefore, when a disaster occurs, there is a possibility that damage will be enormous. Figure 4.1.2.1 showing a flooded residential area in Kurashiki City in western Japan in Okayama Prefecture on July 9, 2018.

Figure 4.1.2.1: Flooded residential area in the western Japanese city of Kurashiki, Okayama Prefecture, on July 9th 2018
(Source: https://www.cgr.mlit.go.jp/photo/h3007gouu/higai/00006.html)

4.2 HISTORY OF FLOOD HAZARDS AND FLOOD-CONTROL MEASURES IN JAPAN

The history of Japanese flood control can be divided into four stages. The first step before the Meiji Restoration of 1865 was to reduce flood damage associated with running rivers by eliminating settlements from flood-prone areas. It was symbiosis with flood. Japanese in the Jomon period (10,000-4,000 BC) were hunters and did not require use of flood-prone fertile fields for agriculture. However, they began using the plain for agriculture during the Yayoi period (4,000-3,000 BC). The shift to agricultural lifestyles has resulted in increased production capacity and concentration of the population on fertile flood plains. The remains of the town during the Yayoi period reveal irrigation canals around the town, as well as large ditches and embankments to protect the site from flooding. Paddy fields have developed on flat land along small rivers, and Japan's population has increased from 0.7 million to 2.5 million between 50 and 200 C.E. The large river renovation project took place during the Kofun era (200-600 AD) when iron tools were first developed for agriculture. For example, Emperor Nintoku planned to excavate a canal, and a dyke was built in Manda. Figure 4.2.1 showing rivers and places which I described.

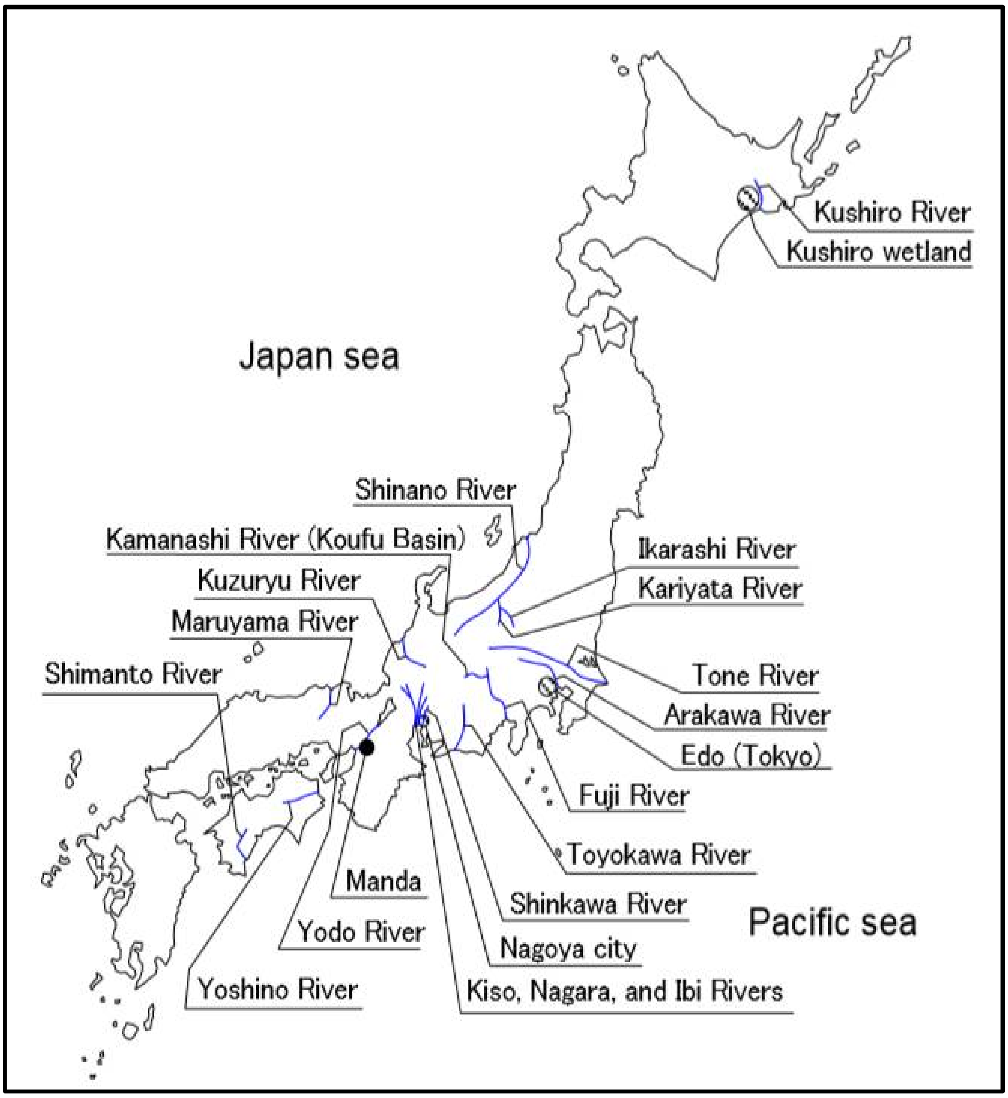


Figure 4.2.1: Rivers and places
Source - https://pdfs.semanticscholar.org/af57/d54d28bcc13a6e56cbbf71a28ca56363f669.pdf

Laws enacted between 600 and 900 AD have led to significant improvements in rivers. Construction of embankments, ponds, and ditches was considered a duty of the Governors. In the middle Ages, many valley ponds were built in the mountains between the 12th and 16th centuries, and reserves were built on reclaimed embankments, with trees. River improvements during the warning period (900-1600 C.E.) include the construction of flood control on the Kamanashi River by General Shingen Takeda (1521-1573 C.E.), who are responsible for Kofu district. General Takeda protected the Kofu basin from a series of flood risks by constructing a one-sided embankment along the Kamanashi River. These measures have resulted in a 76% increase in paddy rice production during the approximately 150 years from the Keicho era (1596-1615 AD) to the Houreki era (1751-

1764 AD). General Ieyasu Tokugawa (1793-1853 AD) improved the Tone and Arakawa rivers when the Tokugawa Shogunate was established in Edo. Edo is now Tokyo.

General Ieyasu Tokugawa increased the area of farmland by limiting flood plains and used flood control operations to transport flood water to the Tone and Ara rivers. Tadatsugu Ina (1550-1610), the retention chief of General Ieyasu Tokugawa, oversaw the development of Tone River. His technique, called the Kanto or Ina method, involved the use of natural systems, strengthening natural dykes, constructing reservoirs, distributing flood power, and protecting critical areas by constructing weak levee. His approach to flood control was to tolerate minor damage from partial flooding as the sediment deposited by the flood provided fertilizer to the farmland. In this way, the river and its immediate environment can coexist. As a result, Japan's population has increased from 10 million to 30 million in the period 1550-1700, and arable land has increased from 10,000-29,500 km2. Paddy fields have undergone major river canal changes.

The rapid population growth meant that in 1865 the Japanese government adopted a policy of increasing food supply by developing riverside rice fields. As a result, many farmers have lived in flood-prone areas. To protect these vulnerable farmers, continuous high river dams have been constructed along the large rivers in the alluvial plains. This is the beginning of the second phase of flood control in Japan, where river projects have been implemented since 1865 to maintain floods in river canals. After the Meiji Restoration (1867), flood control policies were based on Western thinking adopted by government law. Many foreign engineers invited by the Meiji government to Japan to pass on their skills to local engineers. These foreign experts practiced river maintenance and water transport technologies developed primarily in Europe.

In 1873, the Meiji government adopted regulations governing the repair of rivers, ports and roads. Under the direct control of the Meiji government, 14 watercourses, including Yodo, Tone, and Kiso rivers, were involved in waterway maintenance projects related to transport and water safety. Projects on other rivers were conducted by representatives of the Meiji government. However, the floods and the shift from marine transport to land transport have changed the river policy of the Meiji government. Following the approval of the Japanese River Law in 1896, the Japanese government promoted a large-scale flood control project. For example, improvements are being made to the Kuzuryu River, the Shinano River canal is cut off, and the Arakawa drainage works are being carried out.

Since the River Law of 1896 excluded private titles of rivers, all official work on rivers was integrated into the executive right of the Minister for Home Affairs. In other words, the Japanese government controlled all rivers in Japan. Irrigation and flood control policies were adopted during the Taisyo era (1912-1926). The main purpose of these policies was to increase agricultural productivity. In other words, flood control and agriculture were both sides of the same coin. Government policies on agriculture apply to a combination of irrigation and crop management laws. Since World War I, the demand for industrial water has increased due to the urbanization and industrialization of Japan. This has led to the serious question of whether agriculture should be replaced with industry in terms of prioritizing water use. In the first stage of flood control described above, the stagnation water associated with the flood was immediately removed from the land. However, during the second stage, floods occurred frequently and the floods were controlled very slowly.

The third phase of the flood response involved a period of rapid urbanization and population growth after World War II. The Japanese River Law was amended in 1964 due to increased demand for water. In the third stage, multipurpose dams were built to control floods, irrigation and hydropower. Mainly the first-class rivers were managed by the Minister, the second-class rivers were by the prefectural governor, and other types of river areas were by the mayor. The river manager was defined in river law and was revised in 1964.The master plan for the first-class river was determined by the River Council, which operates outside the Ministry of Land, Infrastructure, and Transport. Although river maintenance was almost unexpectedly required in terms of flood control and water use, the negative environmental impact of public works was exacerbated by the adoption of the revised River Code. Flood control is important to save lives, but river work has rapidly destroyed long-developed ecosystems. In 1997, the Japanese River Law was revised, introducing artificial measures such as flood control, irrigation and environmental management. That is, the fourth phase of flood control meant a change in flood control approaches from disaster prevention to flood mitigation. The main points of the 1997 River Law are to consider wildlife ecosystems, maintain a water circulation system, and examine the relationship between rivers and neighboring areas. This represents a significant shift in the political position of the River Law on the environment.

4.3 FORMULATIONS OF RIVER LAW IN JAPAN FOR FLOOD MANAGEMENT

Modern Japanese river policy has been around 100 years since the Enactment of the River Law in 1896. This law has been revised many times to reflect changes in social and economic conditions.

Particularly noteworthy is the 1964 amendment which established a systematic framework for flood management and water use including the introduction of an integrated river system management. The 1964 amendment also instituted a planning system for river which required river administration to draw up a master plan for project implementation for each river system. In order to promote consistent and systematic improvements.

Although the master plan was to be drafted in consultation with the river council. The river managers were basically expected to formulate the plans according to their own discretion. The plans were not required to contain detailed specifications for river improvements and thus provided no concrete sense of what river development should look like. Due to subsequent socio economic changes the river situation has changed dramatically in recent years. Today rivers are considered not only in terms of flood management and water use. But are perceived as pleasant waterfront spaces for people to enjoy. Figure 4.3.1 and 4.3.2 showing progress of River Law in Japan.

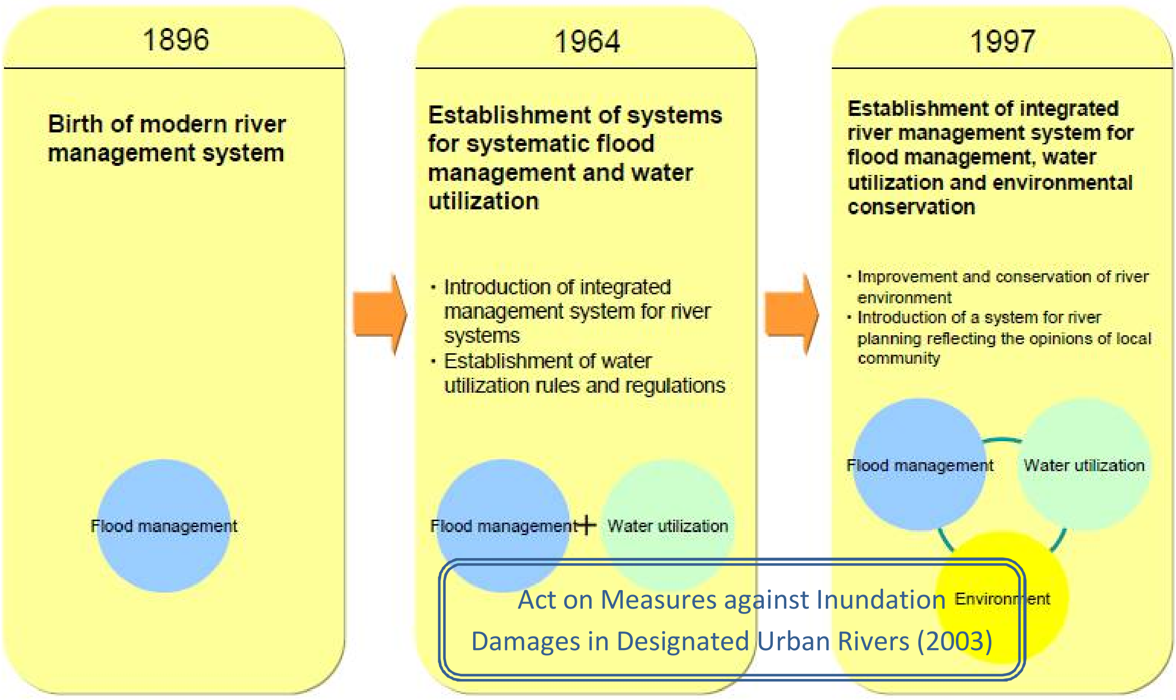


Figure 4.3.1: Formulation of river law in Japan
Source: https://www.mlit.go.jp/river/basic_info/english/pdf/conf_04-0.pdf

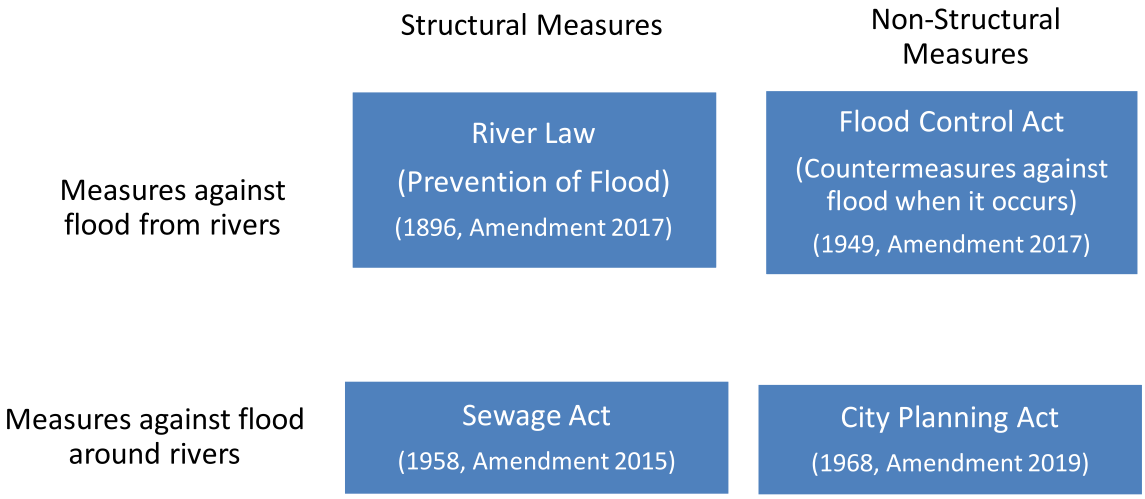


Figure 4.3.2: Outline of Law on Measures against Inundation Damages
Source: https://www.mlit.go.jp/river/basic_info/english/pdf/conf_10.pdf

On the one hand the River Law stipulates the structural measures for the flood from rivers, on the other hand the Flood Control Act (No. 193 of 1949) was designated for the non-structural measures for the flood from rivers. Major revision of the Flood Control Act was made in May 2015 to take into consideration frequent, unexpected flooding damage due to floods, inland waters and storm surges. In the revised act, the existing statutory system was expanded and a new system required the announcement of the largest expected inundation areas caused by floods, internal waters or storm surges, and non-binding obligations were stipulated. As flood hazards have become more frequent and catastrophic nationwide, the Ministry of Land, Infrastructure, Transport and Tourism noted that “catastrophic floods that cannot be prevented by infrastructure will happen anyway.” Further, the Flood Control Act was revised in May 2017, additionally stipulating obligations to develop a system for providing a council for mitigating large scale flooding, a system of announcing water hazard risk information by the mayor of municipalities and creation of evacuation operation/implementation plans at the facilities used by persons requiring special care pursuant to the Municipal Disaster Management Plan, as well as the facilitation of flood prevention activities involving private sectors and formulation of a system to designate zones to mitigate inundation damage to achieve “No failure to escape” and “Minimization of damage on socioeconomic.

4.4 EMERGENCY WARNING SYSTEM FOR SEVERE WEATHER PREPAREDNESS AND EVACUATION SYSTEM IN JAPAN

The Japan Meteorological Agency has published information on preparing for extreme weather conditions, including warnings, advisory and bulletins to prevent or mitigate disasters caused by heavy rains and storms. To support the activities of organizations involved in disaster management and trials to ensure the safety of the population, the Japan Meteorological Agency issued a "newsletter" several days before such a significant event caused the disaster and issued warnings and advisory. Announce and emergency alerts at each of the most dangerous stages. Table 4.4.1 showing Category of information for severe weather preparedness and Figure 4.4.1 Showing Advisory / Warning / Emergency warning and weather forecast are issued by JMA.

Table 4.4.1 Category of information for severe weather preparedness (Source: "Flood and Sediment Disaster", May 2018, Cabinet Office)

Type	Category	Warning Classes
Emergency warning	Heavy rain (sediment disasters, inundation), windstorms, snowstorms, heavy snow, high wave, storm surges	Issued if there is significant likelihood that a serious disaster.
Warning	Heavy rain (landslide, inundation), flood, windstorm, snowstorm, heavy snow, high wave, storm surge	Issued if there is a chance of a serious disaster.
Advisory	Heavy rain, flood, gale, gale and snow, heavy snow, high wave, storm surge, thunderstorm, snow melting, dense fog, dry air, avalanches, low temperature, frost, ice accretion, snow accretion	Issued if there is potential for the development of serious adverse conditions.
	• Real-time risk map • Weather bulletins on Heavy Rains • Typhoon Information • Hazardous wind watch	• Announced every 10 minutes to show where the risk of disasters is rising to supplement warnings. • Announced as required several days before a warning to attract attention,

Weather bulletin	• Bulletins on exceptionally heavy downpours • Probability of Warnings • Weather bulletin on long-term high temperature	and amid ongoing warnings as necessary to explain the progress and prediction of the phenomenon and the points to be considered for disaster management. • Announced as required to show weather conditions not subject to warnings but likely to have significant impacts on society.

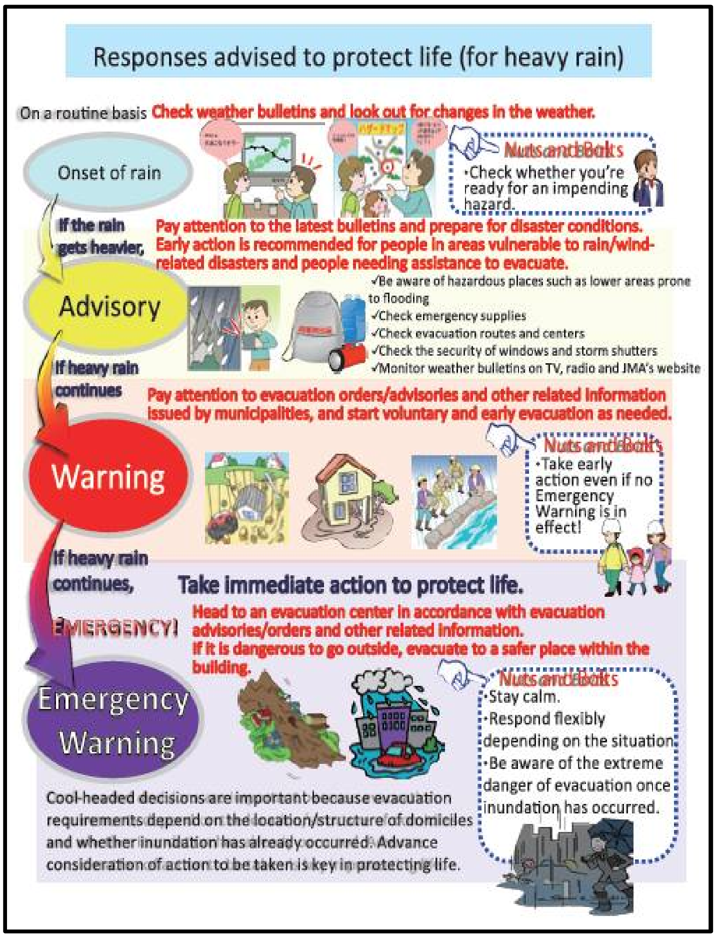


Figure 4.4.1: Advisory / Warning / Emergency warning and weather forecast are issued by JMA.
Source: https://www.jma.go.jp/jma/en/Emergency_Warning/Leaflet (Emergency_Warning_System).pdf

The key to issuing heavy rain alerts is to combine them with real-time risk maps associated with both population uses. More specifically, when a heavy rain alert or sedimentary disaster alert is issued, residents are aware of the real-time risk map and the imminent danger, so they can determine when and where the risk increases. It is important to ensure their respective safety in community. Figure 4.4.2 showing dissemination system of rising risk.

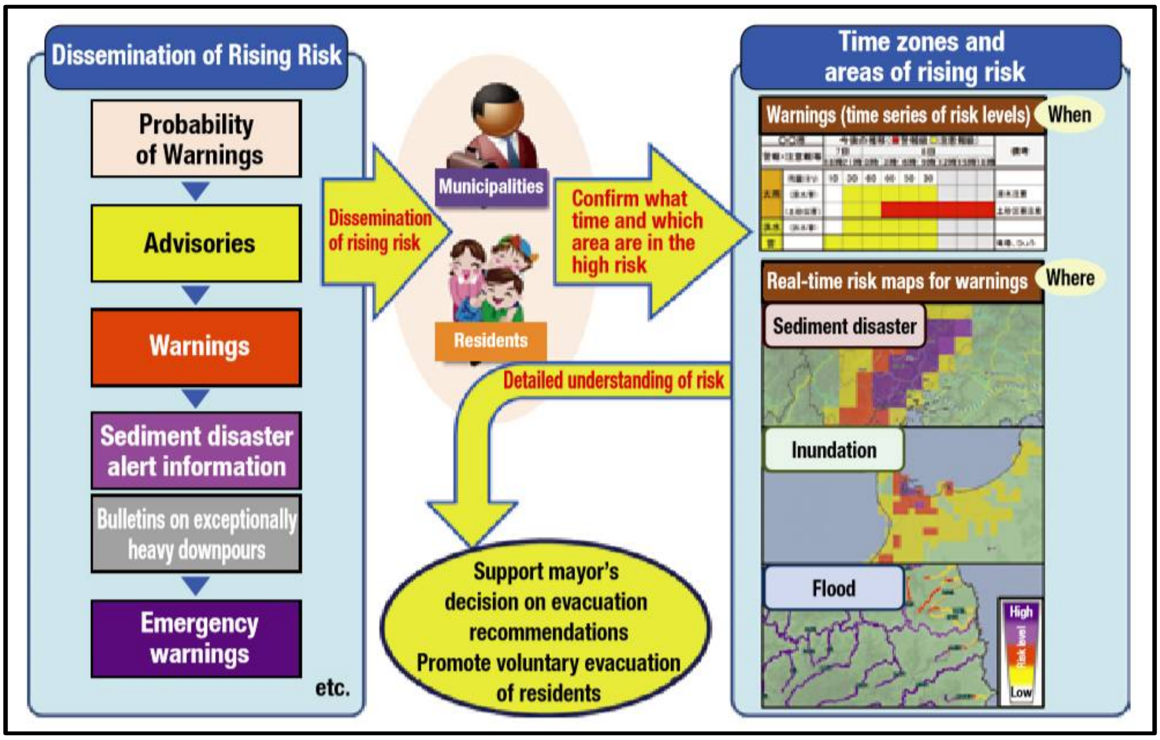


Figure 4.4.2: Dissemination system of rising risk
Source: "Flood and Sediment Disaster", May 2018, Cabinet Office

4.4.1 Emergency warnings/warnings/advisories

A warning is to be announced approximately 3-6 hours in advance to the expected happening of warning level phenomenon which may cause serious disasters. Also, when a warning level phenomenon is expected to occur about 6 hours later or even later, an advisory, which is likely to be replaced by a warning, is to be announced before announcing the warning. For instance, when a warning level phenomenon is expected to occur on the dawn of the following day, the advisory comes with an indication of "High possibility of becoming a warning by dawn".

4.4.2 Bulletins on exceptionally heavy downpours

Bulletins on exceptionally heavy downpours is announced by the Japan Meteorological Agency after a heavy rain warning is issued, in order to inform that the rainfall is at levels rarely observed and may cause sediment disasters, inundation and flood in small and medium rivers. The observation points and municipalities where heavy rain was observed are specified clearly in this announcement. It is possible to check where the disaster risk is actually rising by referring to the "real-time risk map (sediment disaster, inundation, or flood).

4.4.3 Real time River Flood Information

Ministry of Land, Infrastructure, Transport and Tourism (MLIT) publicizes real time water level information of major rivers on its website (English https://www.river.go.jp/e/). Figure 4.4.3.1 showing real time river flood information indication

Figure 4.4.3.1: Real time river flood information indication
Source: "Flood and Sediment Disaster", May 2018, Cabinet Office

4.4.4 Flood Warnings and Advisories for designated rivers

For helping residents' evacuation, the Japan Meteorological Agency, in collaboration with the MLIT and prefectural agencies, forecasts flood of specific sections of rivers while indicating water levels and flow rates. The forecast comprises four types of information: information to call attention to flooding, information to provide a warning on flooding, information on flood hazard, and information on flood occurrence. Each information is announced with the name of the river such as information to call attention to the river flooding or information to provide a warning on the river flooding.

4.4.5 Real-time flood risk map

The real-time flood risk map includes information on small and medium rivers that are not the target of flood forecast (rivers for which water level information is announced and others), that indicates the flood risk level of approximately 1km section each of the river by five levels in different colors on the map. As forecasts up to 3 hours ahead are updated every 10 minutes, it is possible to check which river is exposed to increased flood risk at a glance when a flood warning/ advisory is announced. When the highest risk level "extremely dangerous" (dark purple) is indicated out of the 5 risk levels, it may become difficult to evacuate because the roads may already be covered in flood water. Also, given the exceptionally rapid rise in the water level of small and medium rivers, it is important to check the latest situations of the river with a water gauge and surveillance camera and promptly decide to commence evacuation when the "very dangerous" level (light purple) implying a further rise of water level appears. Figure 4.4.5.1 showing Real-time flood risk mapping in Japan.

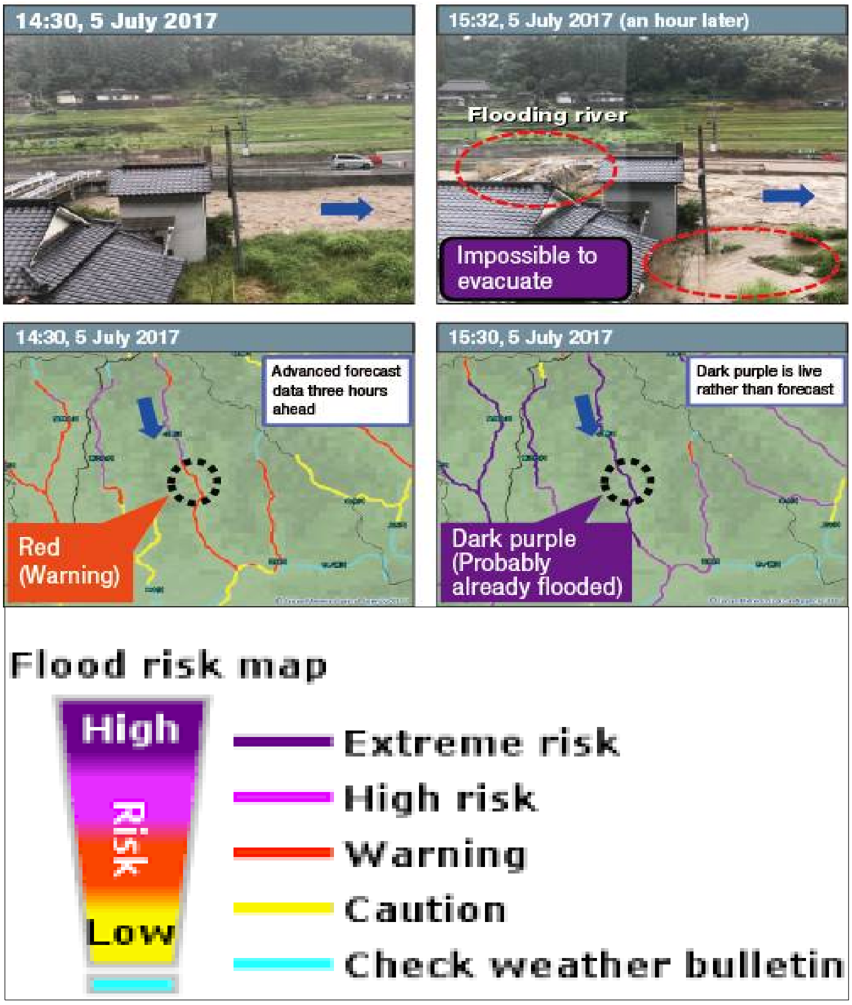


Figure 4.4.5.1: Real-time flood risk mapping in Japan.
https://www.gov-online.go.jp/eng/publicity/book/hlj/html/201803/201803_03_en.html

4.4.6 Flood early warning system in Japan

The Japan Meteorological Agency (JMA) launched a new five-level disaster alert scale used for floods and landslides in late May 2019. It is designed to simplify existing systems, speed up evacuation and reduce the number of victims. For the first time, the alert system includes clear instructions related to the numbers. For example, level 4 means that all residents need to evacuate, and the elderly and disabled have to evacuate at level 3. In the previous system, the Meteorological Agency and local governments issued their own evacuation orders. Today, weather alerts from various organizations are being combined to help people better understand the situation. Figure 4.4.6.1 Five-level disaster alert System.

5-Level Warning System			
Warning Level	Action to take	Information provided by local government	Weather alerts issued by JMA
5	Must take measures to protect lives	Disaster information	Emergency warning
4	Must evacuate	Evacuation order / advisory	Landslide alert info. etc.
3	Elderly people must evacuate	Evacuation preparation information	Rain / flood / storm surge warnings etc.
2	Should check evacuation procedures	–	Rain / flood / storm surge advisories etc.
1	Should be on alert for disasters	–	–

Figure 4.4.6.1: Five-level disaster alert System
(Image Source: https://www3.nhk.or.jp/nhkworld/en/news/backstories/587/)

Level 1: Corresponds to "early warning information" issued by the JMA. It indicates that people should be alert for weather updates.

Level 2: Level two means "heavy rain/flood/storm surge advisories" have been issued by the JMA. People are required to take concrete action, such as avoiding areas where a disaster is likely to occur or reviewing the evacuation routes and meeting points on disaster hazard maps.

Level 3: Indicates "heavy rain/flood warnings" from the JMA or "evacuation preparation information" issued by local governments. The elderly and people who need assistance must start evacuating at this stage.

Level 4: Corresponds to "landslide alert information" issued by the JMA or an "evacuation order" issued by local governments. All residents are required to evacuate to safe places immediately.

Level 5: Is the most severe warning. It corresponds to the JMA's "heavy rain emergency warning." At this stage, it is likely that severe disasters have already occurred. People should make every effort to save themselves. Figure 4.4.6.2 showing final evacuation message dissemination system.

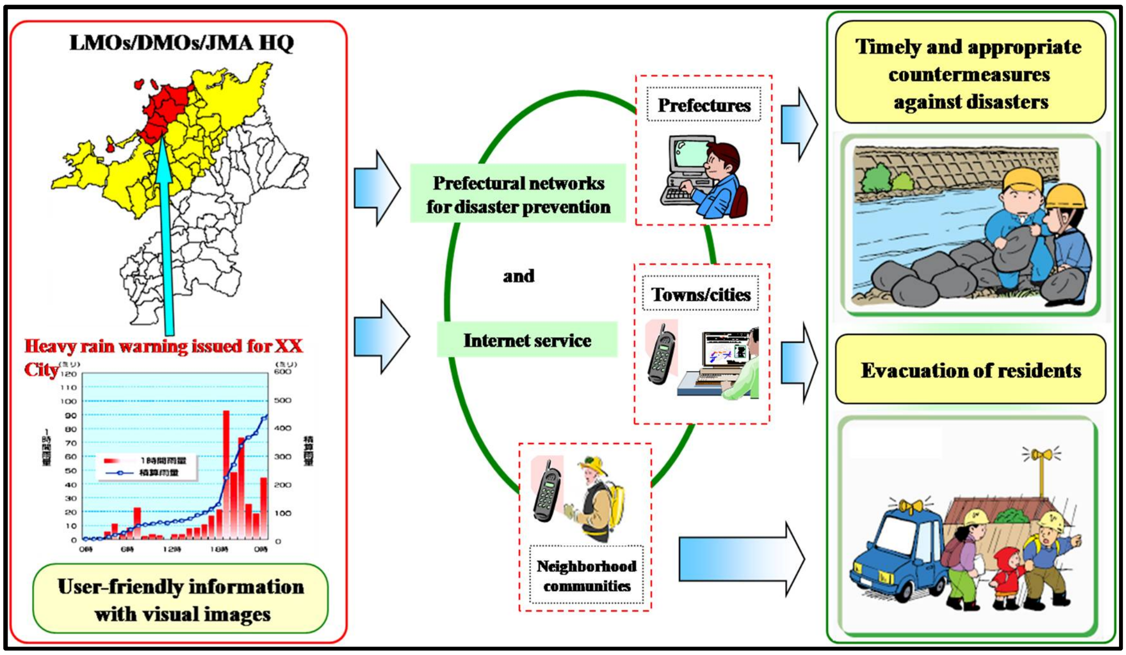


Figure 4.4.6.2: final evacuation message dissemination system
Source: https://www.jma.go.jp/jma/en/Activities/image/fore-

4.5 EMERGENCY RESPONSE MANAGEMENT IN JAPAN

4.5.1 Emergency Management System in Japan

Emergency response phase as part of the overall disaster management system in Japan, it is managed at three levels. Municipalities are directly responsible for implementing Emergency response duties such as flood fighting, rescue, ambulance. Prefectures are authorized to assist.

The national government and its capable authorities oversee the entire coordination process during the response phase. Provide local governments with necessary information about the hazard to the national government with the damage information, and if the scope of the disaster elevates beyond the response capabilities of the municipality puts in action its own disaster response forces. Extraordinary emergency, depending on the magnitude of the disaster if this is the case, it is present at all three levels of the designated public agencies and on-site interventions response headquarters was established. The central government collects disaster information 24 hours a day at the Cabinet Office Information Collection Center. In the event of a large-scale disaster, emergency response team composed by the director-generals of the respective ministries and agencies will meet immediately at the Crisis Management Center in the Prime Minister's Official Residence, to understand and analyze disaster situations, and report to the Prime Minister. Interdepartmental meetings are held at the ministry or higher level to determine basic response policies as needed. Depending on the extent of the damage, the government can establish a Headquarters for Major Disaster Management (Headed by the Minister of Disaster Management) or Headquarters for Extreme Disaster Management (Headed by the Prime Minister). In addition, national government send investigation team led by the Minister of State for Disaster Management, or set up an on-site disaster management headquarters.

4.5.2 Flood Risk Mapping

Japan has strongly promoted flood risk mapping from 2005. The development of dynamic flood risk maps that predict how floods will spread over time is also developing. These hazards maps are varying in size from 1/2500 to 1 / 25,000 depending on the purpose. Local government agencies have created a number of hazard maps. The Cabinet Office, the Ministry of Agriculture, Forestry and Fisheries of Japan, the Fisheries Agency, the Ministry of Land, Infrastructure, Transport and Tourism and other organizations have produced hazards maps on this subject. Many of these hazards maps are open to the public, utilizing the portal site developed by MLIT on the Internet (https://disaportal.gsi.go.jp/index.html). Based on the lessons learned from the experiences in the heavy rain in September 2015, more focus has been put on to facilitate creation of risk maps and to inform the public to effectively utilize the maps for disaster preparedness as a country's basic strategy. The Cabinet Office, other relevant government agencies and local governments have been promoting the development of community disaster management plan utilized the risk maps.

4.5.3 Promotion of Flood-Conscious Societies

Progress of flood risk management in Japan includes the adoption of the National Strategy for Large-scale Disaster Risk Management (MLIT, 2005). This strategy introduces a series of new measures in addition to traditional "hard" structural measures, such as socio-economic impact simulation and goal definition, better cooperation and communication with citizens.

The purpose of the latter measure is to increase local and individual capacities to respond to the flood. In addition, the Ministry of Land, Infrastructure, Transport and Tourism has proposed an "Emergency Action Plan for the Management of Disasters Associated with Heavy Rainfall." The plan has five main elements.

- Improve disaster information services

- Ensure the sharing of disaster information
- Maintain and improve the functions of disaster prevention facilities
- Rebuild local disaster management capacity
- Thorough review of disaster preparedness.

Further, with the bitter experience of the typhoon in August 2016, the Flood Control Act was revised, including the creation of a Mega flood Management Committees system, in June 2017. Emergency action plan was compiled for rebuilding flood-conscious societies, and promoted the integrated and systematic taking of structural and non-structural measures. Furthermore, the plan was revised based on the basic policy “Flood Risk Management for Wide-area and Long-lasting” for measures to “enhance the measures for the prevention and mitigation of damage across society, and to make integrated, multilayered preparations for disasters, through prior preparations and enhanced cooperation among a wide variety of stakeholders” “presented by in January 2019.

4.6 OVERVIEW OF FLOOD FIGHTING ACTIVITIES IN JAPAN

It is essential to prevent or mitigate water levels in rivers caused by heavy rainfall before damage occurs. This involves examining the condition of the embankment and, if dangerous areas are identified, sandbagging them before destroying them to reinforce the embankment. Activities of this nature, such as river inspection and sand deposition, are called flood fighting activities.

Japan's flood control activities have naturally evolved from countries where people have to protect their property. But it was probably from the 16th century that these efforts began to gain an organized character. The current flood defense method is thought to have been developed experimentally mainly during the Edo period (1700-1867) and applied throughout Japan. Today, flood control activities are implemented according to the flood control law.

If there is a danger of floods due to heavy rains, the first step is to disseminate flood forecasts, promote flood control activities, and inform residents near the river. Subsequently, if the imminent threat of flood damage requires the implementation of flood control activities, the authorities will issue a flood alert, activate the flood control system and continue to inform the population near the river. Figure 4.6.1 showing progression of flood fighting activities in Japan.

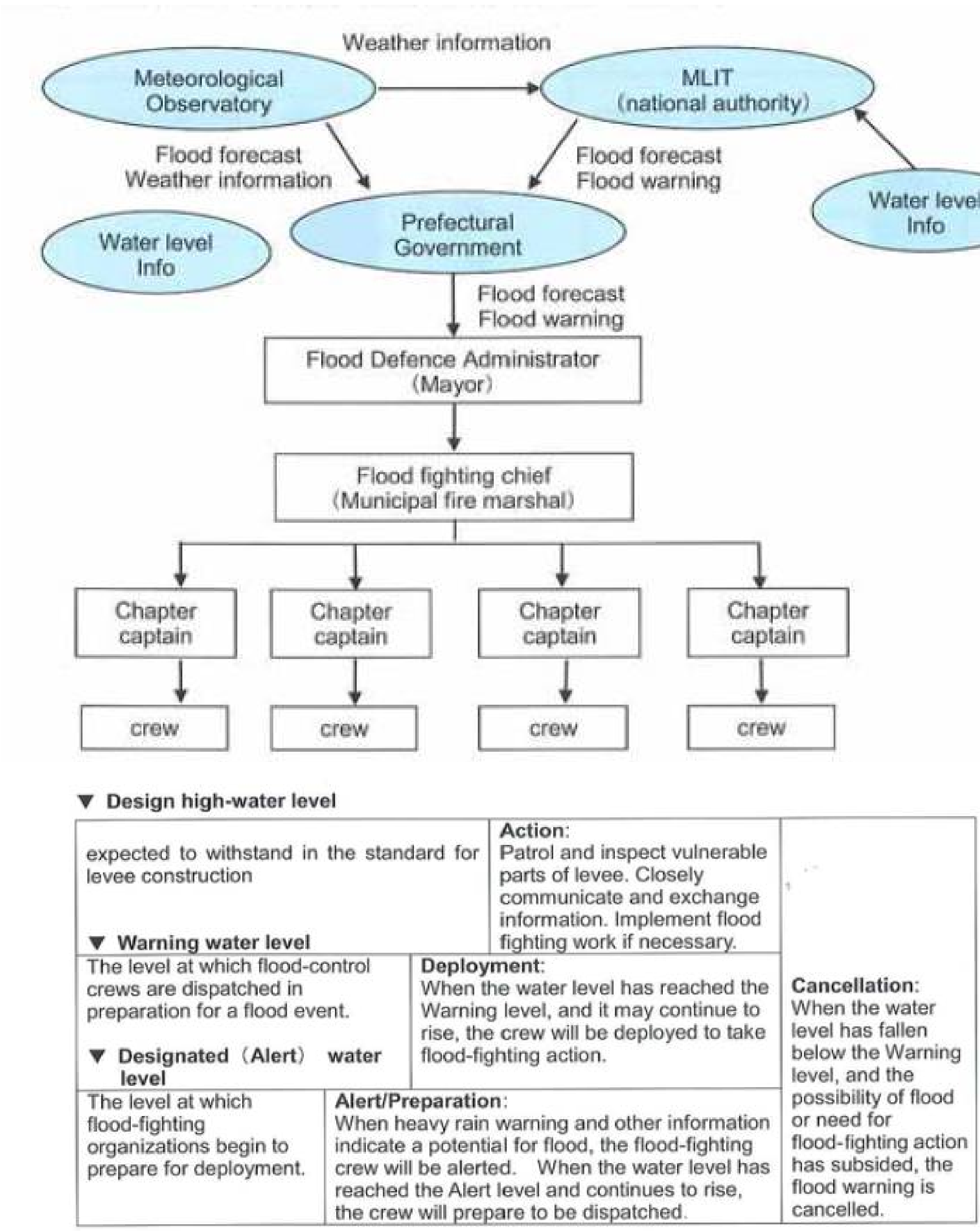


Figure 4.6.1: Progression of flood fighting activities in Japan

In accordance with the Flood Control Law, the responsibility for flood control rests with the municipality collectively referred to as the flood control agency. There are about 3,200 flood organizations in Japan. In addition to the establishment of the flood control team. These organizations may use fire services for directly controlled flood control activities. On the other hand, the perpetual government is responsible for ensuring that flood control agencies can carry out appropriate flood control activities. This includes developing flood control plans that enable flood organizations to effectively prevent flooding. Other prefectural responsibilities include issuing flood forecasts and warnings, notifying, providing emergency evacuation guidelines, and subsidizing flood control budgets.

Prefectural governors and administrators of flood control organizations need to create a flood plan that integrates the various elements needed to combat the flood, including observation, precaution, communication, contact, transport and operational logistics, Cooperation and mutual support between the floods Organization.

In case of emergency, the flood control agency will maintain the necessary authority to carry out flood control activities, such as setting priority road intersections and hazardous areas. At the same time, the Minister of Land, Infrastructure and Transport and the Governor Permanent have the authority to manage flood control authorities and teams. Permanent governors have the additional possibility of requiring a SDF (SDF) dispatch.

4.7 IMPROVING EQUIPMENT AND FACILITIES TO ENHANCE FLOOD DAMAGE PREVENTION

Another important aspect of flood damage prevention is the provision and maintenance of appropriate facility and equipment. This involves maintaining the functions of flood fighting depots established by flood fighting administrators. Maintaining facilities such as river disaster prevention stations and other regional flood fighting hubs as well as drainage pump vehicles for pumping out inside water and installing CCTVs for quick assessment of river flooding conditions and information outlets and networking them with fiber optics. Figure 4.7.1 Showing river disaster prevention stations and drainage pump vehicle and Figure 4.7.2 Showing development of optical fiber network.

Figure 4.7.1: River disaster prevention stations and drainage

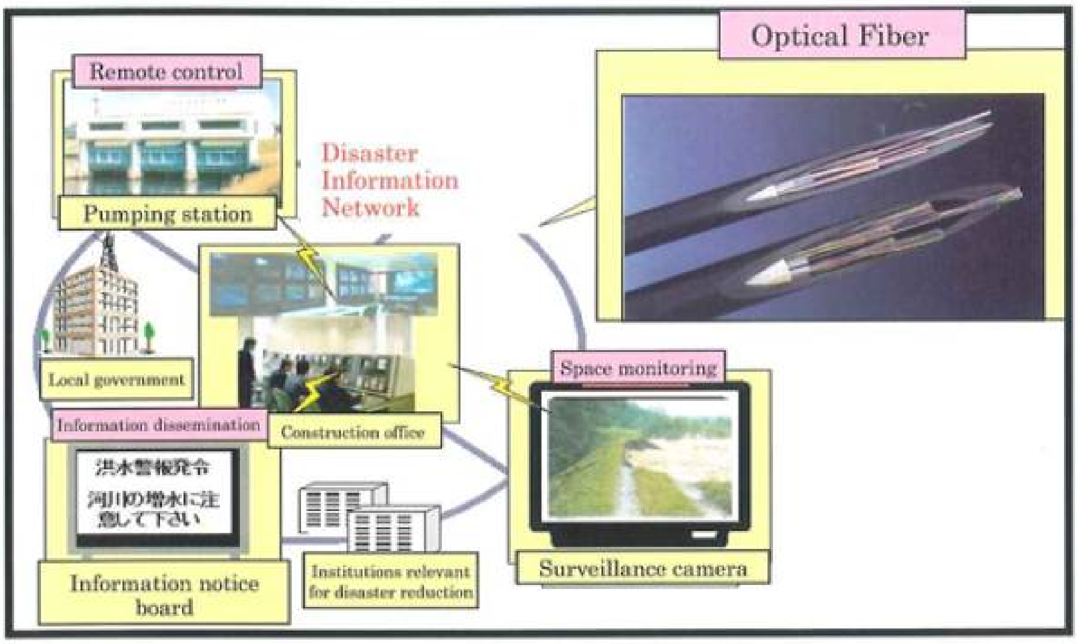


Figure 4.7.2: Development of optical fiber network

4.8 CASE STUDY: EMERGENCY RESPONSE IN JAPAN WESTERN JAPAN FLOODS, 2018

Western Japan was hit by significant rains from late June to early July 2018. The rain front, which moved from central China to the Sea of Japan, was stagnant in northern Japan. Later, it travelled north and arrived on July 4 near Hokkaido. On July 5, the rain front moved south and stagnated in western Japan. July 5-8, 15 lines the precipitation system was formed over the western part of the Tokai region. In nine of these systems, Total rainfall over 3 hours exceeded 150 mm. Also, Typhoon Prapiroon (1807) Tropical storms and changes to typhoons around the south southeast sea of Okinawa Island on June 29 Intensity around Okinawa Island on July 2. Due to the rain front and typhoon Prapiroon (1807), Hot and very humid air continued to flow around Japan, causing heavy rain massive areas throughout Japan, particularly in Western Japan. Figure 4.8.1 showing daily precipitation from July 3rd to July 7th, 2018.

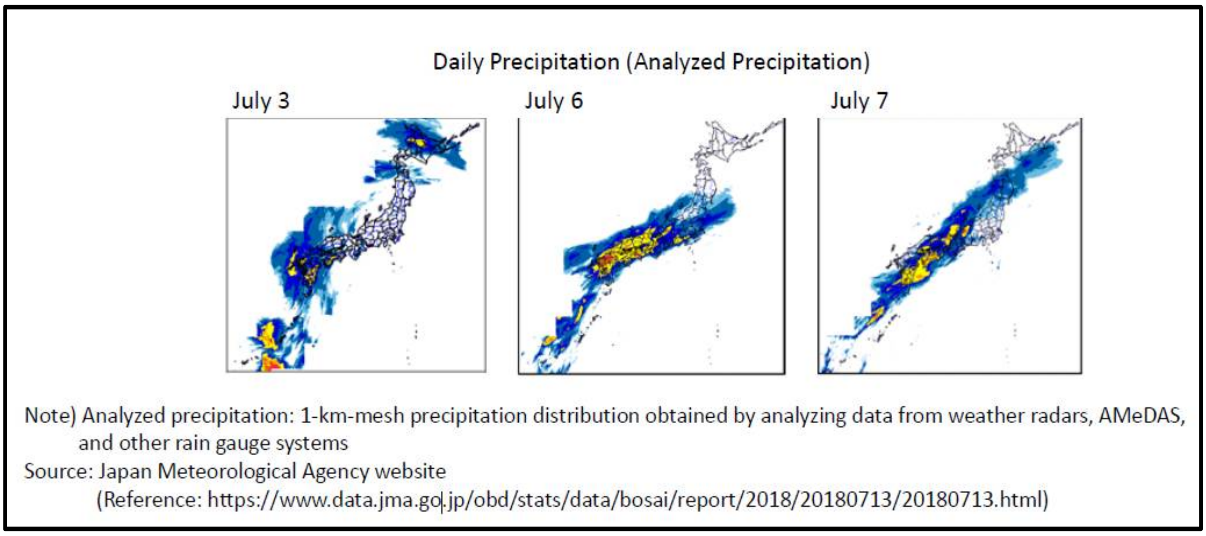
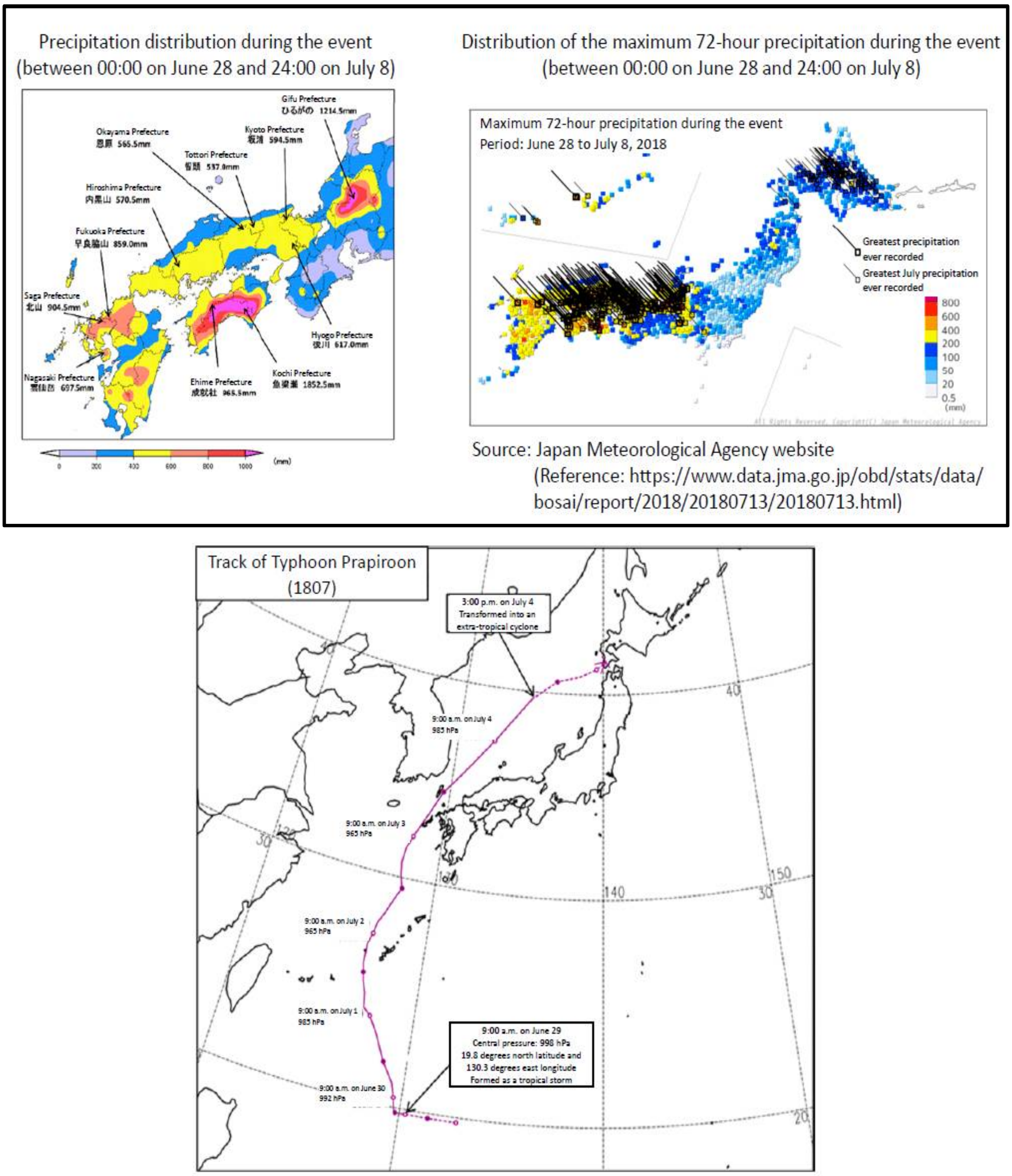


Figure 4.8.1: Daily precipitation from July 3rd to July 7th, 2018

The total precipitation from June 28 to July 8 exceeds 1,800 mm in part of the Shikoku region, 1,200 mm in the Tokai region records 2 to 4 times the average monthly precipitate on July. Also, the highest 24-, 48-, and 72-hour precipitation in recorded history there are many observation points in Kyushu, Shikoku, Chugoku, Kinki, Tokai, and Hokkaido. It recorded torrential rains have affected a large area of Japan over a long period. Figure 4.8.2 showing Precipitation distribution during the event and Distribution of the maximum 72-hour precipitation during the event. Figure 4.8.2 Showing Track of Typhoon Precipitation on 28th June and July 8th, 2018.



Source: Japan Meteorological Agency website
(Reference: https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/bstve_2018_m.html)

Figure 4.8.2: Track of Typhoon Precipitation on 28th June and July

The heavy rains in July 2018 caused river floods, inundation, sediments and other disasters leading to the worst storm disaster in 36 years. Many prefectures are most affected by this flood such as Okayama, Hiroshima and Ehime prefectures. In Hiroshima Prefecture, debris flows occurred simultaneously in various places including Hiroshima City Kure City and Saku Town. Figure 4.8.3 showing Floods in Hiroshima, Japan, July 2018.

Figure 4.8.3: Floods in Hiroshima, Japan, July 2018
Source: http://floodlist.com/asia/japan-floods-july-2018

In Okayama Prefecture, a flood occurred in Mabi town, Kurashiki city urban and other areas damaged due to the breach of levees along the Odagawa River and other rivers. Figure 4.8.4 showing Kurashiki City before flood and after flood

Figure 4.8.4: Kurashiki City before flood and after flood.
Source:https://www.google.com/search?q=:+Kurashiki+City+before+flood+and+after+flood

Violation of this lifting the water level remained high for a long time due to the "backwater phenomenon" at the point where the tributary, the Odagawa River, met the main stream, the Takahashigawa River. In Ehime prefecture, the flood was caused by heavy rain exceeds the capacity of river management facilities. Debris flow generated in Yoshida town and Uwajima City. Caused a sediment disaster and destroyed a water treatment plant. Figure 4.8.5 Showing Sediment disaster near Yoshida Town, Uwajima City, and Ehime Prefecture.

Figure 4.8.5: Sediment disaster near Yoshida Town, Uwajima City, and Ehime Prefecture.

Nationally, the heavy rainfalls caused damage to 346 points in 47 government-administered rivers of 22 riverine systems, and 267 prefectural government-administered rivers of 69 riverine systems. Inland inundation occurred in 88 municipalities in 19 prefectures. 2,581 sediment disasters occurred in 32 prefectures (debris flow: 791; landslide: 56; cliff failure: 1,734). Figure 4.8.6 Showing Levee breaches in the Takahashigawa River, Okayama Prefecture.

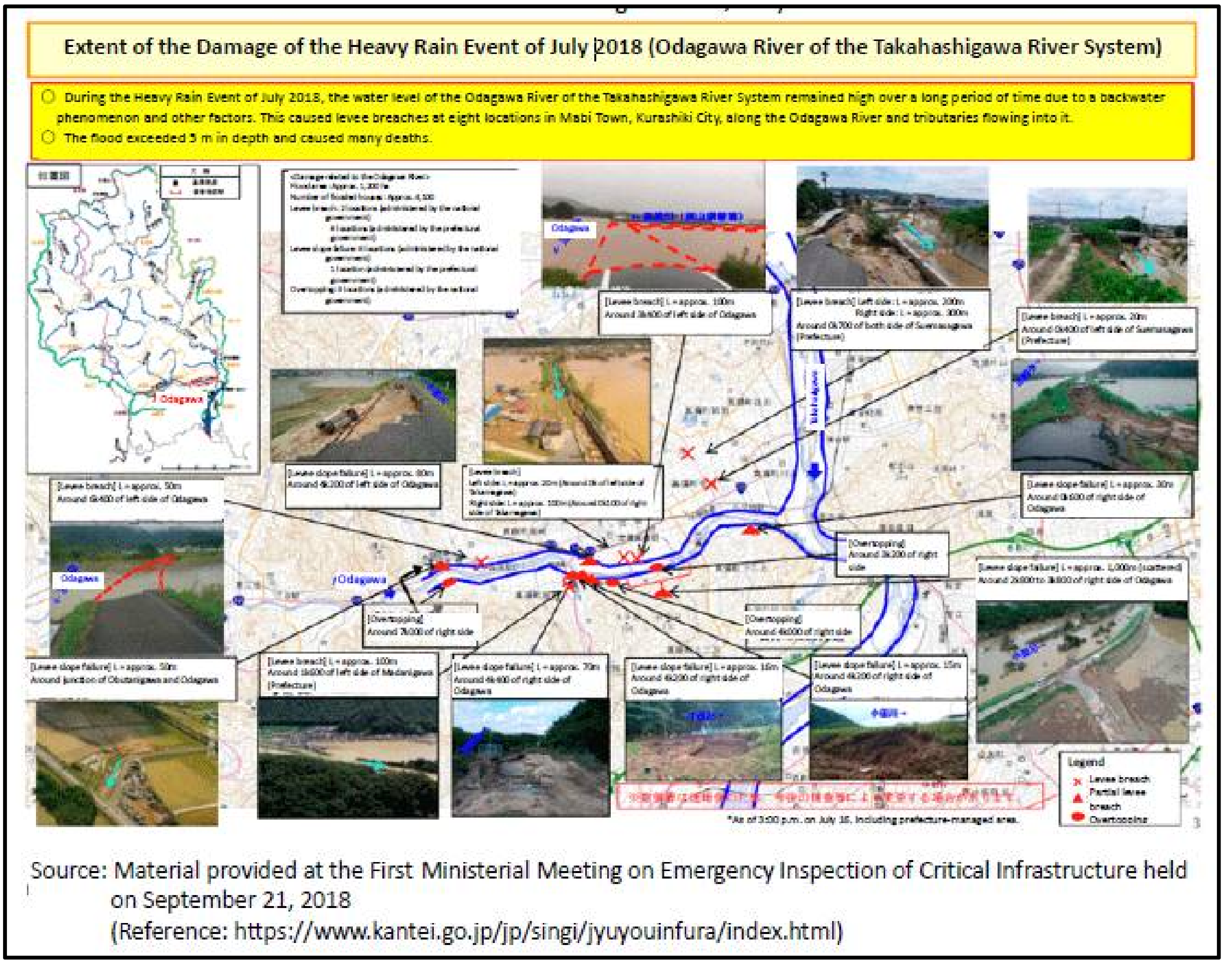


Figure 4.8.6: Levee breaches in the Takahashigawa River, Okayama Prefecture

237 dead (115 Hiroshima Prefecture, 66 Okayama Prefecture, 31 Ehime Prefecture and 25 other prefectures), 8 people missing and 432 severely or lightly injured are recorded. (Information by Fire information and Disaster Management Agency, as of January 9, 2018). Table 4.8.1 Showing number of human casualties as of January 9, 2019.

Table 4.8.1 Number of Human casualties as of January 9, 2019

Prefecture Fatality	Fatality	Missing persons	Seriously injured	Lightly injured
Okayama	66	3	9	152
Hiroshima	115	5	61	85
Ehime	31	-	33	02
Others	25	-	20	70
Total	**237**	**8**	**123**	**309**

Damage to houses included 6,767 completely destroyed, 15,234 half-destroyed or partially damaged, and 28,469 flooded. (Information by the Fire and Disaster Management Agency, as of January 9, 2019. Table 4.8.2 Showing number of house damages as of January 9, 2019.

Table 4.8.2 Number of Human casualties as of January 9, 2019

Prefecture	Completely destroyed	Half destroyed	Partially damaged	Above-floor flooding	Below-floor flooding
Okayama	4,828	3,302	1,131	1,666	5,446
Hiroshima	1,150	3,602	2,119	3,158	5,799
Ehime	625	3,108	207	187	2,492
Others	164	1,231	534	2,162	7,559
Total	**6,767**	**11,243**	**3,991**	**7,173**	**21,296**

Damage to lifeline utilities included power outages affecting a maximum of approximately 80,000 Households (approximately 60,000 households serviced by the Chugoku Electric Power Company and approximately 20,000 serviced by the Shikoku Electric Power Company). Power supply for residential areas was recovered on July 13, 2018. Table 4.8.3 Showing Damage of lifeline utilities as of January 9, 2019.

Table 4.8.3 Damage of lifeline utilities as of January 9, 2019

Service	Maximum number of Households affected	Recovery
Power	80,000(Approx.)	Recovered on July 13 (residential areas)
Water	263,593	Recovered on August 13 (excluding the areas where houses were damaged)

There were also disruptions to gas supply affecting approximately 290 households. This was recovered on July 8. (Information by the Ministry of Economy, Trade and Industry, as of January 9 2019). The total number of shelters in all prefectures was 3,779 at its peak, including 436 in Okayama Prefecture, 660 in Hiroshima Prefecture, and 462 in Ehime Prefecture. The maximum number of evacuees was approximately 28,000 (approximately 2500 in Okayama Prefecture, approximately 12,000 in Hiroshima Prefecture, and approximately 800 in Ehime Prefecture). (Information by the Fire and Disaster Management Agency, as of July 7, 2018).

4.8.1 Response of Government Ministries and Agencies

From July 2, 2018, the government held a series of Inter-Agency Disaster Alert Meetings to prepare for emergencies. Through Cabinet Meetings, the government ministries and agencies coordinated with each other for managing the disaster under the direction of the Prime Minister. Based on the damage information gathered by the Cabinet Office information-gathering teams, the government established the Major Disaster Management Headquarters headed by the Minister of State for Disaster Management at 8:00 a.m. on July 8. The Headquarters held a total of 23 meetings. The Prime Minister attended most of the meetings and led activities to grasp the extent of the damage, the overall coordination of response measures, and the prevention of secondary disasters.

Response Activities

Date	Activity
July 2	Inter-Agency Disaster Alert Meeting
July 5	Press conference by the JMA (regarding the heavy rain that would last until around the 8th); Inter-Agency Disaster Alert Meeting
July 06	Press conference by the JMA (regarding the possibility of the announcement of an emergency warning); instruction given by Chief Cabinet Secretary Suga; Inter-Agency Disaster Management Meeting Hiroshima Prefecture invokes the Disaster Relief Act with respect to Hiroshima City and Saka Town, Aki-gun (date of Invocation: July 5).
July 07	Cabinet meeting; instructions given by Prime Minister Abe. Deployment of Cabinet Office advance information-gathering teams (to Okayama and Hiroshima Prefectures)
July 08	Establishment of the Major Disaster Management Headquarters (a total of 23 meetings were held by September 6) Deployment of a Cabinet Office advance information-gathering team (to Ehime Prefecture) Hiroshima Prefecture decides to invoke the Act on Support for Reconstructing Livelihoods of the Affected due to Disaster with respect to Hiroshima City (date of invocation: July 5). (The Act was invoked with respect to 88 municipalities in 12 prefectures as of September 26.)
July 09	Deployment of a government investigation team led by H.E. Mr. Okonogi, then Minister of State for Disaster Management to Okayama and Hiroshima Prefectures Establishment of a Team to Support the Daily Lives of the Affected

July 10	Relief Goods Procurement and Transport Team was established under the Team to Support the Daily Lives of the Affected.
July 11	Prime Minister Abe visits one of the affected areas (Okayama Prefecture).
July 12	Cabinet approval on the use of contingency reserves (approx. 2 billion yen)
July 13	Prime Minister Abe visits one of the affected areas (Ehime Prefecture).
July 14	Designation as a Specified Disaster
July 15	H.E. Mr. Okonogi, then Minister of State for Disaster Management visits one of the affected areas (Hiroshima Prefecture). The first announcement of the possibility of designation as a Disaster of Extreme Severity The announcement of the Support Measures for the affected of the Heavy Rain Event of July 2018
July 21	H.E. Mr. Abe, Prime Minister visits one of the affected areas (Hiroshima Prefecture). The second announcement of the possibility of designation as a Disaster of Extreme Severity
July 22	H.E. Mr. Abe, Prime Minister instructs the government to develop a package for the restoration of lives and livelihoods of the affected.
July 24	Designation as a Disaster of Extreme Severity (Cabinet approval on the 24th; promulgated on the 27th)
July 31	H.E. Mr. Okonogi, then Minister of State for Disaster Management visits one of the affected areas (Ehime Prefecture).
August 02	Approval on the Support Package for the Life and Livelihood Restoration from the Heavy Rain Event of July 2018
August 03	Cabinet approval on the use of contingency reserves (approx. 105.8 billion yen)
August 05	H.E. Mr. Abe, Prime Minister visits one of the affected areas (Hiroshima Prefecture).
August 21 to 22	H.E. Mr. Yamamoto, Minister of State for Disaster Management visits affected areas (Okayama, Ehime, and Hiroshima Prefectures).
November 07	Approval of the FY2018 supplementary budget, including expenses for recovery and reconstruction from the Heavy Rain Event of July 2018 (503.4 billion yen)

4.8.2 Rescue Operation and Invocation of the staff allocation system to support local governments in affected areas

The government began rescue operations immediately in early July. Police, fire, disaster Administrative agencies, Self Defense Force (SDF), Ministry of Land, Infrastructure and Transport (MLIT), etc. The organization has dispatched rescue teams from all over Japan to the affected areas to carry out rescue and search activities. As well as activities for the prevention and survival of secondary damage.

The Ministry of Internal Affairs and Communications (MIC) invoked the staff sharing system to support Local governments in affected areas, a national system to send government staff to support affected local governments, for the first time since its establishment in March 2018. 29 prefectures and cities sent 15,033
Government officials to 20 local governments in the affected areas until September 15 to help the management of shelters, issuance of Disaster Affected Certificates, and other administrative tasks. This system uses a counterpart method, meaning that each affected municipality is paired to a supporting prefecture or designated city basically on a one-on-one basis. For the Heavy Rain Event of July 2018, Okayama City was supported by Yokohama City while Kurashiki City was supported by Tokyo, Saitama, Fukuoka, and Niigata Prefectures. The system was amended in March 2019 based on the lessons learned from the disaster.

4.8.3 Push-Mode Support

The government implemented "Push Model Support" for the heavy rain event in July 2018. It was conducted during the 2016 Kumamoto earthquake. Under the coordination of the Cabinet Office from July 8, Departments and agencies are asking the supervised industry to get help. Under this Food, air conditioners, toilets, and other relief supplies were delivered to the affected area as of July 26th. Figure 4.8.3.1 Showing Push-mode support system.

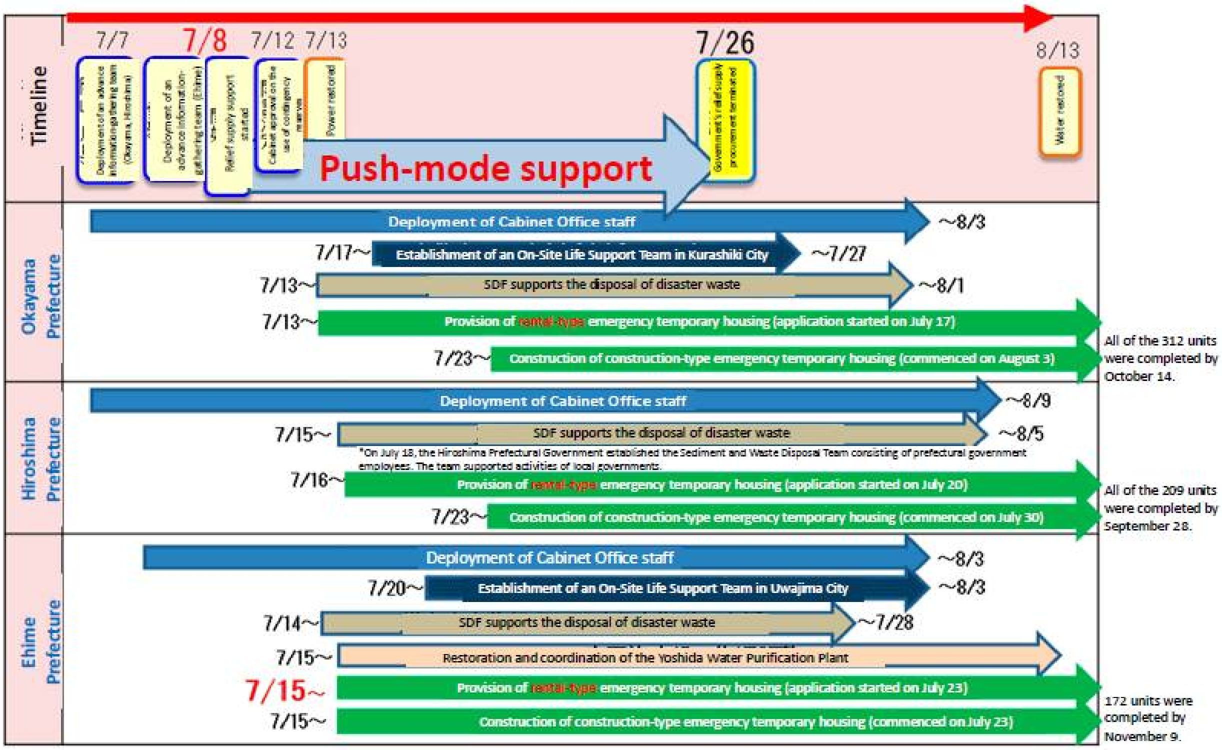


Figure 4.8.3.1: Push-mode support system

4.8.4 Deployment of the Information Support Team

In the event of a disaster, various organizations carry out support activities simultaneously. Information sharing is essential for efficient disaster response by these organizations. For this reason, the government established the Information Support Team (ISUT) led by the members of the Cabinet Office and sent it to the Hiroshima Prefectural Government in the disaster-affected area.

4.8.5 Support by Volunteers

A series of Disaster Volunteer Centers were established in the affected areas, to which many volunteers came to offer support. A total of 260,000 volunteers from across Japan came to disaster-affected areas, including Hiroshima, Okayama, and Ehime Prefectures, to help remove mud from houses and tidy up rooms and furniture. In order to coordinate support activities among volunteers, NPOs and local governments, information sharing meetings were held on a regular basis in Tokyo, Okayama, Hiroshima, and Ehime Prefectures.

4.8.6 Invocation of the Disaster Relief Act and the Act on Support for Reconstructing Livelihoods of the Affected due to Disaster, and Designation as a Disaster of Extreme Severity

Due to this disaster, the Disaster Relief Act was invoked with respect to 110 municipalities in 11 prefectures, while the Act on Support for Reconstructing Livelihoods of the Affected due to Disaster was invoked with respect to 88 municipalities in 12 prefectures. A series of major disasters caused by the seasonal rain front, including Severe Tropical Storm Maliksi (1805), Tropical Storm Gaemi (1806), Typhoons Prapiroon (1807) and Maria (1808) and the Heavy Rain Event of July 2018, comprised a Disaster of Extreme Severity in 2018. On July 24, the Cabinet issued a Cabinet Order to designate this series of disasters as a Disaster of Extreme Severity.

4.8.7 Watch-Over Care and Counseling Services

Affected people may need to move into a very different environment after the disaster, such as temporary housing. They also may face various issues regarding the reconstruction of their lives. In order to ensure that affected people are able to lead their lives with a sense of ease, the Ministry of Health, Labor and Welfare (MHLW) provided watch-over care and counseling services to prevent isolation, give advice on life-related issues, and create social opportunities among residents in the areas affected by the Heavy Rain Event of July 2018, namely, Okayama, Hiroshima, and Ehime Prefectures. Figure 4.8.7.1 Showing visiting the affected as part of watch-over care and counseling services, Mabi Mutual Support Center, Kurashiki City, Okayama Prefecture.

Figure 4.8.7.1: Visiting the affected as part of watch-over care and counseling services, Mabi Mutual Support Center, Kurashiki City, Okayama Prefecture.

4.9 COMPREHENSIVE FLOOD MANAGEMENT MEASURES IN JAPAN

In June 1977, the river Committee issued an interim report on promoting comprehensive flood management measures in response to the increase and acceleration of surface water runoff due to rapid urbanization. The measures incorporate three pillars proposed by the river council, creating a comprehensive flood management program for designated rivers and promoting civil engineering projects for river rehabilitation. Figure 4.9.1 showing three pillars flood management measures in Japan.

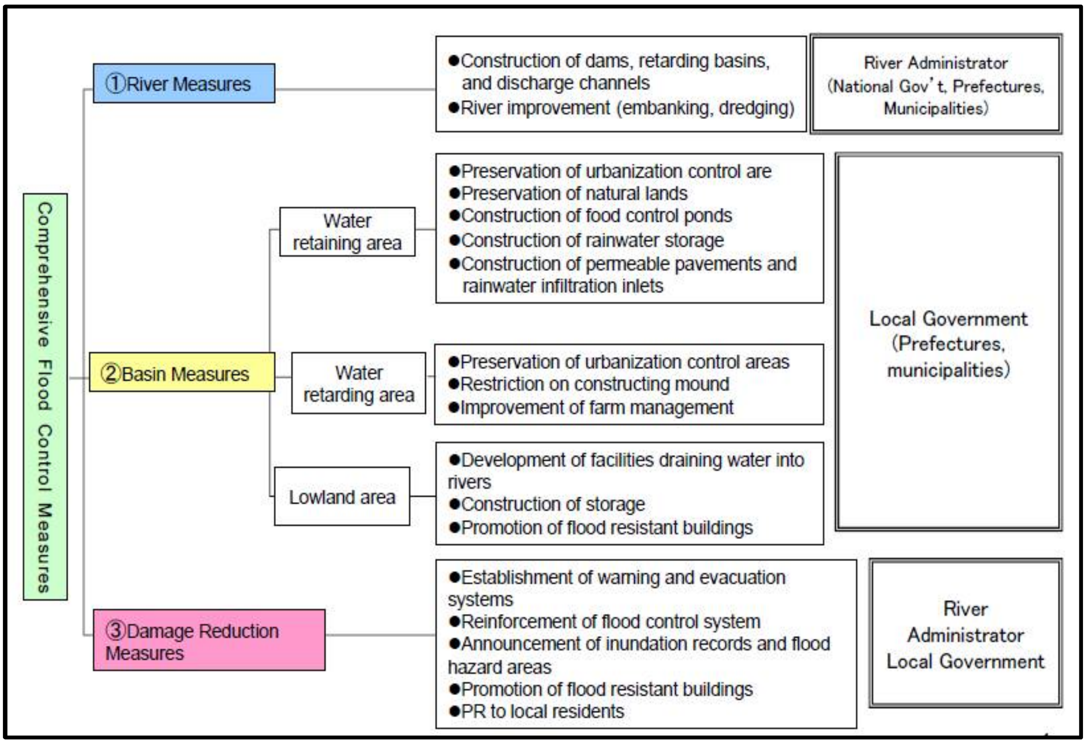


Figure 4.9.1: Three pillars flood management measures in Japan

The basin improvement plan should include a consensus on the required capacity of flood management reservoirs to be built under new development proposals and other policy measures ordered for large-scale development projects. Damage mitigation approaches include building regulations in disaster-prone areas, promoting water-resistant buildings, and publishing flood histories. Figure 4.9.2 showing Comprehensive Flood Control Measures in River Basin.

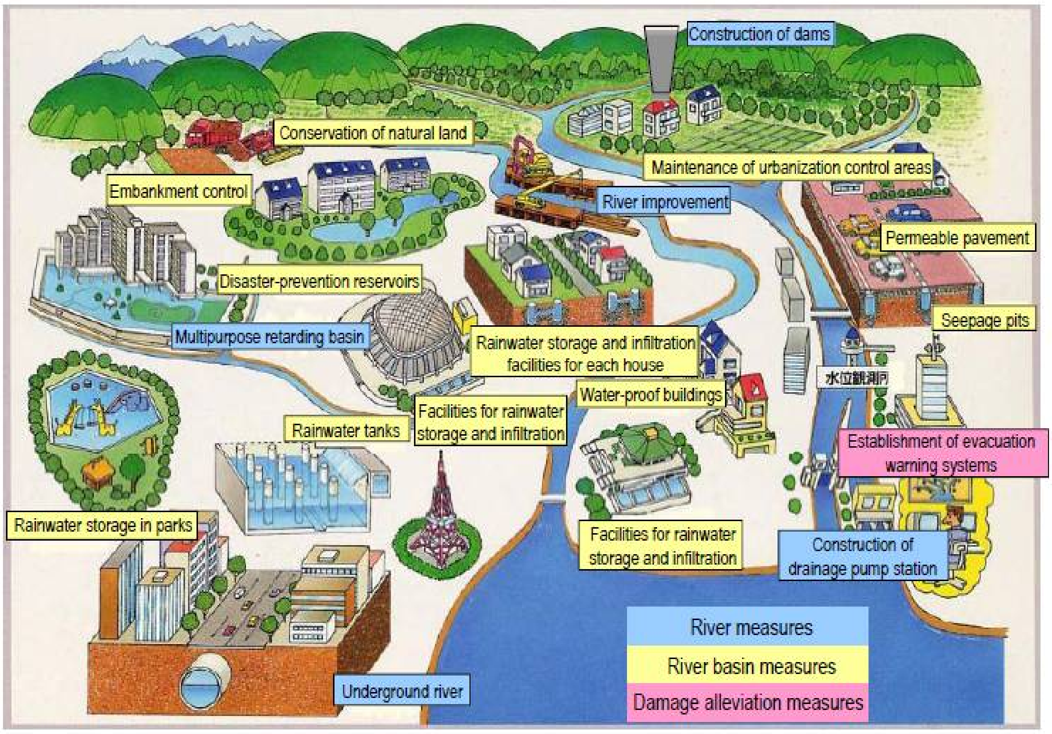


Figure 4.9.2: Comprehensive Flood Control Measures in River Basin

River improvements – The Tsurumi River benefits from major public works, including construction and dredging. The total volume of sediment removed from the riverbed to cross the river channel is three to four times the volume of Tokyo Dome. The flow capacity of the Tsurumi River has doubled since 1975, when comprehensive flood control was launched. Figure 4.9.3 showing Widen and dredge rivers under River channel improvements.

Figure 4.9.3: Widen and dredge rivers under River channel improvements

Multipurpose Retarding Basin – The Tsurumi river multipurpose retarding basin is located in Kozukue/Toriyamachisaki in Yokohama's Kouhoku ward where the Tsurumi River and the Toriyama River merge. The master plan ultimately aims to divert a volume of 800 m3 /s (out of the peak design discharge rate of 2600 m3 / s at the Sueyoshi Bridge) through the retarding basin and the control reservoirs in the mid and upper reaches of the river.

The Yokohama international sport stadium was built in the Yokohama general athletic park in located in the retarding basin. It was one of the largest sport stadiums in Japan with a capacity of 70,000 people and a total floor area of 166,000 m2. In order to avoid compromising flood management capacity, the Yokohama international sports stadium employs raised floor construction. Figure 4.9.4 Showing Multi-Purpose Retarding Basin of Tsurumi River.

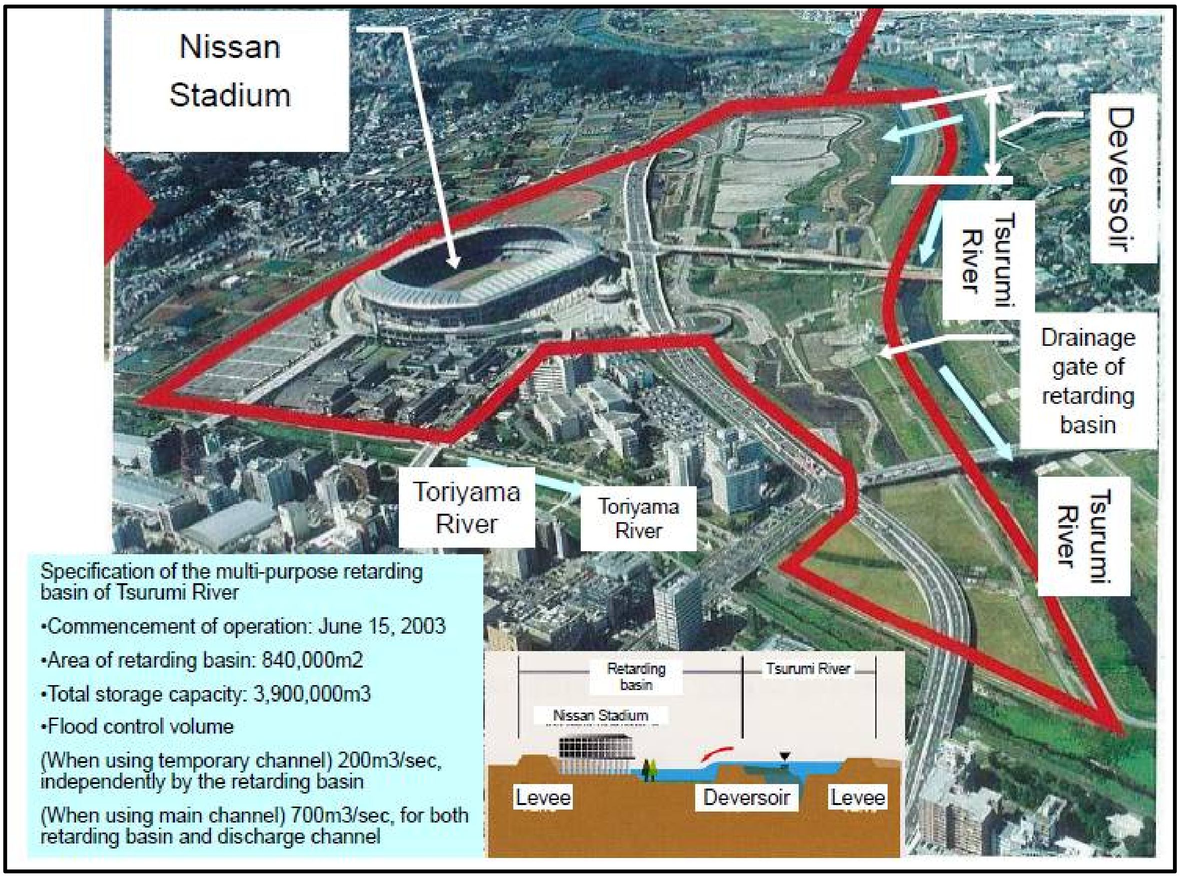


Figure 4.9.4: Multi-Purpose Retarding Basin of Tsurumi River

Constructing flood control pond (Discharge Control Facility) - Flood pond normally control temporarily stores rainfall so that it does not inundate rivers all at once. Facilitate designed to temporarily hold rainwater in order to prevent flashing into the river are called discharged control facilities. There are currently approximately 3,000 facilities (with a storage capacity of approximately 2.77 million m2) installed in the Tsurumi river basin. Figure 4.9.5 showing Kingaoka Regulating pond.

Figure 4.9.5: Kingaoka Regulating pond

Sewerage improvement (water retention in sewer lines) – In order to prevent flooding following a heavy rainfall, rainwater is temporarily store in the sewer lines. Figure 4.9.6 showing Sewerage system in Tokyo.

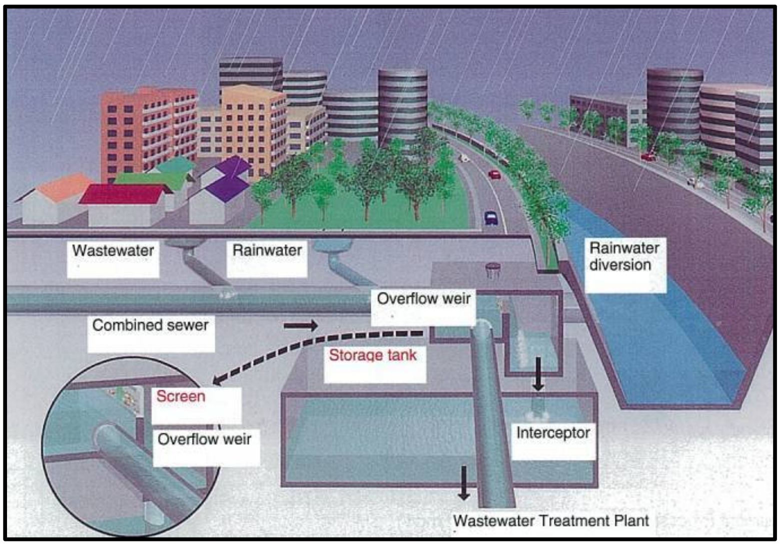


Figure 4.9.6: Sewerage system in Tokyo.

Installation of Infiltration facilities – Sub-grade permeation facilities include permeable sumps, drainage trenches and drainage wells. Figure 4.9.7 showing Installation of Infiltration facilities system.

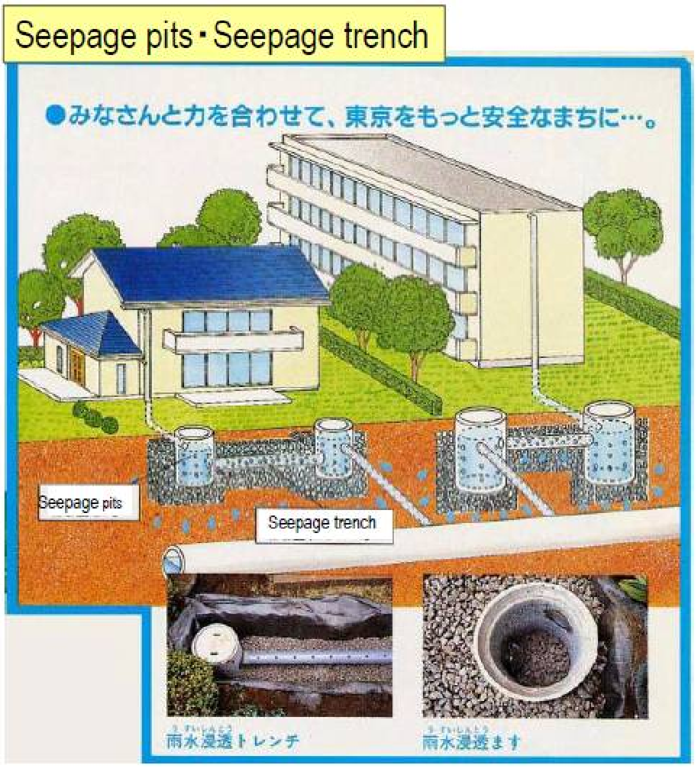


Figure 4.9.7: Installation of Infiltration facilities system

Rainwater storage between buildings in apartment complexes shown in figure 4.9.8.

Figure 4.9.8: Rainwater storage between buildings in apartment complexes

4.10 FLOODS IN SRI LANKA

Location of Sri Lanka in the path of two opposing monsoon systems Receive monsoon rainfall for most of the year. Monsoon rains bring rainfall during part of the balance period really shortens the dry season to months. This weather configuration, combined with frequent cyclones, The Island is vulnerable to floods. Previous records show that a flood is happening it happened during most of the year, except for the driest month. A small part of Sri Lanka is completely flood-free, some areas are more prone to floods. River falling into the sea West coast from Deduru Oya to Nilwala Ganga is frequently affected Flood downstream. In addition, with the largest Mahaweli River Thus, Walawa in the south is two rivers that are prone to flooding. Some rivers Drain east like Kumbukkan Oya, Gal Oya, Maha Oya, Heda They are also affected by the flood. Also almost all the original river. In addition, almost all the rivers originating from the central highlands are subject to flooding in the hilly region.

Sri Lanka is exposed to many types of floods, in particular:

- Bank-full discharge – Most important in terms of incidence and impact. This type of flood occurs when surface run-off entering the river exceeds the discharge capacity of the river channel.
- Flash Flood – Sudden accumulation of water on low-lying areas leads to flash floods. Common occurrence in urban areas.
- Breaching of reservoirs and channel bunds- Mostly occurring in the dry zone.
- Tsunami – Along the coastal areas

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 past and recent floods the number of affected people is increasing in high urbanized districts more rapidly than low urbanized districts. Figure 4.10.1 showing Increase of urbanization in Sri Lanak from 2005 to 2018.

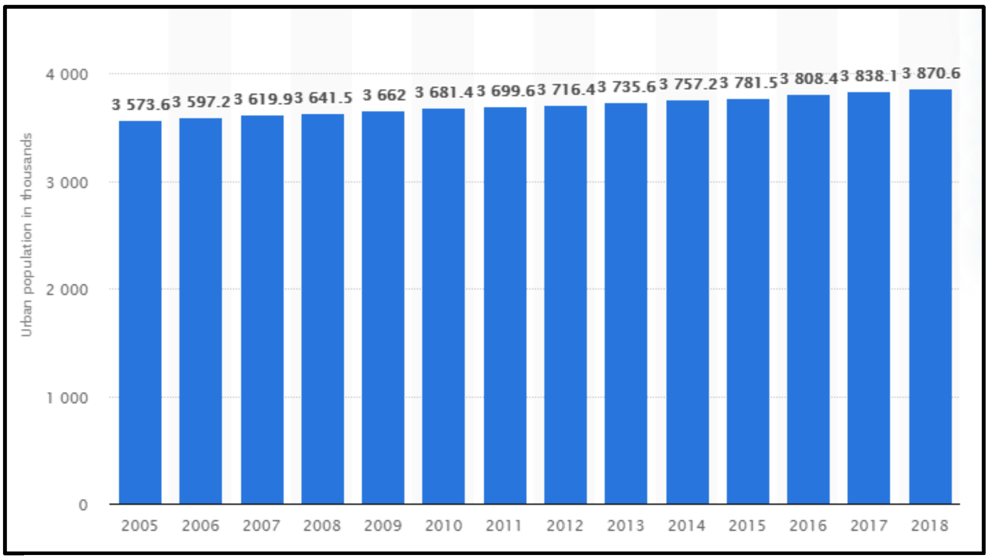


Figure 4.10.1: Increase of urbanization in Sri Lanak from 2005 to 2018
Source: https://www.statista.com/statistics/603515/sri-lanka-urban-population

Especially in Colombo Metropolitan area, the population in flood prone area is rapidly increasing, not only in Kelani river 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 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. Figure 4.10.2 showing traditionally villages located on low land and recent urbanization produces new risk.

Figure 4.10.1: traditionally villages located on low land and recent urbanization produces

Heavy rains in several years resulted in huge flooding in the many district in Sri Lanka overflowing of the main Rivers and its associated water streams. In the aftermath of Tsunami incident in 2004, many floods have been reported in the North, East, North Central and North-Western Provinces of the island. All these events have created series of socio-economic and environmental impacts at different levels across the country. Table 4.10.1 showing impact of flood from 2006 to 2016 in Sri Lanka.

Table 4.10.1 Impact of flood from 2006 to 2016 in Sri Lanka

Table 4.10.1 Impact of flood from 2006 to 2016 in Sri Lanka

Year	No of Affected People	No of Death	No of Injured People	No of Missing People	No of completely Damaged Houses	No of Partially Damaged Houses
2006	605903	34	22	1	1334	5412
2007	499881	16	12	2	1635	9690
2008	1262506	44	11	3	1305	6323
2009	453429	3	2	0	140	1534
2010	1163932	24	10	1	1180	7199
2011	724349	40	49	1	6390	14268
2012	158411	25	13	0	942	6698
2013	450343	2	0	0	84	281
2014	1174073	35	32	3	4877	15220
2015	237331	15	18	1	419	5046
2016	444505	26	20	0	379	2518
Total	7174663	264	189	12	18685	74189

4.11 STATUS OF AMENDMENT OF FLOOD ORDINANCE IN SRI LANKA

Flood Ordinance No. 22 of 1955 has not been amended for around 60 years since 1955. Irrigation Department (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, Disaster management Centre (DMC), Sri Lanka Land Reclamation and Development Cooperation (SLLRDC) and Urban Development Authority (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 Ministry of Disaster Management (MDM). This amendment work is also a component of Sri Lanka Comprehensive Disaster Management Program (SLCDMP). The status is that ID submitted the proposal to the

Secretary of Ministry of Irrigation and water resources (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 approved after the deliberation of the bill by the Parliament. 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 rivers.

4.11 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 Figure 4.11.1. 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.

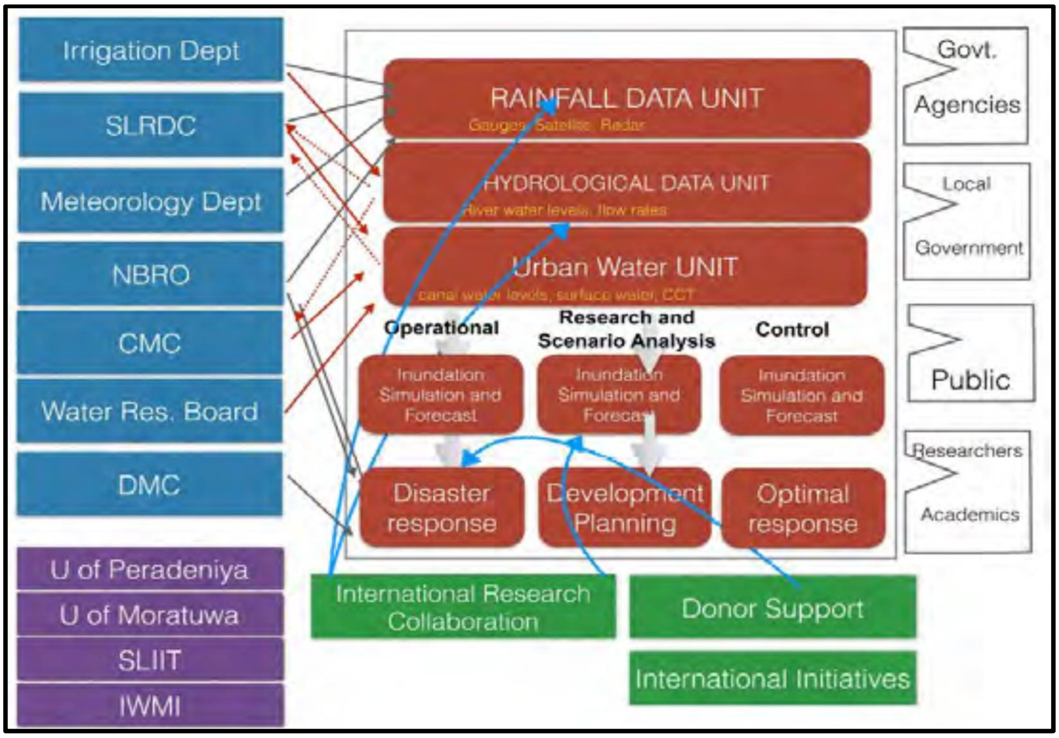


Figure 4.11.1: Concept of the Flood Control and Water Management Centre

4.12 FLOOD EARLY WARNING MECHANISM IN SRI LANKA

The Department of Meteorology (DM) 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 National Meteorological Centre (NMC), Director General and other 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, Ministry of Fisheries and Aquatic Resources Development, forces, police, Coast Guard, regional office of DM, media, etc. The warning is sent to the agencies from the Communication Center of DM 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, DM uploads the warnings to the DM website and records it on answer phone. Irrigation Department. 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 Final Report Data Collection Survey on Disaster Risk Reduction Sector in Sri Lanka. All reservoirs and dangerous area information are mentioned in the warnings as necessary.

The SOP about issuance of flood warnings is included in the National Emergency Operation Plan (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.

I. 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 DM.

II. When the observed water level exceeds flood warning level (4 warning levels), the warning is issued by ID. Signature of Additional Director General 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.

III. The warnings are disseminated to DMC and media by using FAX.

IV. At district level, regional/divisional offices of ID usually disseminate the water level information to DDMCU, local media, forces and police, directly. In some cases, the media contact the regional/divisional offices to ask for the river condition.

4.12.1 Early Warning Flow from DMC to the People

The technical agencies send warning messages to the relevant agencies. Emergency Operation Centre (EOC) of DMC is always included in the addressees as DMC has the

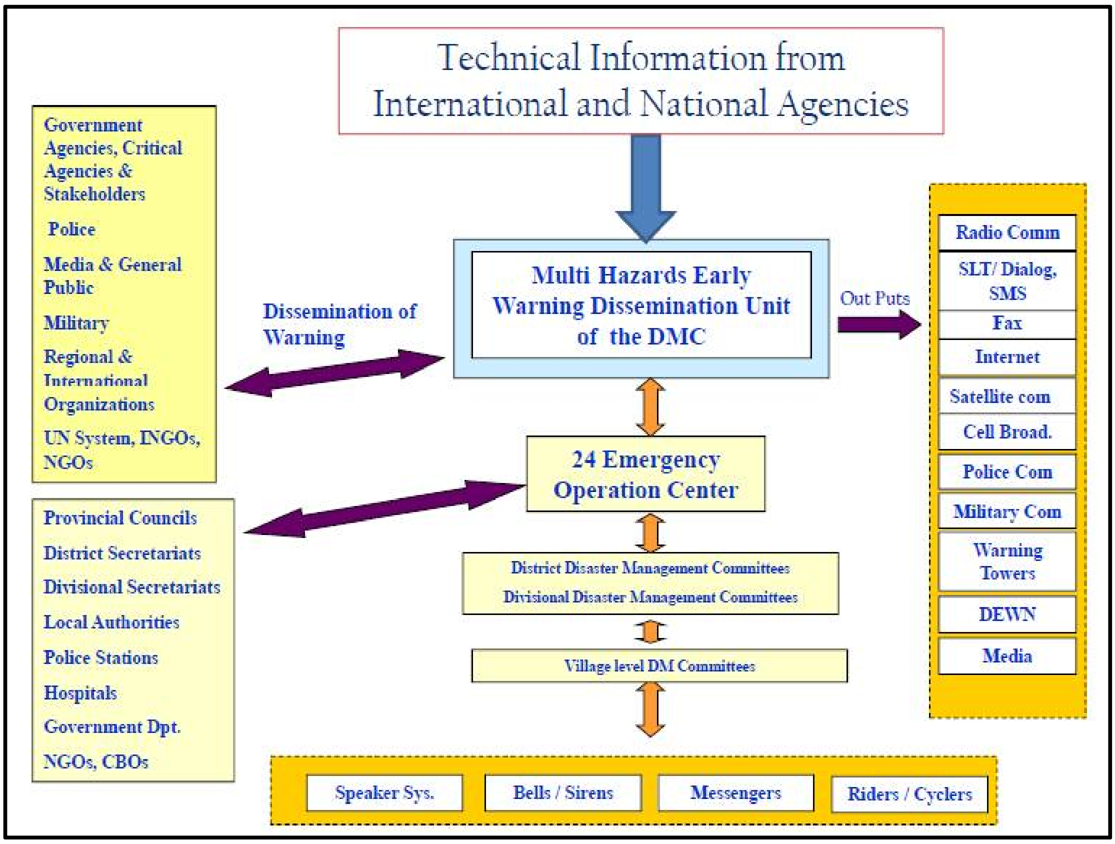


Figure 4.12.1.1: Early Warning Deamination System in Sri Lanka

main responsibility to transfer the messages to the local level. The warning messages are sent from EOC to District Disaster Management Coordinating Unit (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 National Building Research Organization (NBRO). In disaster situation, DDMCU works in close collaboration with such local offices of the technical agencies shown in Figure 4.12.1.1 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.

4.12.2 Emergency Operations Centre (EOC) in DMC

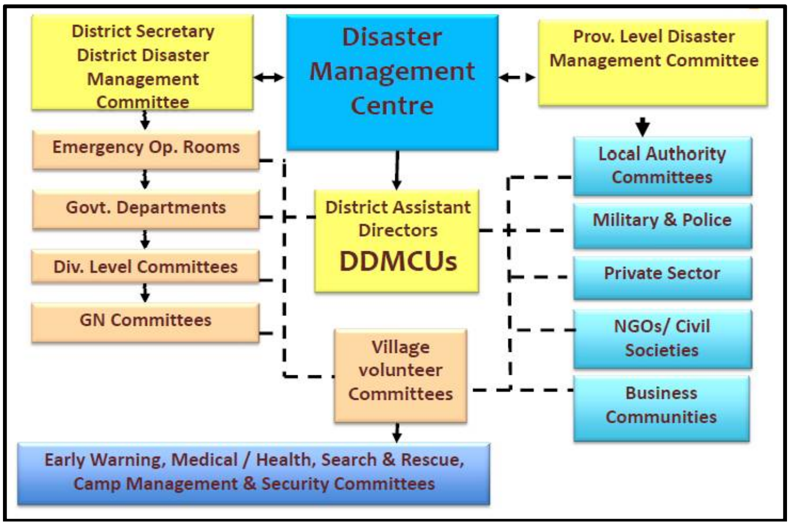
An EOC at the national level is an important pre-requisite to ensure an effective and coordinated response in any emergency. The EOC is well equipped, adequately staffed and will operate 24x7 to coordinate all incident information and resources for management. It will receive, analyze, and display information about the incident to enable decision-making. The EOC will also find, prioritize, deploy, and track critical resources. It will enhance decision making, communication, collaboration, and coordination. It is staffed with personnel from different skills required for the operations. The EOC will have all necessary equipment with conference facilities and display systems. It will comprise one fully-fledged 24x7 Operations Centre with a call Centre. Function of Emergency call center shown in figure 4.12.2.1

Figure 4.12.2.1: Function OF Emergency call center

4.13 EMERGENCY RESPONSE IN SRI LANKA

Since the onset of the floods, the Government of Sri Lanka with the cooperation of national and international non-government organizations (NGOs) has been assisting flood-affected communities. The relief assistance started with providing cooked meals and health care facilities including administration of first aid, and distribution of non-food items (NFI), such as standard hygiene pack (adult and baby), sleeping mats, lanterns and bed sheets.

Most importantly, the military deployed forces and infrastructure to conduct search and rescue operations in highly affected and vulnerable areas. Emergency response mechanism in sub national level shown in figure 4.13.1.



4.13.1 Figure 4.13.1: Emergency response mechanism in sub national level

Involvement of Armed Forces in Emergency Response

DMC has coordinated with the Ministry of Defense and established National and District S&R teams and equipped and trained them. Arrangements are being made to plan out and select platoons of the Armed forces in different locations of the country so that in case of a disaster the military platoon in the closest vicinity will be contacted for assistance in response. Under preparedness planning for emergency response these would have already been selected and necessary awareness given to selected teams about the likely hazards in the respective geographical areas and specific preparedness measures etc. As already mentioned under section 6.2 Emergency Operations Centre (EOC), DMC has coordinated with the Military and established an evacuation plan for Tsunami vulnerable coastal districts where the detachment commander takes the initiative to activate the evacuation plan even at mid night when all others are fast asleep. With such an arrangement, availability of trained manpower, communication equipment, transport etc. will be guaranteed. Above all discipline will be ensured. Such camps are there in all districts and linking up with them will be very easy. In a disaster with the training and contact pre-arrangements having done the required teams can be called without any delay at all and directly by the provincial / district administrations or the DDMCU. The Police, Sri Lanka Army, Sri Lanka Air Force and Sri Lanka Navy will have to be strengthened for undertaking such activities.

4.14 RELIEF, IMMEDIATE RECOVERY, REHABILITATION AND RECONSTRUCTION

In the National Policy for DM high priority has been accorded to several aspects during and after a disaster. These include

I. response, relief and immediate recovery of essential services,

II. Medium and longer term reconstruction and rehabilitation to a higher standard than before the occurrence of the disaster.

National Disaster Relief Services Centre (NDRSC) has been established within the Ministry of DM and assigned with the relief functions. This shows that immediate recovery of essential services, reconstruction and rehabilitation should be given adequate attention in the national and sub-national level planning. DMC will coordinate with all ministries and agencies handling different functions related to immediate recovery, rehabilitation and reconstruction, to ensure effective management of activities in these phases. In these activities due consideration will be given to the recommendations of the Report on the Sri Lanka Case Study of the Evaluation of the Linkage of Relief, Rehabilitation and Development (LRRD) regarding interventions in connection with the tsunami disaster in December 2004 of the Tsunami Evaluation Coalition13. At the same time attention will be given to immovable cultural property after a disaster by way of conservation / restoration of same. Presently National Disaster Relief Services Centre (NDRSC) has been established within the MDM and assigned with the main functions.

- Providing emergency funds for dry rations, meals and for drinking water.
- Distributing and coordinating relief items to disaster affected communities (stock, collect and distribute relief items in coordination with the district, division and GN divisions).

Ministry of finance is responsible for providing funds for immediate / emergency rehabilitation of infrastructure after a disaster. Long term rehabilitation and reconstruction will be the responsibility of the respective sector agencies. Disaster Relief Mechanism in Sri Lanka shown in Sri Lanaka.

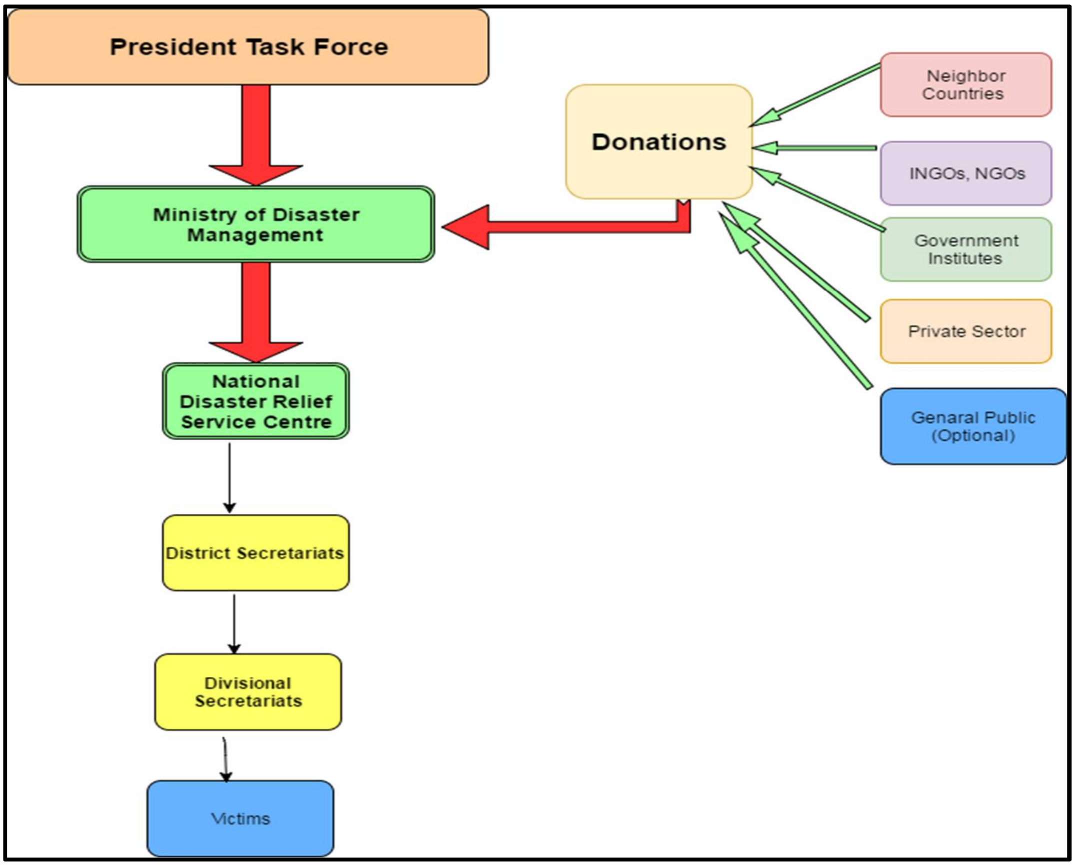


Figure 4.14.1: Disaster Relief Mechanism in Sri Lanka

4.15 FLOOD AND WATER MANAGEMENT BY CASCADE TANK SYSTEM IN SRI LANKA

Cascade system is a connected series of tanks organized within a micro-catchment of the

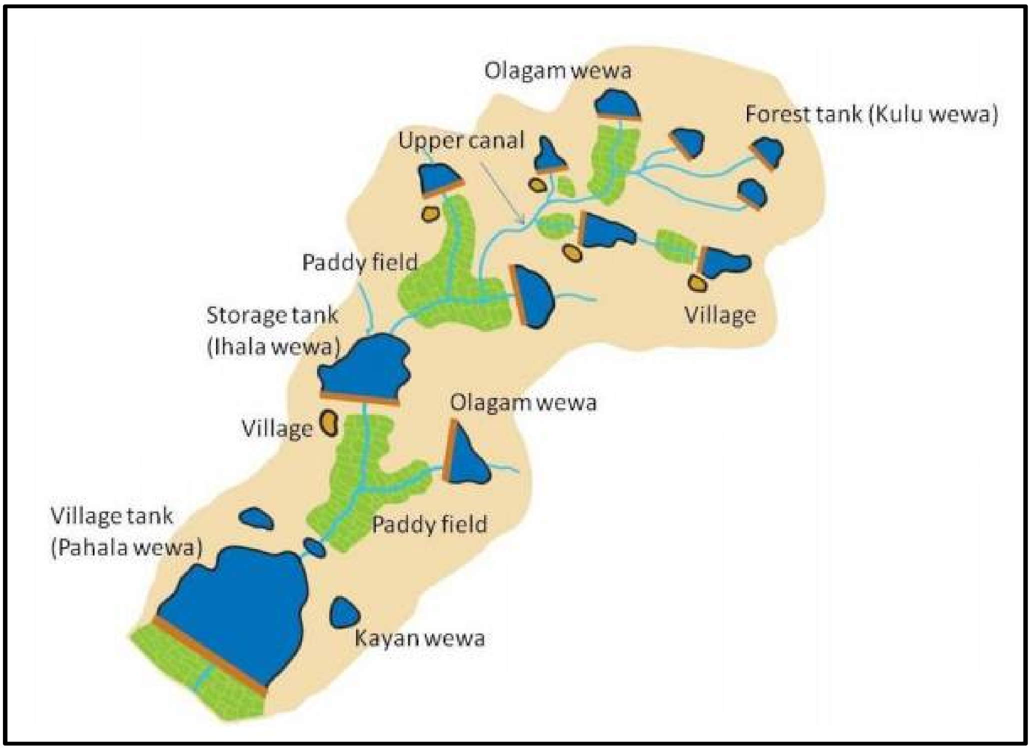


Figure 4.15.1: Organization of tanks and their connectivity within a typical tank cascade system

dry zone in Sri Lanka. The tanks are used to store water from a seasonal stream. Irrigation tanks are often not isolated tanks but are part of a larger interconnected system of tanks called a 'tank cascade system'. It has connected with series of tanks organized within a micro-catchment. A 'cascade system' is the traditional unit used in the management of tanks. From ancient times it is referred to as 'Ellangawa'. The term is made up of the Sinhalese words 'ellan', meaning hanging and 'gawa', meaning one after the other. The figure 4.15.1 shown the organization of tanks and their connectivity within a typical tank cascade system.

Different river basins have different numbers of cascade systems within them. For example, the Mee Oya river basin has only one associated cascade system, while the Malwathu Oya river basin has 179 associated cascade systems.

Traditionally, there is one village tank (Maha Wewa/Pahala Wewa) for use by each village. The village tank is the main component of the tank cascade system. Water from all

other tanks in the system drain into the village tank. This tank is used for agriculture, as well as other community activities.

Although the main purpose of the tank cascade system was to provide water for irrigation purposes, the tank cascade system included tanks that had other purposes too. The purposes of the other tank types are connected in different ways to provide a good and constant supply of water to the village tank. The proper functioning of the village tank is therefore dependent on the condition of all the other types of tanks that are found in the tank cascade system. The ecosystem services and support to biodiversity varies considerably between each type of tank shown as Figure 4.15.2.

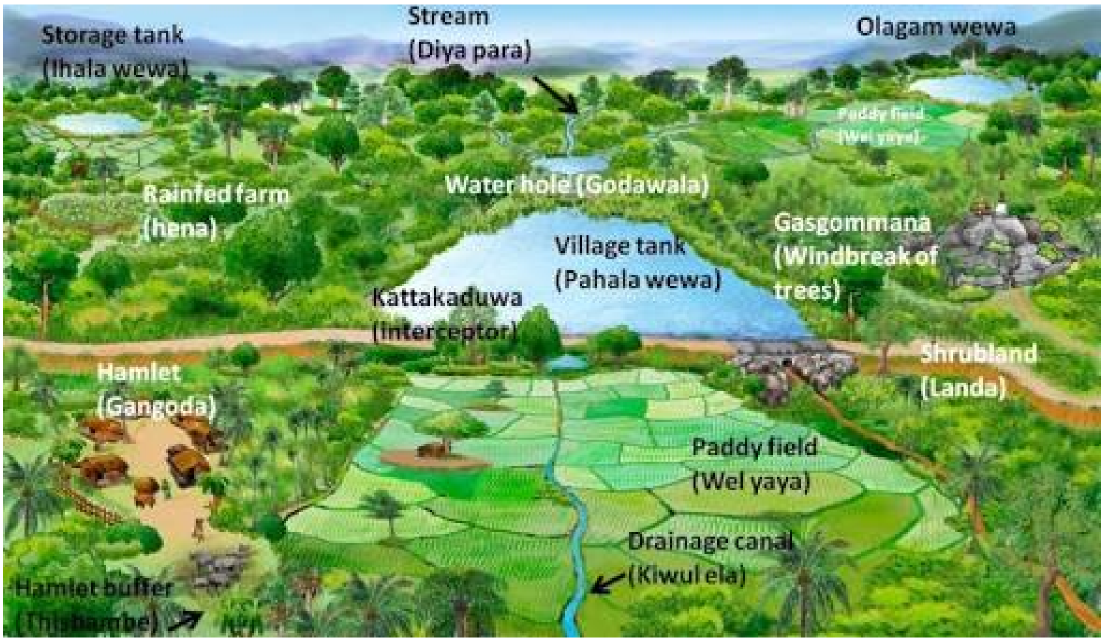


Figure 4.15.2: The ecosystem services and support to biodiversity varies considerably between each type

Kulu Wewa (Forest tank): constructed in the upper catchment of the village in order to provide water for wild animals, filter debris and silt, and capture the rainwater that will enter into the village tank through seepage. By providing water for wild animals, these forest tanks reduce the likelihood of these animals coming into the village to look for water and damaging crops.

Kayan Wewa: built where the upper catchment has been cleared or degraded. It is used to trap sediment and controls salinity.

Olagam Wewa: lies close to the village, but is not associated with a permanent settlement or cultivation. It is used as a source of water for seasonal cultivation.

Goda wala (Water hole): constructed for the trapping and deposition of silt, to avoid siltation and sedimentation of the main village tank.

Ihala Wewa (Storage tank): constructed for the storage of water, and is associated with paddy cultivation and other community activities.

In the old system of the tank cascade each tank did not have a village. There were tanks to serve specific purpose. The tank located at the highest elevation of the entire tank system and across the main stream of the cascade serve the purpose of detailing silt and debris. Also it reduced the energy of flow water that caused erosion. In the system there were tanks within the forest areas also serving the purpose of maintaining a micro-eco system

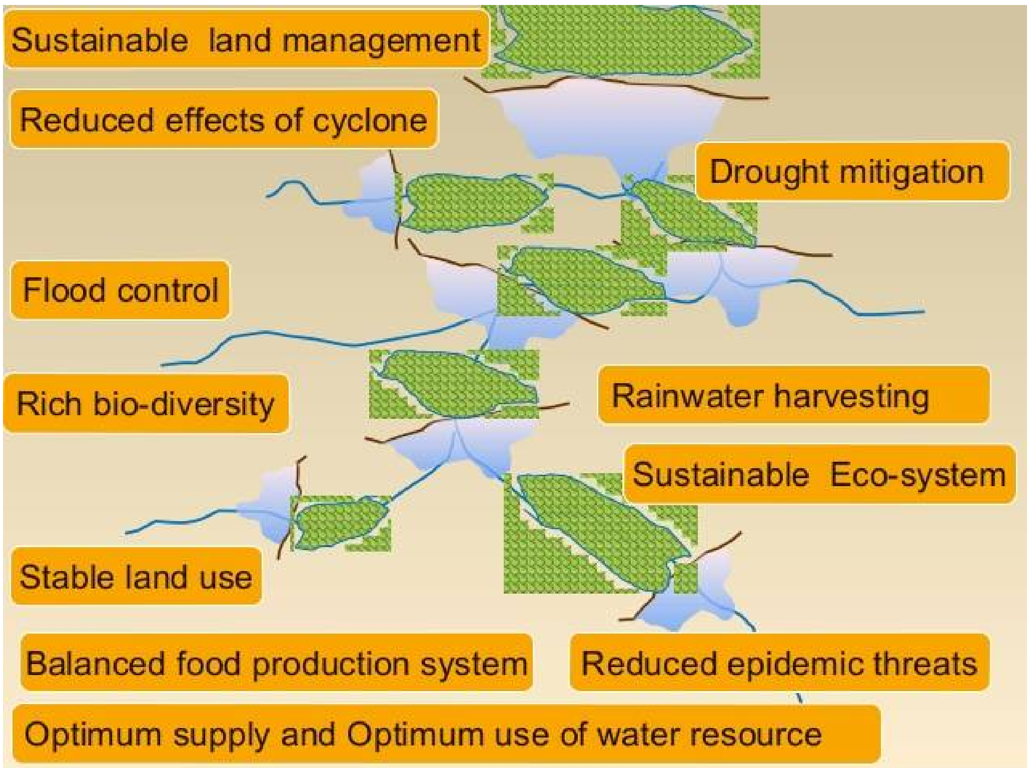


Figure 4.15.3: Benefits of this tank cascade system

that helped improve the ground water table. There were tanks store excess water during the rainy season for use in the dry season for agriculture. In addition to agriculture production benefits the small tank cascade system offered several other benefits such as flood control, fish breeding, maintenance of water table, extending the period of water availability, soil conservation and reduction of siltation. Benefits of this tank cascade system shown as figure 4.15.3.

While this system is well functioning in the past, it is currently inactive in some areas due to the several reasons and large number of tanks were completely abandoned.

Chapter 5

5. CONCLUSIONS

Japan, one of the most disaster-prone countries in the world, has developed a sophisticated and comprehensive disaster management system. Based on the three-layered national system of government and the country's administrative boundaries, the formation and evolution of the disaster management system in Japan has been strongly influenced by unfavorable geographical location, as well as by climate and topographic disasters and various Large-scale disasters have been the driving force for more change and improvement. Although it inherits basic elements from previous systems, the current management of disasters in Japan has been formed in the last 50 to 60 years. The rapid development of the country during this period allowed it to make considerable investments in DMS and integrate the latest technological advances in the country.

Rather than being administered by a central disaster management system in Japan, the system is decentralized and there has been a growing trend towards decentralization in recent years. As one of the most prominent features of the system, decentralization allows more government agencies to get involved in disaster management, although in various

Figure 4.4 Land use in Haliela DS area, 2016 measures and with different responsibilities it promotes ability to deal with development disasters in each agency or region individually and improves the overall disaster management system.

When talking about disaster or emergency response in Japan, it is important to distinguish the main additional, specialized and voluntary response forces and organizations. Through the main agencies, we assume that the municipalities and the Japanese Coast Guard have primary responsibility for ensuring and conducting rapid response operations in the land area, the second in the territorial waters of Japan. The specialized agencies are trained emergency medical assistance teams: DMAT and JMAT and specialized teams from various public companies designated for disaster management within the framework of the DCBA. In turn, the additional relief forces are administered by national government organizations such as FDMA, MLIT and MHLW which take disaster response measures once the scale of the disaster is beyond the capabilities of intervention of a municipal government. At the same time, the MLITT, the FDMA and the MHLW are central agencies for national supervision and coordination of emergency response activities, as well as large-scale disaster assistance.

In Sri Lanka, there is a system which is established for the emergency response based on the risk of the hazard level. But compared with Japan Government plan and the system for the emergency response is well established and disseminated throughout the country. Administrative level and role of the government officers in Sri Lanka are very comprehensive to manage the disaster. However, lack of experience to handle the large scale disaster, lack of resources and political interferes in the Disaster Management activities are more influence in the DRR.

Through this study, most of the DRR activities and response management system in japan can be extracted and apply to Sri Lankan Disaster Management System. Existing DMS in Sri Lanka should be revised according to the Japan standard and established it country administrative level.

LIST OF REFERENCES

A Better Integrated Management Of Disaster Risks: Toward Resilient Society To Emerging Disaster Risks In Mega-Cities, Eds., S. Ikeda, T. Fukuzono, And T. Sato, Pp. 23–40.Terrapub and Nied, 2006.

Comprehensive Study on Disaster Management in Sri Lanka Final Report, March 2009, Japan International Cooperation Agency

Disaster Management Act No 13 of 2005

Disaster Management in Japan, White Paper, 2015

DMC, 2005; Road Map for Safer Sri Lanka

Emergency management planning guide 2010–2011, Statutes of Canada

Factor Analysis of Water-related Disasters in Sri Lanka, June 2017

Flood and Sediment Disaster", May 2018, Cabinet Office

Flood Management in Japan Koji IKEUCHI Director of River Planning Division, Water and Disaster Management Bureau, MLIT, Japan

GFDRR Annual Report 2017

Guide to disaster management measures Cabinet Secretariat, Government of Japan Disaster Management Bureau, Cabinet Office, and Government of Japan

International Organization for Standardization, Draft International Standard iso/Dis 31000

Risk Management – Principles and Guidelines on Implementation (2009)

Mitigation of Flood Hazards In Japan M. Takezawa1, H. Gotoh1 & Y. Takeuchi2 1nihon University, Tokyo, Japan

National Emergency Operation Plan 2016 -2020

National Emergency Operation Plan 2016 -2020

Official Web-Page of Federal Emergency Management Agency, USA.

Available At: www.Fema.Gov

Sri Lanka Comprehensive Disaster Management Programme, (2014-2018)

https://www.straitstimes.com/asia/south-asia/230000-displaced-by-sri-lanka-floods

https://www.data.jma.go.jp/gmd/cpd/longfcst/en/tourist_japan.html

https://www.statista.com/statistics/270086/urbanization-in-japan

http://www.mlit.go.jp/river/basic_info/english/pdf/conf_01-0.pdf

https://www.japan-zone.com/news/2018/07/09/japan-flooding-update

http://www.qsr.mlit.go.jp/bousai/index_c19.html

https://www.researchgate.net/publication/259166095_a_globalscale_test_for_monsoon_indices_used_in_palaeoclimatic_reconstruction

http://agora.ex.nii.ac.jp/digital-typhoon/index.html.en

https://www.cgr.mlit.go.jp/photo/h3007gouu/higai/00006.html

https://pdfs.semanticscholar.org/af57/d54d28bcc13a6e56cbbf71a28ca56363f669.pdf

https://www.mlit.go.jp/river/basic_info/english/pdf/conf_04-0.pdf

https://www.mlit.go.jp/river/basic_info/english/pdf/conf_10.pdf

https://www.gov-online.go.jp/eng/publicity/book/hlj/html/201803/201803_03_en.html

https://www.sciencedirect.com/science/article/pii/S2212682113000322