Research Paper on

An Integrated Framework for the Earthquake Preparedness: An Assessment of the Applicability of Japanese Experience in Bangladesh

By

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LIST OF ABBREVIATIONS

ADRC : Asian Disaster Reduction Centre

BRAC : Bangladesh Rural Advancement Centre

CPP : Cyclone Preparedness Program

CCA : Climate Change Adaptation

CDMP : Comprehensive Disaster Management Program

DM : Disaster Management

DRR : Disaster Risk Reduction

DMB : Disaster Management Bureau

DMRD : Disaster Management and Relief Division

DDM : Department of Disaster Management

DMIC : Disaster Management Information centre

DLA : Detailed Livelihood Assessment

DRRO : District Relief & Rehabilitation Officer

ECNEC : Executive Committee for National Economic Council

EMMA : Emergency Market Mapping and Analysis Tool-Kit

EU : European Union

EQ : Earthquake

GOB : Government of Bangladesh

GR : Gratuitous Relief

ILO : International Labour Organization

IRP : International Recovery Platform

ILIA : Initial Livelihood Impact Appraisal

JICA : Japan International Cooperation Agency

MODMR : Ministry of Disaster Management and Relief

NDRCC : National Disaster Response Coordination Centre

NGO : Non- Government Organization

NHK : Nippon Hoso Kyokai

NPO : Non-Profit Organization

PIO : Project Implementation Officer

PDRP : Pre-Disaster Recovery Planning

REOPA : Rural Employment Opportunity for Public Assests

SOD : Standing Order on Disaster

UNDP : United Nation Development Program

VR : Visiting Researcher

VGF : Vulnerable Group Feeding

WFP : World Food Program

Table of Contents

1.1 Introduction:

The geophysical location, land characteristics, multiplicity of rivers and the monsoon climate render Bangladesh highly vulnerable to natural hazards. Climate change adds a new dimension to community risk and vulnerability. The Disaster Management Vision of the Government of Bangladesh is to reduce the risk of people, especially the poor and the disadvantaged, from the effects of natural, environmental and human induced hazards, to a manageable and acceptable humanitarian level, and to have in place an efficient emergency response system capable of handling large scale disasters. In this regard, Ministry of Disaster Management and Relief has developed the mission to reduce the vulnerability by bringing a paradigm shift in incident management from conventional response and relief practice to a more comprehensive risk reduction culture.

As a developing country, Bangladesh is striving for optimum development and allocates more than 500 million USD for annual development each year. But considerable amount of the development initiative and investment are jeopardized by unwanted incidents. Proper management & communication skill related to hazards can reduce losses and damages. Different types of communication practices like early warning and timely forecasting can make it possible to avoid huge losses, and to safeguard the development process. Appropriate knowledge of the disaster management and relevant communication can be very helpful for comprehensively dealing with the hazards. Thus development initiatives can reach at an optimum level.

The government, in coordination with NGOs and international organizations, has done a commendable job in responding to the flood risk management and cyclone preparedness but most of the remaining major environmental incidents like earthquake are still unreachable at the point of prediction, emergency response and management due to lack professionals, appropriate tools, processes and guidelines.

Recent study shows that Bangladesh is possibly one of the countries, most vulnerable to potential earthquake threat and damage. The Seismic activity of Bangladesh is shown an earthquake of even medium magnitude on Richter scale can produce a mass graveyard in major cities of the country, particularly Dhaka, Sylhet and Chittagong. However, under the present stage of human occupancy, buildings, infrastructures and other physical structures of different areas of a city will not be equally vulnerable to any such shock. Earthquake vulnerability of any place largely depends on its geology and topography, population density, building density and quality, and finally the coping strategy of its people and it shows clear spatial variations. It is thus necessary to identify the scale of such variations and take necessary measurements to cope with that.

1.2 Background of the Research:

Bangladesh, a densely populated country in South Asia, is located in the north-eastern part of the Indian sub-continent at the head of the Bay of Bengal. Tectonically, Bangladesh lies in the north-eastern Indian plate near the edge of the Indian craton and at the junction of three tectonic plates - the Indian plate, the Eurasian plate and the Burmese micro-plate. In broad terms, Bangladesh is an earthquake-prone country; its northern and eastern regions in particular are known to be subjected to earthquakes of magnitudes greater than 5 on the Richter scale. The geo-tectonic set-up of the country, which is located along two of the planet's active plate boundaries, suggests high probabilities of damaging future earthquakes and the possibility of rarer but extraordinarily large earthquakes that can cause damage far from their epicenters. The juxtaposition of the Himalayan orogen along with its syntaxes northeast of Bangladesh and the convergent Burma Arc plate boundary in the east make this land in particular, vulnerable to high-magnitude earthquake events.

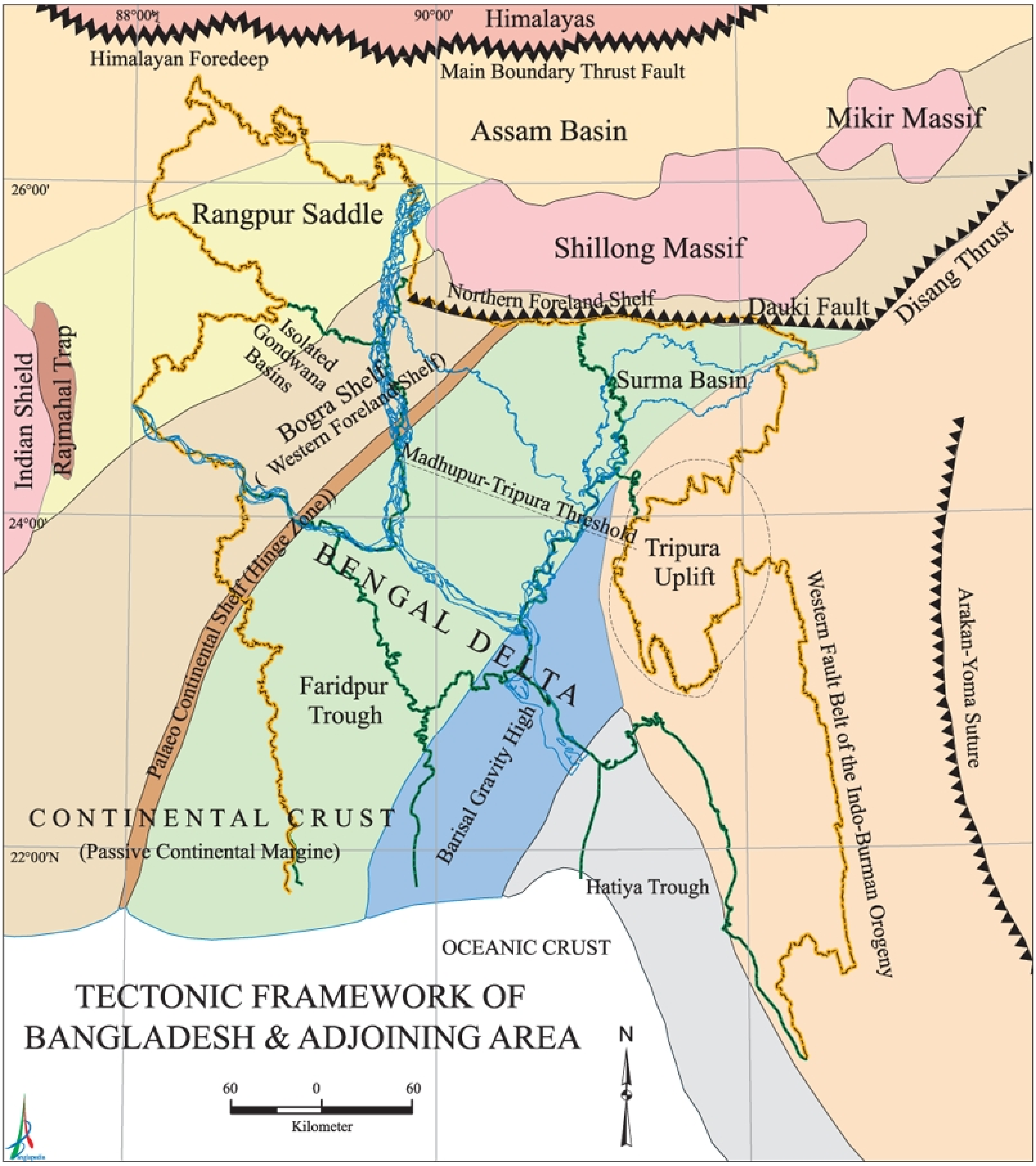


Figure-1.1: Tectonic Framework of Bangladesh & adjoining area, source Haque, (2007).

The hazard that is inferred from tectonic analysis is backed by historic evidence. Bangladesh, a country of multiple natural disaster vulnerabilities, and its capital Dhaka are under the looming threat of cataclysmic earthquakes. Records show that large earthquakes have previously ravaged the country and the neighboring region several times over the last 450 years.

The north and northeastern parts of Bangladesh are the most active seismic zones, and had experienced earthquakes of moderate to high intensity in the past. The great earthquake of 1897 had its epicentre in the Shillong Plateau of India, and caused widespread damage in adjacent areas of what was then known as Bengal. Two other major earthquakes that caused severe damage in areas adjacent to the epicentres were in 1885, known as the Bengal Earthquake, and in Srimangal in 1918. In addition, major earthquakes occurred in Bangladesh, and surrounding areas in the years 1833, 1897, 1906, 1918, 1923, 1926, 1927, 1930, 1934, 1939, 1941, 1943, 1947, 1950, 1951 , 1954, 1957, 1962, 1965, and 1988. Earthquakes with magnitudes between 7.0 and 8.7 on the Richter scale have been experienced in this country, but they are rare events.

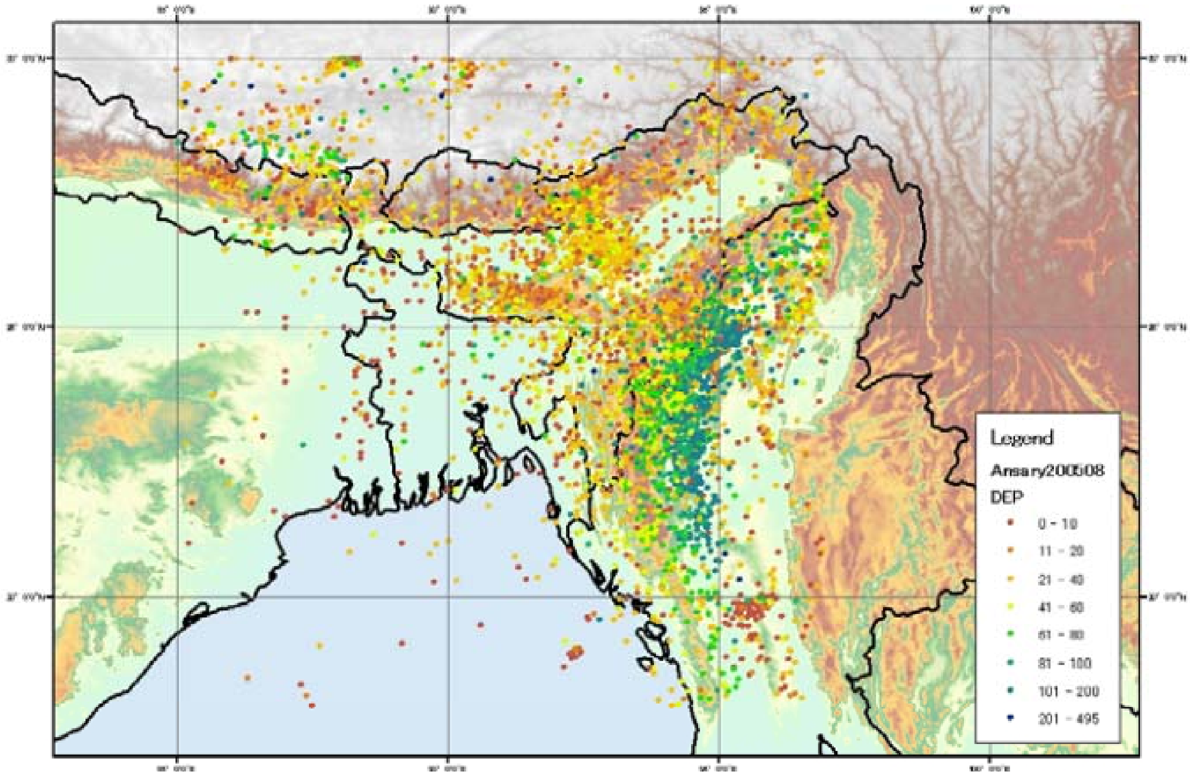


Figure-1.2: Epicentres of Historical Earthquake in Bangladesh (1664-2007), source: by Bilham et al.(2003).

1.3 Significance of this Research:

As, Tectonically, Bangladesh lies in the northeastern Indian plate near the edge of the Indian craton and at the junction of three tectonic plates – the Indian plate, the Eurasian plate and the Burmese microplate. These form two boundaries where plates converge– the India-Eurasia plate boundary to the north forming the Himalaya Arc and the India-Burma plate boundary to the east forming the Burma Arc. The Indian plate is moving ~6 cm/yr in a northeast direction and subducting under the Eurasian (@ 45 mm/yr) and the Burmese (@ 35 mm/yr) plates in the north and east, respectively (Sella *et al*., 2002; Bilham, 2004). This continuous motion is taken up by active faults. However, they do so sporadically, primarily in large earthquake ruptures.An active fault in the upper crust tends to be locked so that plate motion is absorbed elastically until stress rises to the breaking point and the fault ruptures. Thus the probability of an earthquake from a given fault depends on the rate of motion and on the time since the last rupture. Active faults of regional scale capable of generating moderate to great earthquakes are present in and around Bangladesh. These include the Dauki fault, about 300 km long trending east-west and located along the southern edge of Shillong Plateau (Meghalaya- Bangladesh border), the 150 km long Madhupur fault trending north-south situated between Madhupur Tract and Jamuna flood plain, Assam-Sylhet fault, about 300 km long trending northeast-southwest located in the southern Surma basin and the Chittagong-Myanmar plate boundary fault, about 800 km long runs parallel to Chittagong-Myanmar coast. The Chittagong- Myanmar plate boundary continues south to Sumatra where it ruptured in the disastrous 26 December 2004 Mw 9.3 earthquake (Steckler *et al.* 2008). These faults are the surface expression of fault systems that underlie the northern and eastern parts of Bangladesh. Another tectonic element, the 'Himalayan Arc' is characterized by three well defined fault systems (HFT, MBT and MCT) that are 2500 km long stretching from northwest syntaxial bend in Pakistan in the west to northeast syntaxial bend in Assam in the east. It poses a great threat to Bangladesh as significant damaging historical earthquakes have occurred in this seismic belt (Bilham *et al*., 2001; Mukhopadhyay *et al*., 2004 and Mullick *et al*., 2009). The tectonic set-up and the plate motions together place Bangladesh potentially vulnerable to earthquake. Bangladesh, a major part of the Bengal Basin, is home to one of the largest and most active deltas of the world formed by the Ganges-Brahmaputra-Meghna river system. It is almost entirely formed of recent alluvial

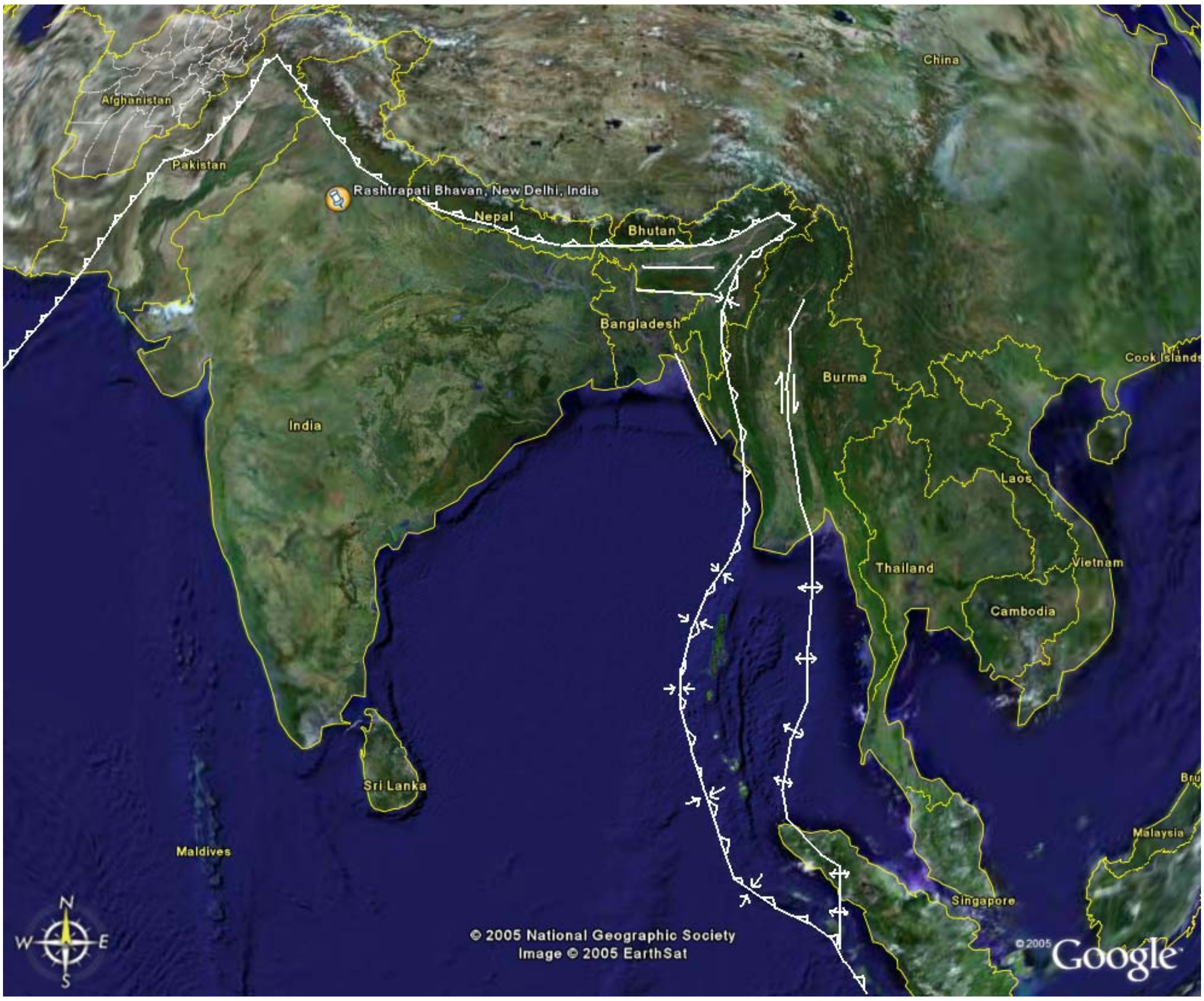


Figure-1.3: Plate Boundary between Indian and Eurasian Plate, Akhter, S.H.(2010).

and deltaic deposits. Topographically, Bangladesh is mainly composed of low-lying flat country with the exception of slightly elevated Pleistocene uplands in the central and northwestern parts of the country and Tertiary hilly terrain in the northeast and southeast parts. These hills are part of the folding associated with the BurmaArc plate boundary (Steckler *et al.* 2008).

Significant damaging historical earthquakes have occurred in and around Bangladesh and damaging moderate-magnitude earthquake occur every few years. The country's position adjacent to the very active Himalayan front in the north and Burma deformation front in the east expose it to strong shaking from a variety of earthquake sources that can produce tremors of magnitude 8 or greater. The potential for magnitude 8 or greater earthquakes on the nearby Himalayan and Burmese fronts, which depends on the rate at which elastic strain is accumulated, is very high. The effects of strong shaking from such an earthquake would directly affect much of the country including Dhaka. In addition, historical seismicity within Bangladesh indicates that potential for damaging moderate to strong earthquakes exist throughout much of the country. Large earthquakes occur less frequently than serious floods, but they can affect much larger areas and can have long-lasting economic, social, and political effects.

The tectonic set-up of Bangladesh, especially its position close to three converging lithopheric plates with the presence of seismogenic faults, suggests that the country, including its capital Dhaka, must have suffered from severe earthquakes in the historical past. The occurrence of earthquakes and consequent destruction in Bangladesh and neighboring regions are poorly documented. Few records of them are available in published and unpublished literatures.

At present disaster management aims to achieve a paradigm shift from conventional response and relief practice to a more comprehensive risk reduction culture. In this process prepared is the most important phase. In the case of earthquake, preparedness is the most suitable way to reduce the risk because prevention is not possible and scope of mitigation is very limited.

The Integrated Natural Disaster Risk Management means that people can recognize and assess many kinds of natural disaster risk, and deal with the risk they may meet so as to receive the biggest safe guarantee by using the lowest cost. It is a comprehensive and integrated approach that embraces the management of all types of natural disasters and all phases of disaster management cycle, focuses on disaster hazard and vulnerability, i.e. the underlying conditions of disasters, and emphasizes a multi-level, multi-dimensional, multi-disciplinary coordination among stakeholders.

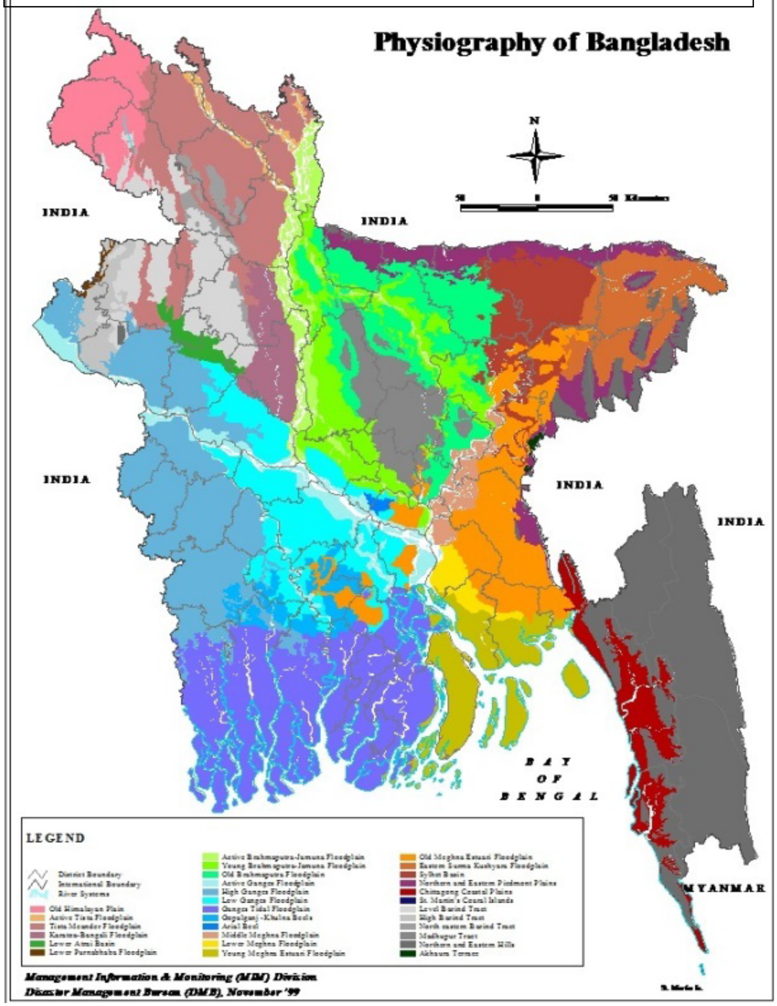
Japan is one of the most earthquake prone countries of the world and it has gained a long experience of managing different aspects of earthquake with its esteemed technical expertise. So Bangladesh can be benefited if ways are identified to apply Japanese experiences and technical know-how in this context.

1.4 Disaster Risks in Bangladesh: An overview

1.4.1 Physiography of Bangladesh:

Bangladesh is a low-lying, riverine country with a largely marshy jungle coastline of 710 km (441 mi) on the northern littoral of the Bay of Bengal. Formed by a delta plain at the confluence of the Ganges (Padma), Brahmaputra (Jamuna), and Meghna Riversand their distributaries and tributaries, Bangladesh's alluvial soil is highly fertile, but vulnerable to flood and drought. Hills rise above the plain only in the Chittagong Hill Tracts in the far southeast and the Sylhet division in the northeast. The whole country consists of mainly low and flat land, except for the hilly regions in the northeast and southeast. A network of rivers, with their tributaries and distributaries, crisscross the country. Physiographically, the country can be divided into hills, uplifted land blocks, and the majority alluvial plains with very low mean elevation above sea level the In terms of geographical location, Bangladesh is in the context of the GBM river system. Geologically, Bangladesh is a part of the Bengal Basin, one of the largest geosynclinals in the world. The Basin is bordered on the north by the steep Tertiary Himalayas; on the northeast and east by the late Tertiary Shillong Plateau, the Tripura hills of lesser elevation, and the Naga-Lusai folded belt; and in the west by the moderately high, ancient Chotanagpur plateau. The southern fringe of the basin is not distinct, but geophysical evidence indicates it is open towards the Bay of Bengal for a considerable distance. The formation and growth of the Bengal Basin is directly related to the origin and morphology of the Indo-Gangetic trough, which itself is overlaid and filled by sediments thousands of meters thick. The broad geological features of the Bengal Basin and its prominent tectonic elements are Indian platform, Bengal foredeep, Arakan Yoma folded system, and the Sub-Himalayan Foredeep. Other features are Rangpur Saddle, Dinajpur slope, Bogra slope, Hinge Zone, Barisal High, and Troughs of Sylhet, Faridpur and Hatiya, etc.

Figure-1.4: Physiography of Bangladesh, source DMB.



1.4.2 Climate:

Bangladesh has a tropical monsoon climate characterized by wide seasonal variations in rainfall, high temperatures, and high humidity. Regional climatic differences in this flat country are minor. Three seasons are generally recognized: a hot, muggy summer from March to June; a hot, humid and rainy monsoon season from June to November; and a warm-hot, dry winter from December to February.In general, maximum summer temperatures range between 38 and 41 °C (100.4 and 105.8 °F). April is the hottest month in most parts of the country. January is the coolest month, when the average temperature for most of the country is 16–20 °C (61–68 °F) during the day and around 10 °C (50 °F) at night. Winds are mostly from the north and northwest in the winter, blowing gently at 1 to 3 kilometers per hour (0.6 to 1.9 mph) in northern and central areas and 3 to 6 kilometers per hour (1.9 to 3.7 mph) near the coast. From March to May, violent thunderstorms, called northwesters by local English speakers, produce winds of up to 60 kilometers per hour (37.3 mph). During the intense storms of the early summer and late monsoon season, southerly winds of more than 160 kilometers per hour (99.4 mph) cause waves to crest as high as 6 meters (19.7 ft) in the Bay of Bengal, which brings disastrous flooding to coastal areas. The annual rainfall is about 1,600 mm (63.0 in), most parts of the country receive at least 2,300 mm (90.6 in) of rainfall per year. About 80% of Bangladesh's rain falls during the monsoon season.

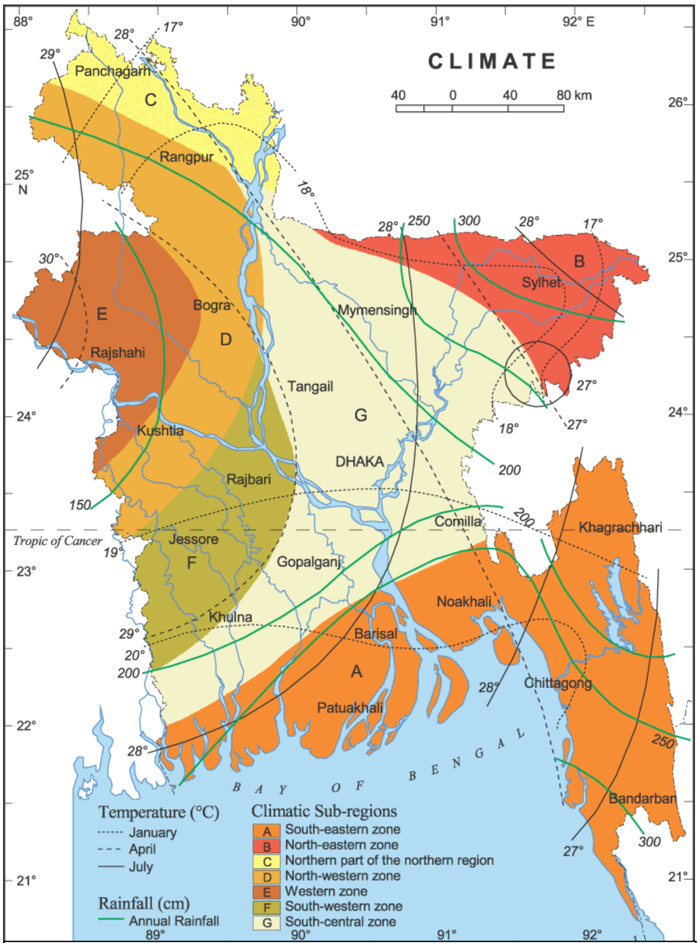


Fig-1.5: Climate in Bangladesh, Source, DMB

1.4.3 Natural Hazards in Bangladesh:

Historical statistics would suggest that Bangladesh is one of the most disaster prone countries in the world with great negative consequences being associated with various natural and human induced hazards. The geophysical location, land characteristics, multiplicity of rivers and the monsoon climate render Bangladesh highly vulnerable to natural hazards. The coastal morphology of Bangladesh influences the impact of natural hazards on the area. Especially in the south eastern area, natural hazards increase the vulnerability of the coastal dwellers.

Disasters and Bangladesh

- Flood
- Tropical Cyclone
- Storm Surge
- Tornado
- River Bank Erosion
- Drought
- Earthquake

Key factors of vulnerability

- Geographical location
- Dominance of flood plains
- Low elevation from the sea
- Global warming & climate change
- High population density
- High level of poverty

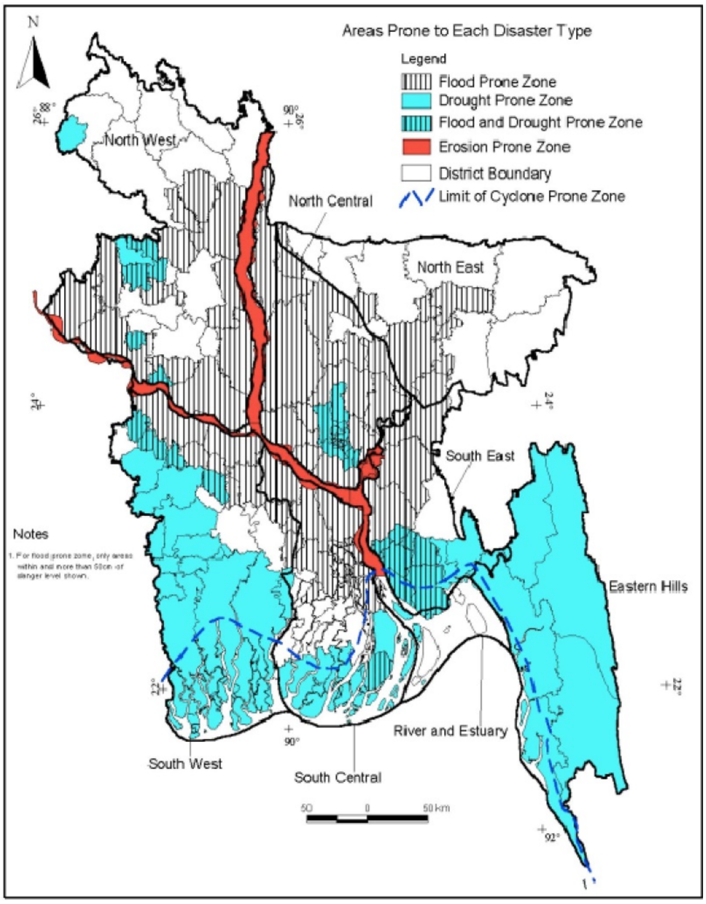


Fig-1.6: Disaster Prone Areas, Map Source: DMB

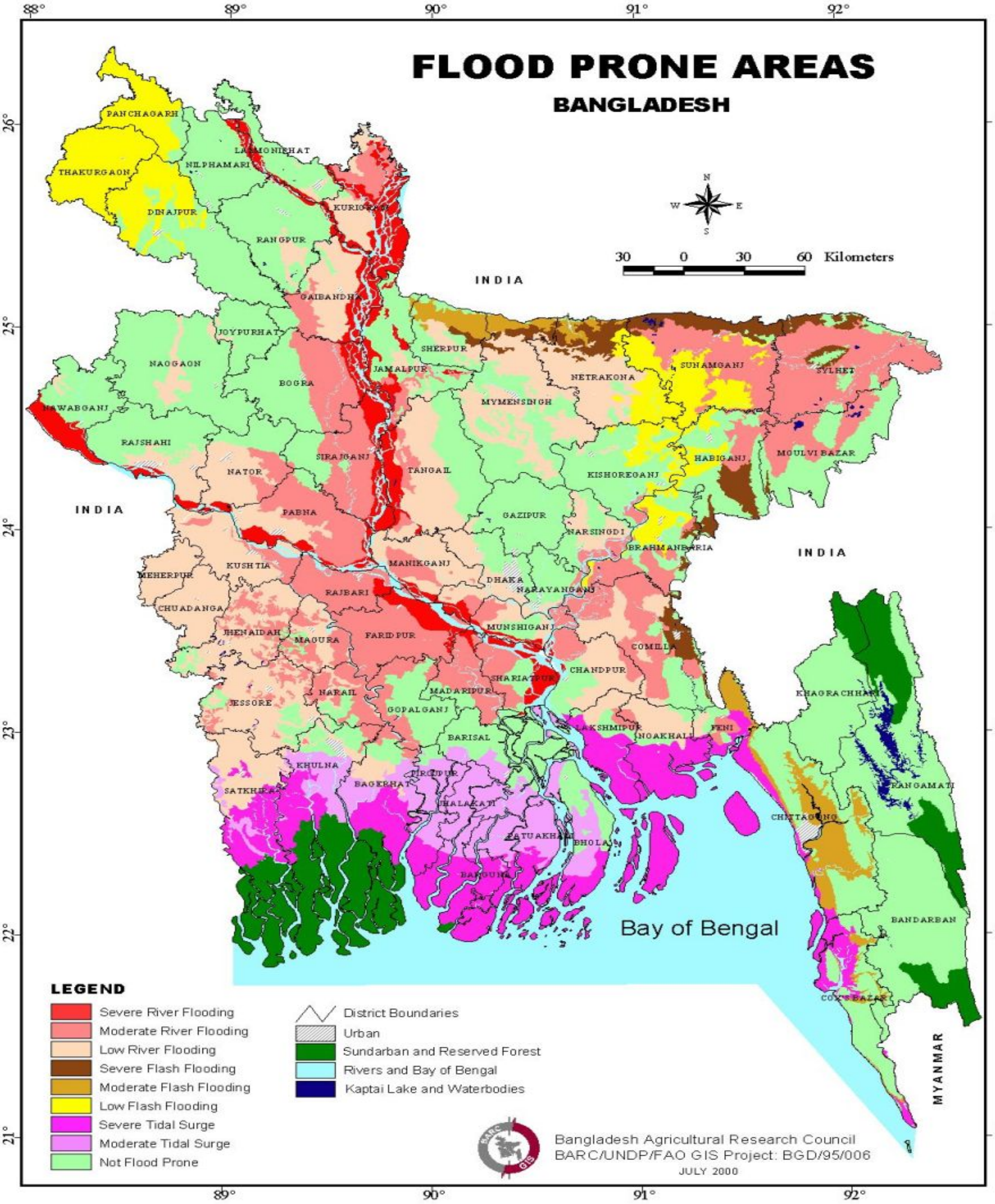
Flood:

Floods are annual phenomena, with the most severe occurring during the months of July and August. Regular river floods affect 20% of the country, increasing up to 68% in extreme years. The floods of 1988, 1998, 2004 and 2007 were particularly catastrophic, resulting in large-scale destruction and loss of lives.

- Flash floods caused by overflowing of hilly rivers in eastern and northern Bangladesh (in April-May and September-November).
- Rain floods caused by drainage congestion and heavy rains.
- Monsoon floods caused by major rivers usually in the monsoon (during June-September).
- Coastal floods caused by storm surges.

The 1998 flood lasted for 65 days from July 12 to September 14 and affected about 67% of area of the country. In the year 2000, Bangladesh faced an unusual flood over its usually flood-free south western plain, which also caused loss of life and massive damage to property. In 2004, floods inundated about 38% of the country. About 747 people lost their lives. About 2,500 kilometers of embankment were damaged and about 74 primary school buildings were washed away. This flood caused economic losses of about US$2,200 Million.

Fig-1.7: Flood Prone Areas, Map Source: DMB



Tropical Cyclone:

Tropical cyclones from the Bay of Bengal accompanied by storm surges are one of the major disasters in Bangladesh. The country is one of the worst sufferers of all cyclonic casualties in the world. Number of casualties is due to the fact that cyclones are always associated with storm surges. Storm surge height in excess of 9m is not uncommon in this region. For example, the 1876 cyclone had a surge height of 13.6 m and in 1970 the height was 9.11 m. In fact, the 1970 cyclone is the deadliest cyclone that has hit Bangladesh coastline. With a wind-speed of about 224 km per hour and associated storm surge of 6.1 to 9.11m, it was responsible for deaths of about 300,000 people.

Table 1: Major cyclones that hit the Bangladesh coast

Date		Maximum Wind speed (km/hr)	Storm Surge height (metres)	Death Toll
11 May	1965	161	3.7-7.6	19,279
15 December	1965	217	2.4-3.6	873
01 October	1966	139	6.0-6.7	850
12 November	1970	224	6.0-10.0	300,000
25 May	1985	154	3.0-4.6	11,069
29 April	1991	225	6.0-7.6	138,882
19 May	1997	232	3.1-4.6	155
15 November	2007	223	4.2-4.6-	3363
25 May (AILA)	2009	92	--	190
16 May (Mahasen)	2012	130	--	16

Source: Bangladesh Meteorological Department 2013

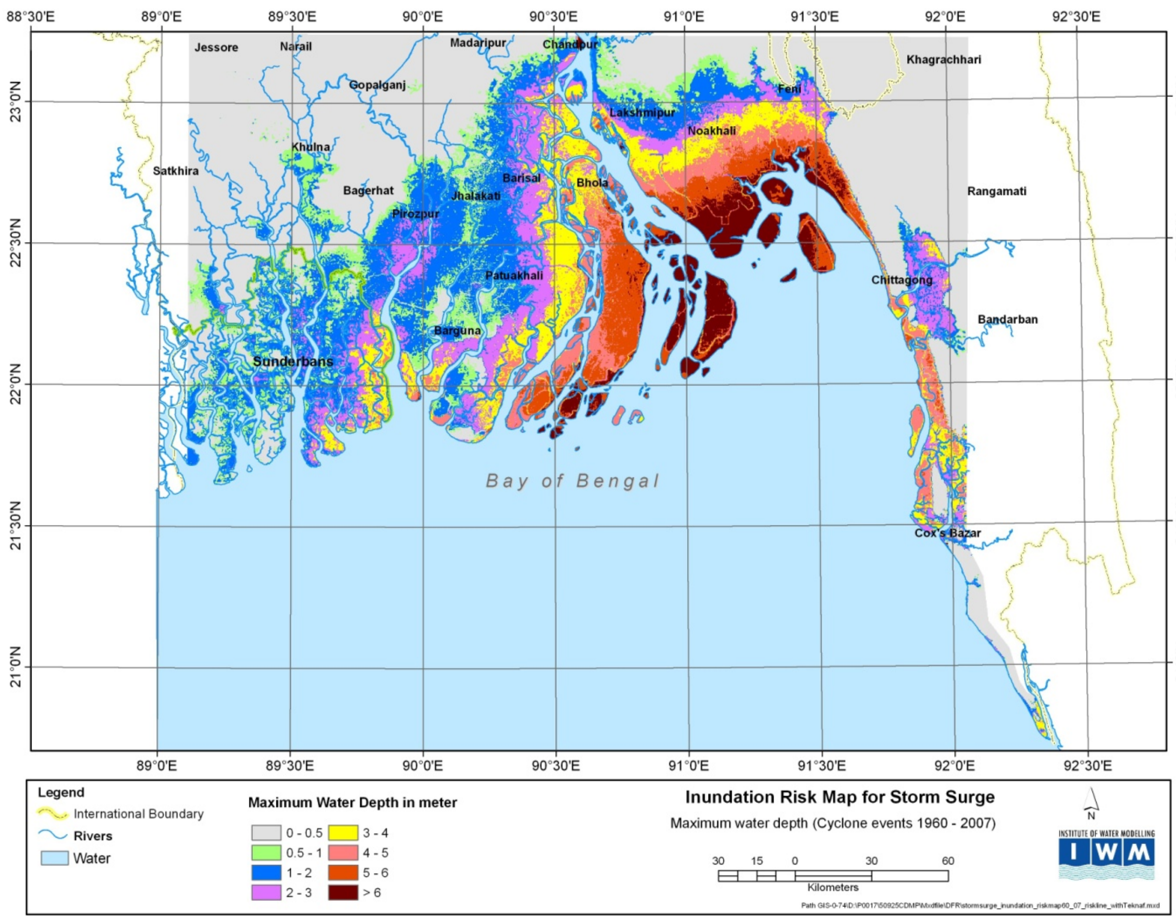


Figure-1.8: Inundation Risk Map for Strom Surge, source, IWM

Tornado:
The two transitional periods between southwest and northeast monsoons over the Indian sub-continent are characterized by local severe storms. The transitional periods are usually referred to as pre-monsoon (March-May), and post-monsoon (October-November). It is the pre-monsoon period when most of the abnormal rainfall or drought conditions frequently occur in different parts of Bangladesh. Also there are severe local seasonal storms, popularly known as nor'westers (kalbaishakhi). Severe nor'westers are generally associated with tornadoes. Tornadoes are embedded within a mother thundercloud, and moves along the direction of the squall of the mother storm. The frequency of devastating nor'westers usually reaches the maximum in April, while a few occur in May, and the minimum in March. Nor'westers and tornadoes are more frequent in the afternoon. Nor'westers may occur in late February due to early withdrawal of winter from Bangladesh, Bihar, West Bengal, Assam, and adjoining areas. The occasional occurrence of nor'westers in early June is due to the delay in the onset of the southwest monsoon over the region.

Table-2: The devastating nor'westers and tornadoes that hit Bangladesh:

14 April 1969	Demra (Dhaka)
17 April 1973	Manikganj (Dhaka)
10 April 1974	Faridpur
11 April 1974	Bogra
09 May 1976	Narayanganj
01 April 1977	Faridpur
26 April 1989	Saturia (Manikganj)
14 May 1993	Southern Bangladesh
13 May 1996	Tangail
04 May 2003	Brahmanbaria
21 March 2005	Gaibandha
22 March 2013	Brahmanbaria

Wind speeds in nor'westers usually do not exceed 113-130 km/hr (70-80 miles/hr), though often their speeds exceed 162 km/hr (100 miles/hr). When the winds become whirling with funnel shaped clouds having a speed of several hundred kilometers or miles per hour, they are called tornados. Nor'westers bring the much-needed pre-monsoon rain. They can also cause a lot of havoc and destruction. Tornados are suddenly formed and are extremely localized in nature and of brief duration. Thus, it is very difficult to locate them or forecast their occurrence with the techniques available at present. However, high-resolution satellite pictures, suitable radar, and a network of densely spaced meteorological observatories could be useful for the prediction or for issuing warnings of nor'westers and tornados.

River Bank Erosion:
River erosion in Bangladesh is no less dangerous than other sudden and devastating calamities. Losses due to river erosion occur slowly and gradually. Though losses are slow and gradual, they are more destructive and far-reaching than other sudden and devastating calamities. The effects of river erosion are long-term. It takes a few decades to make up the losses, which a family has incurred by river erosion. There has been little progress, however, for improving the lives of erosion-affected people due to resource constraint. This is an on-going disaster and there is no specific indicator to measure the extent of damage. So

the extent of damage caused by river erosion in most cases is based on various reports/information. Needless to say whatever the difference in ascertaining the extent of damage river erosion causes huge loss of property throughout the year. According to "World Disaster Report 2001" published by IFRCS every year about 10,00,000 people are affected by river erosion and 9,000 hectare cultivable lands are banished in river. Among these only a few affected people are able to find new shelters while others become homeless for uncertain period. A recent study of CEGIS (2005) shows that bank erosion along Padma River during 1973 – 2004 was 29,390 hectares and along Jamuna River during 1973 – 2004, it was 87,790 hectares.

Droughts:

Drought conditions due to deficiency in rainfall affect different parts of Bangladesh mostly during the pre-monsoon and post-monsoon periods. Between 1949 and 1991, droughts occurred in Bangladesh 24 times. Very severe droughts hit the country in 1951, 1957, 1958, 1961, 1972, 1975, 1979, 1981, 1982, 1984 and 1989. Past droughts have typically affected about 47% area of the country and 53% of the population (WARPO, 2005). Bangladesh faces unpredictable drought hazard in the dry monsoon due to inadequate and uneven rainfall. It varies from place to place, however, and the northwestern region suffers most from the drought. As much as 17% of the Aman crops, the main paddy crops in the wet season may be lost in a typical year due to drought.

Earthquake:

The historical seismic data of Bangladesh and adjoining areas indicate that Bangladesh is vulnerable to earthquake hazard. The record of approximately 150 years shows that Bangladesh and the surrounding regions experienced seven major earthquakes (with Mb = 7). In the recent past, a number of tremors of moderate to severe intensity had already taken place in and around Bangladesh. The Sylhet Earthquake (Mb = 5.6) of May 8, 1997, the Bandarban Earthquake (Mb = 6.0) of November 21, 1997, the Moheshkhali Earthquake (Mb = 5.1) of July 22, 1999, the Barkal (Rangamati) Earthquake (Mb=5.5) of July 27, 2003, the Meghalay Earthquake (Mb=5.2) of March 02, 2013 and many more shakes in the recent years may be cited as examples. Bangladesh and the northeastern Indian states have long

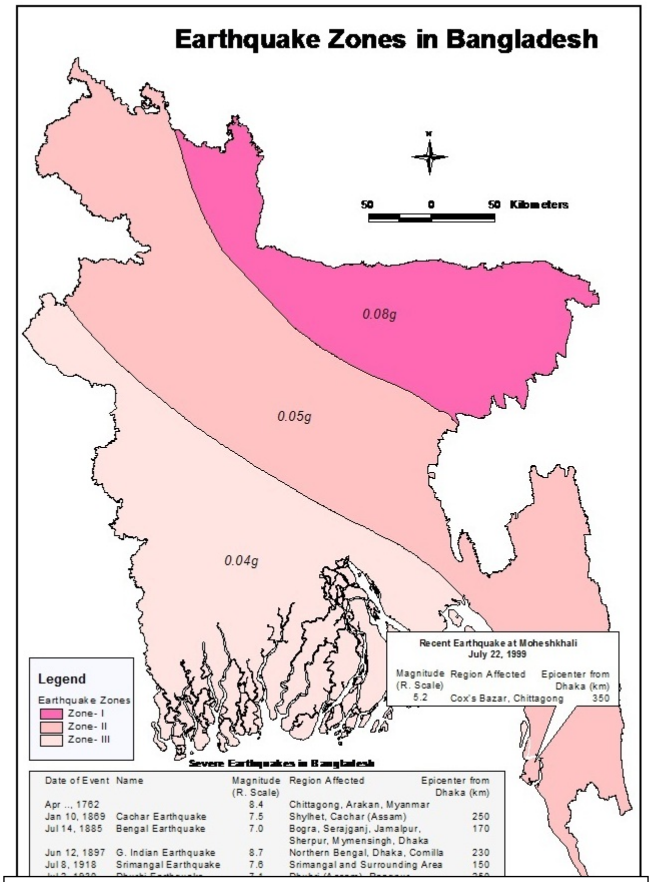


Fig-1.9: Earthquake Zones in Bangladesh, source GSB.

been one of the seismically active regions of the world, and have experienced numerous large earthquakes during the past 200 years. Many of seismic-tectonic studies have been undertaken on the area comprising the Indo-Burman ranges and their western extension and in the northern India. Major active fault zones of the country have been delineated through geological trenching and dating methods. A seismic zoning map of Bangladesh has been proposed in 1979 by Geological Survey of Bangladesh (GSB) dividing the country into three seismic zone which was accompanied by an outline of a code for earthquake resistant design. Later, a new updated seismic zoning map and detailed seismic design provisions have been incorporated in Bangladesh National Building Code (BNBC 1993). A seismicity map of Bangladesh and its adjoining areas has also been prepared by BMD and GSB. Bangladesh has been classified into three seismic zones with zone-3 the most and zone-1 the least vulnerable to seismic risks.

Table-3: List of Major Earthquakes Affecting Bangladesh

Date	Name	Magnitude (Richter)	Epicentral Distance from Dhaka (km)	Epicentral Distance from Sylhet City (km)	Epicentral Distance from Chittagong (km)
10 January, 1869	Cachar Earthquake	7.5	250	70	280
14 July, 1885	Bengal Earthquake	7.0	170	220	350
12 June, 1897	Great Indian Earthquake	8.7	230	80	340
8 July, 1918	Srimongal Earthquake	7.6	150	60	200
2 July, 1930	Dhubri Earthquake	7.1	250	275	415
15 January, 1934	Bihar-Nepal Earthquake	8.3	510	530	580
15 August, 1950	Assam Earthquake	8.5	780	580	540

1.5 Objectives of the Research:

1.5.1 Specific Aims:

- To understand tools and processes on earthquake preparedness at a national and local level in Japan.
- To review response models and ways of working with other key responders.
- To asses applicability *of* Japanese experience on earthquake response and recovery in Bangladesh.
- Replicating Japanese vast experience on earthquake risk reduction in Bangladesh.
- To prepare recommendations for improvement of the National Earthquake Risk Reduction Plan in Bangladesh.

1.5.2 Long term Goals:

This research will recommend an integrated framework for the earthquake preparedness to review the existing standing orders, plans and policies. It will assist to align the strategic direction of the earthquake preparedness with national priorities and international commitments and outline the strategic direction and priorities to guide the design and implementation of earthquake management plans, policies and programmes. It will contribute to articulate the vision and goals for the National Earthquake Risk Reduction Plan in Bangladesh.

1.6 Data and Information and Potential Resources:

To fulfil the specific aims of the research, it would be used qualitative and quantitative data from various published and unpublished sources in Bangladesh and Japan. Undermentioned data and information have been used to conduct this research:

- Institutional and Legal Frameworks for Earthquake Preparedness.
- Earthquake Response Plans of National, Prefectural and Local level.
- Models
- Attribute data on past time earthquakes.
- Statistical data
- Maps, Satellite Image and photos.
- Graphics and Charts.
- CBDRR Observations from field visit.

Maps, Satellite Image, photo, statistical information, frameworks, charts and models have been used from potential sources like Government Office, DRR agencies, previous research, articles and Journals. CBDRR Observations would be gathered from field visit, interviews, lectures and briefings.

1.7 Research Methodology:

To attain the research objectives under-mentioned activities have been performed

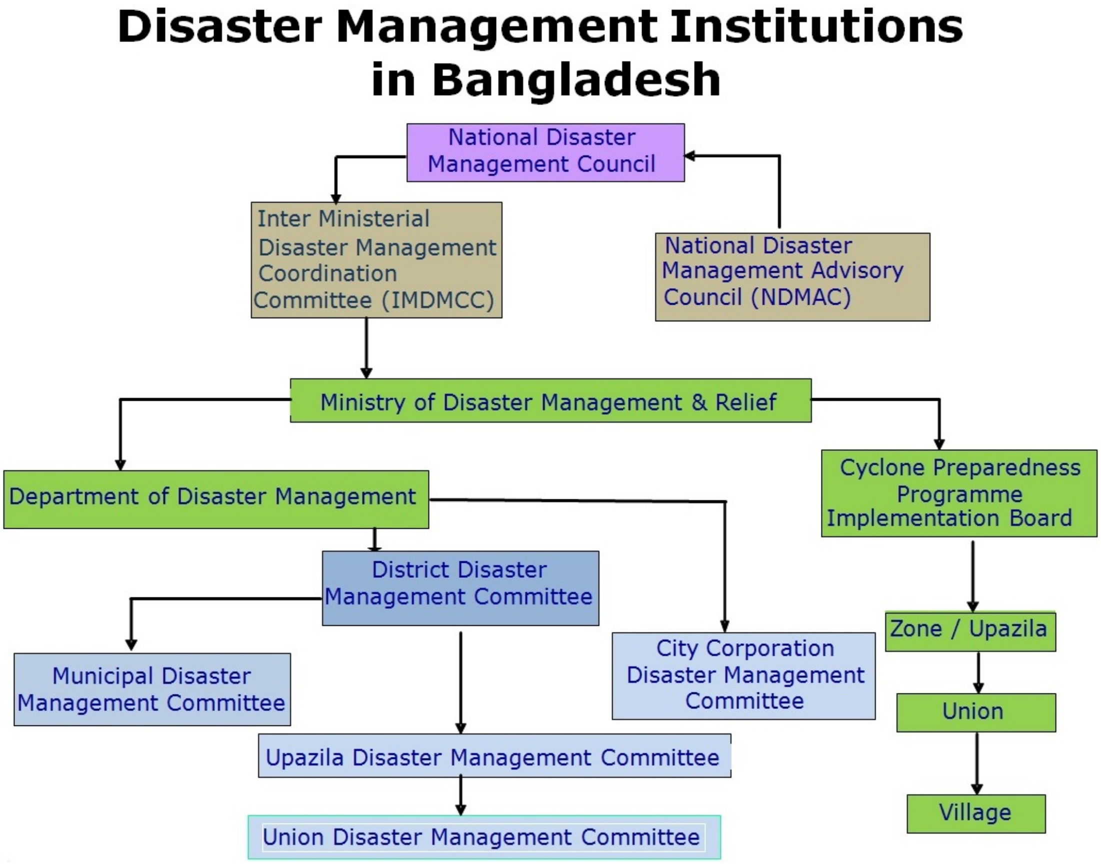
1.7.1 Research Activities:

- Literature Review.

- Critical review of the current earthquake preparedness in Bangladesh
- Understanding the earthquake preparedness in Japan.
- Study of the case studies of great earthquakes in Japan to understand how well the Early Warning System and coordination worked.
- Understanding CBDRR programs conducted in Japan with special focus on Earthquake and compares the participation of the community in the DRR process.
- Learn how the community is prepared in Japan: learning, training, and drills.
- Field Visits to emergency operation centres/emergency services response centres of National, Prefectural and Local Governments to understand the networking and coordination for emergency response.
- Visits to DRR agencies such as Cabinet Office, JMA, and Disaster Management Authority etc. in Japan to understand their legal system & frameworks, organizational network and earthquake preparedness plan.

Chapter-2: Disaster Management System in Bangladesh:

A series of inter-related institutions, at both national and sub-national levels have been created for disaster management. As per the Rules of Business of the Government of Bangladesh, the Ministry of Disaster Management and Relief (MoDMR) is mandated to formulate policies, prepare plans, and monitor and coordinate all aspects of disaster activities. The field level activities of MoDMR are carried out by two subordinate offices e.g. the Department of Disaster Management and Cyclone Preparedness Centre (CPP), While DDM is responsible for dissemination of all information on natural disasters, including flood information at community level, flood preparedness, awareness raising and capacity building activities, and also is responsible for conducting relief and rehabilitating operations with the help of district and upazila administrations.
The Ministry issued the Standing Orders on Disaster (SOD) in January 1997 to guide and monitor disaster management activities in Bangladesh. The SOD has been prepared for concerned persons to understand their duties and responsibilities regarding disaster management. All Ministries, Divisions/Departments and Agencies shall prepare their own



Action Plans in respect of their responsibilities under the Standing Orders for efficient implementation. The National Disaster Management Council (NDMC) and Inter-Ministerial Disaster Management Coordination Committee (IMDMCC) will ensure coordination of disaster related activities at the National level. Coordination at District, Thana and Union levels will be done by the respective District, Thana and Union Disaster Management Committees. The Disaster Management Bureau will render all assistance to them by facilitating the process. A series of inter-related institutions, at both national and sub-national levels have been created to ensure effective planning and coordination of disaster risk reduction and emergency response management.

2.1 Regulative Framework

In order to manage the paradigm shift in disaster management, a disaster management regulative framework is established under which the Bangladesh Disaster Management Framework is implemented, and in which work of Ministries, Departments, NGOs and civil society are undertaken. The regulative framework provides the relevant legislative, policy and best practice framework under which the activity of Disaster Risk Reduction and Emergency Response Management in Bangladesh is managed and implemented. The framework is comprised of:

Disaster Management Act

The Disaster Management Act creates the legislative framework under which disaster risk reduction and emergency response management is undertaken in Bangladesh, and the legal basis in which activities and actions are managed. It also creates mandatory obligations and responsibilities on Ministries, committees and appointments.

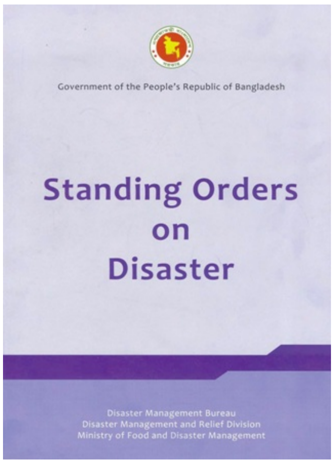
National Disaster Management Policy

The National Disaster Management Policy defines the national policy on disaster risk reduction and emergency response management. and describes the strategic policy framework, and national principles of disaster management in Bangladesh. It is strategic in nature and describes the broad national objectives, and strategies in disaster management.

National Plan for Disaster Management (2010-15)

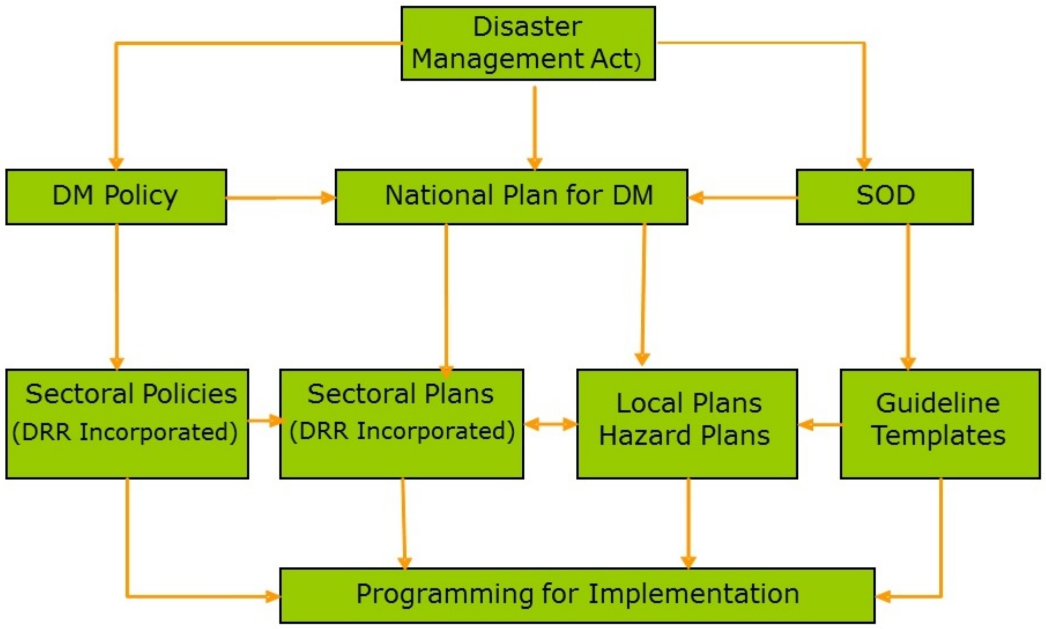
The National Plan for Disaster Management defines in broad outline the systemic and institutional mechanisms under which disaster risk reduction and emergency response management is undertaken in Bangladesh. It outlines disaster management vision, strategic goals and conceptual framework. It establishes disaster management regulative and planning frameworks, and identifies priority areas for disaster risk reduction and emergency response management

Standing Orders on Disaster (SOD)



The Standing Orders on Disaster outlines the disaster management arrangements in Bangladesh and describes the detailed roles and responsibilities of committees, Ministries, Departments and other organizations involved in disaster risk reduction and emergency response management, and establishes the necessary actions required in implementing Bangladesh's Disaster Management Model, e.g., defining the risk environment, managing the risk environment, and responding to the threat environment.

Disaster Management Regulative Framework



2.2 NATIONAL DISASTER CONTEXT

- Frequently hit by various natural disasters like Cyclones, Storm surges, Floods, Tornadoes, Droughts and other calamities.
- Monsoon flooding is an annual occurrence shaping lives and livelihoods.
- Almost 200 disaster events have occurred causing more than 500,000 deaths
- and leaving prolonged damage to livelihoods, infrastructure and the economy.
- Climate change is likely to cause significant impact in the form of severe floods, cyclones, droughts, sea level rise and salinity affecting agriculture, livelihoods, natural orders, water supply, health etc.
- The disaster vulnerable people demonstrates strong coping capacity to face the disaster challenges.

2.3 National and international Drivers

- Millennium Development Goals (MDG)
- Hyogo Framework for Action (HFA)
- United Nations Framework Convention on Climate Change (UNFCCC)
- SAARC Framework for Action (SFA)

Coordinated Response to Disaster Emergency

2.4 National Committees under SOD

- National Disaster Management Council (NDMC)
- Inter-Ministerial Disaster Management Co-ordination Committee (IMDMCC)
- National Disaster Management Advisory Committee (NDMAC)
- Cyclone Preparedness Program Implementation Board (CPPIB)
- Disaster Management Training and Public Awareness Building Task Force (DMTATF)
- Focal Point Operation Coordination Group of Disaster Management (FPOCG)
- NGO Coordination Committee on Disaster Management (NGOCC)
- Committee for Speedy Dissemination of Disaster Related Warning/ Signals (CSDDWS)

2.5 Field Level Committees under SOD

- District Disaster Management Committee (DDMC) headed by the Deputy Commissioner (DC) to co-ordinate and review the disaster management activities at the district level
- Upazila Disaster Management Committee (UZDMC) headed by the Upazila Nirbahi Officer (UNO) to co-ordinate and review the disaster management activities at the Upazila level
- Union Disaster Management Committee (UDMC) headed by the Chairman of the Union Parishad to co-ordinate, review and implement the disaster management activities of the concerned union
- Pourashava Disaster Management Committee (PDMC) headed by Chairman of Pourashava (municipality) to co-ordinate, review and implement the disaster management activities within its area of jurisdiction
- City Corporation Disaster Management Committee (CCDMC) headed by the Mayor of City Corporations to co-ordinate, review and implement the disaster management activities within its area of jurisdiction.

2.6 National Institutions for Disaster Management:

Department of Disaster Management (DDM)

DDM is designed as a small dynamic professionals unit at national level to perform specialised functions in the field of disaster preparedness, local disaster action planning, contingency planning, raising public awareness, training and facilitating improved disaster information flows. DDM works under MODMR and overviews and coordinates all activities related to disaster management from the national level down to the grass-roots level. DDM is committed to enhancing regular dialogues and fostering co-operation in practical disaster preparedness matters 'before, during and after' a disaster between all levels of government, donors, non-government organisations, community groups and others. DDM's main strength is the mandate and authority for dissemination of early warning of different disasters. DDM has a total of 48 technical professionals stationed at their head office in Dhaka. It has a vast network under its authority through a standing order.
Currently, DDM is working on cyclone and flood information warning dissemination, but it has plans to extend its dissemination activities to other disasters. A process of hazard mapping is also under consideration. A website (http://www.ddm.gov.bd) is currently available with only static historic information, but it could be made dynamic for updating with early warnings like the FFWC website.

Cyclone Preparedness Program (CPP)

- Community Based Early warning through devoted volunteers.
- A Joint Venture Program of GOB & BDRCS.
- To minimize loss of lives and properties in cyclonic disaster by strengthening the capacity in disaster management of the coastal people of Bangladesh.
- Covers 13 districts and 37 Upazilas (Sub-District).
- Total Volunteers: 49,215

Comprehensive Disaster Management Program (CDMP)

CDMP is a strategic institutional and programming approach that is designed to optimize the reduction of long-term risk and to strengthen the operational capacities for responding to emergencies and disaster situations including actions to improve recovery from these events. Strategic Focus Areas:

- Professionalizing the Disaster Management System: Establishment of Policy Program Partnership Development Unit, Professionalizing development of Disaster Management System, etc.
- Partnership Development: Advocacy and Capacity Building of DMCs.
- Community Empowerment: Program Gap Analysis, Risk Reduction Planning, Livelihood Security and hazard Awareness, etc.
- Expanding Preparedness Program across a broader range of hazards: Earthquake and Tsunami Preparedness, Climate Change and Research.
- Strengthening Emergency Response Capabilities: DMIC and Response Management.

Space Research and Remote Sensing Organization (SPARRSO)

SPARRSO acts as the centre of excellence and national focal point for the peaceful applications of space science, remote sensing and geographic information system (GIS) in Bangladesh. SPARRSO also advises the government in all matters relating to space technology applications and policies. SPARRSO maintains close collaboration with national, regional and international organizations, institutions and agencies and disseminates research results, satellite data and information to the relevant public, autonomous and private agencies for their development and policy-making activities. SPARRSO's mandate includes monitoring and research on environmental issues. For this purpose they receive images daily to observe weather patterns and floods and prepare flood reports including flood maps showing flood-affected areas.

Bangladesh Meteorological Department (BMD)

BMD is the government organization authorized for all meteorological activities in the country. It maintains a network of surface and upper air observation stations, radar and satellite stations, agro-meteorological observation stations, geomagnetic and seismological observation stations and meteorological telecommunication system. BMD contributes to flood forecasting and warnings by preparing short/medium and long term weather forecasts, 3-hourly surface charts, 6 and 12-hourly upper air charts, heavy rainfall warnings, and special weather bulletins with storm surge information. BMD is the only government authorized organization mandated to issue all sorts of weather forecast and record meteorological observations (surface and upper air) in Bangladesh. BMD has been affiliated to the World Meteorological Organization (WMO) since 1972.

FFWC is a division of the Directorate of Processing and Forecasting, under the Chief Engineer, Hydrology. Together FFWC, Surface Water Hydrology (SWH) and Construction and Instrumentation (C&I) undertake the transmission and processing of data for flood forecasting and warning services. It maintains a strong institutional network for disseminating flood forecasts at national level.

2.7 Other Institutions for Disaster Management:

Center for Environmental and Geographic Information Services (CEGIS)

CEGIS is a Public Trust organization under the Ministry of Water Resources and functions under a Board of Trustees chaired by the Secretary of the Ministry of Water Resources on behalf of the government. CEGIS works in the fields of initial environment examination, environmental impact assessment, disaster management modelling, natural resource and risk management, GIS/RS mapping, and survey. CEGIS serves government and non-government organizations. CEGIS has developed several disaster and warning related tools including a Community Based Flood Information System (CFIS); an Environmental Monitoring Information Network (EMIN); and a Climate Forecast Application Network (CFAN). Currently, CEGIS is in the process of development/acquiring technology for a regional basin flood forecast modeling for use in Bangladesh. Also, CEGIS has started to acquire knowledge on urban and flash flood forecasting.

An operational pilot system was developed to produce daily flood monitoring and forecast maps for use at the community level under Community Flood Information System (CFIS). CFIS project was designed as a pilot operational system to produce accurate and timely information on current and forecasted flood conditions for a floodplain community by using easy understandable mobile SMS. This created an important opportunity for low-cost, reliable, and deeply penetrating dissemination of flood forecasts for vulnerable communities.

CEGIS has developed a methodology for predicting the morphology process and bank erosion along the Jamuna, Ganges and Padma Rivers based on space-based technology. The methodology makes it possible to predict morphological development and bank erosion one to two years ahead.

The Institute of Water and Flood Management (IWFM)

IWFM is a research institute of the Bangladesh University of Engineering and Technology (BUET). Its mandate includes conducting research on floods focusing on integrated water management, organizing seminars and workshops related to floods, and offering a post graduate diploma in Water Resources Development.

Institute for Water Modelling (IWM)

IWM is an institute of learning and research in the fields of water modelling, computational hydraulics and allied sciences established as a Public Trust under the ministry of Water Resources. IWM activities in flood forecasting and warning include the collection of real time hydrometric data for running flood forecasting and inundation models; annually updating and validating the forecasting models; providing technical backstopping and training to FFWC; assisting FFWC to expand into new areas; developing dynamic flood inundation models (MIKE FLOOD) and issuing medium (10 days) flood predictions based on climate forecasts produced by the CFAB project.

2.8 Bangladesh National progress report on the implementation of the Hyogo Framework for Action (2009-2011):

Priority for action 1

"Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation"

PROGRESS:

- ✓ A new ministry established to deal with disaster management affairs exclusively named Ministry of Disaster Management & Relief (MoDMR)
- ✓ National Disaster Management Plan (2010-2015) approved in April, 2010 linked with Vision 2021 and 6th Five Year Plan
- ✓ Revised Standing Orders on Disaster (SOD) , which explicitly outlined the DRR & CCA business for GO, NGO, public representatives & citizens
- ✓ National Disaster Management Act has been published in 2012

Priority for action 02

"Identify, assess and monitor disaster risks and enhance early warning"

- ✓ Updating of the risk assessment 12 guidelines in revised SOD
- ✓ Specific Sectoral Disaster Risk Reduction guidelines develops by CDMP
- ✓ Detailed risk assessment mapping for earthquake and tsunami for three cities Dhaka, Chittagong & Sylhet prepared and planned for new eight cities
- ✓ DRR budget now 4.5% of national Budget
- ✓ Climate Change Fund (CCF) US $ 100m/Year
- ✓ Bangladesh Climate Change Resilience Fund (BCCRF) US $ 110m
- ✓ Resource allocation increased to all line ministries towards DRR
- ✓ Development Partners support increases towards national DRR initiatives

<u>Priority for action 03</u>

"Use knowledge, innovation and education to built a culture of safety and resilience at all levels"

- ✓ Bangladesh DM Education Research and Training (BDMERT) established
- ✓ Key ministries, research institutions and civil society organization established website for sharing of disaster related knowledge
- ✓ DMIC established network with 64 Districts HQ and planned to expand to all 485 Upazilas by 2012
- ✓ BMD. FFWC, CPP, BTV, Radio, mobile phone companies & Other electronic and print media contributing significantly in dissemination of early warning and disaster Messages
- ✓ Disaster & climate risk information are included in text book from elementary to higher secondary level
- ✓ DRR education & special course in universities, institutions, armed forces div, civil service college etc

<u>Priority 04</u>

"Reduce the underlying risk factors "

- ✓ National Adaptation Program of Action (NAPA) & Bangladesh Climate Change Strategy & Action Plan has already prepared
- ✓ Bilateral & multilateral donors exploring the possibilities of creating multi-donor trust fund to accelerate financing for research and adaptation
- ✓ Climate change Cell established and focal points identified for each ministries
- ✓ DRR & CCA link developed with the introduction of various program launched by different ministries i.e sustainable land management program, climate resilience crop verities, cyclone resistance house etc
- ✓ Strong institutional arrangement for implementing social protection program
- ✓ National committee for updating national building code, land use plan
- ✓ Disaster risk reduction & EIA for all development projects

Priority for action 05

- ✓ National Plan for DM, DM Act, SOD mentioned tasks for all sectoral safety preparedness
- ✓ For existing structure, retrofitting techniques are being introduced to combat earthquake
- ✓ Mock drill guidelines for school and hospitals safety
- ✓ Earthquake contingency developed for AFD, FSCD, DGHS & DRR
- ✓ 30,000 members of local DMCs imparted training on comprehensive DM
- ✓ DMB established damage, loss and need assessment cell
- ✓ 60,000 volunteer are working 13 cyclone prone district
- ✓ Search and rescue equipment
- ✓ Adequate reserve of relief materials in each district

2.9 Recent DRR Projects:

- Construction of Bridges/Culverts (up to12m long)
- Construction of Cyclone resistance Houses
- Procurement of Equipment for Search and Rescue operation on Earthquake and other disasters.
- Development of Community Volunteers
- Construction of Flood and Cyclone Shelter
- Comprehensive Disaster Management Program (CDMP) Phase 2
- Inundation Map/Risk Map for storm Surges
- Cyclone shelter Data Base
- Micro-zonation Map for greater districts
- Disaster Management Information center (DMIC)
- Mobile Communication for early warning by Cell Broadcasting System (CBS) , SMS and Interactive Voice Response (IVR)

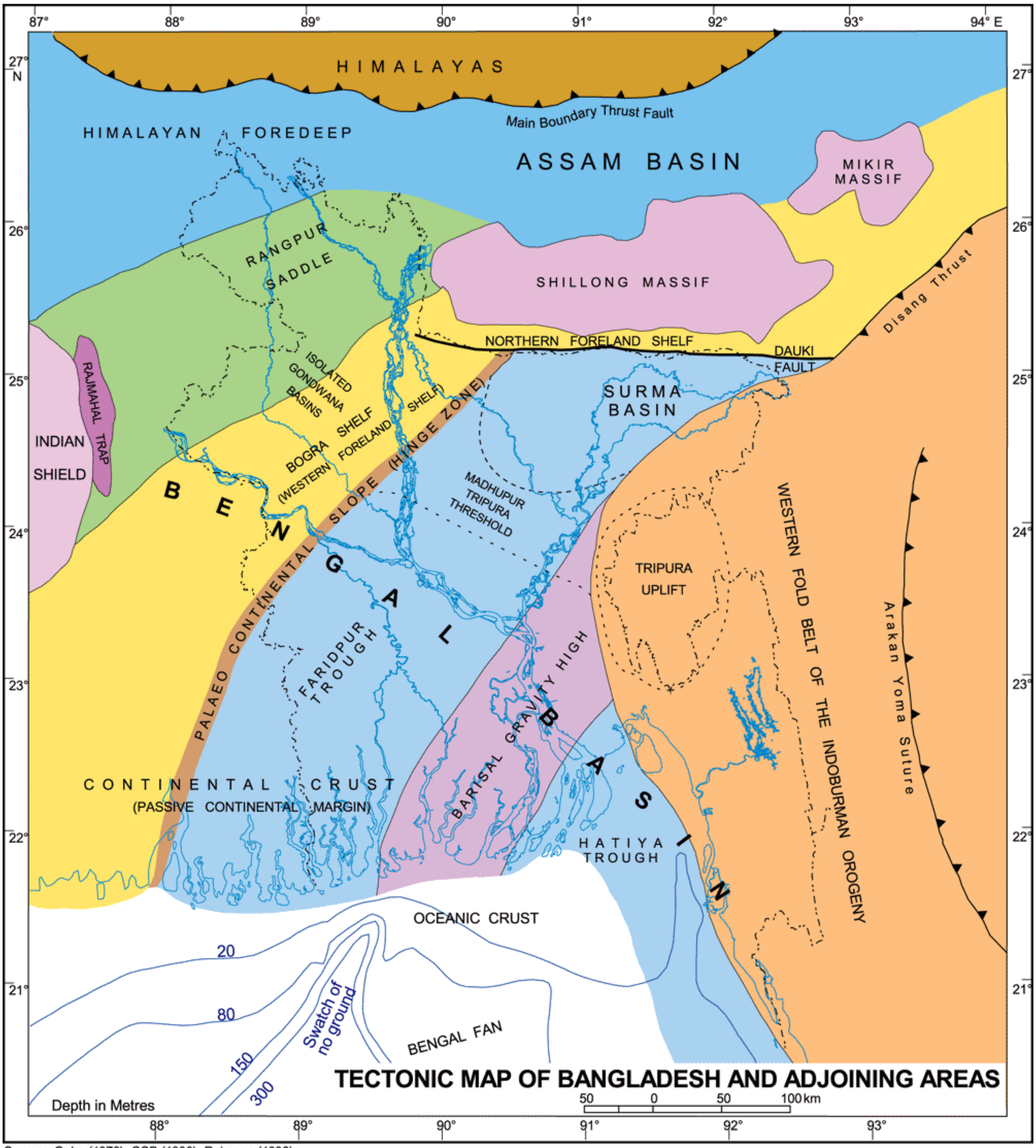
Chapter-3: Earthquakes in Bangladesh:

Tectonic frame work of Bangladesh and adjoining areas indicate that Bangladesh is suited adjacent to the plate margins of India and Eurasia where devastating earthquakes have occurred in the past. Historical seismic catalogues (ISET, 1993) reveal that Bangladesh has been affected by earthquake disasters since ancient times. Earthquakes occurring in 1664, 1828, 1852 and 1885 are shown to have Dhaka as epicentral area. Similarly cities like Rangpur, Sylhet, Mymensingh, Chittagong, Saidpur, Sirajgonj, Pabna etc. have been shown to be epicentral area of some of the major earthquakes in the past. Although the ancient records do not specify the earthquake epicenter by giving coordinates in terms of latitudes and longitude, it is difficult to figure out whether these cities were directly hit by earthquakes. However occurrences of earthquakes both inside and outside of the country and around major cities indicate that earthquake hazard exists for the country in general and the cities in particular. Consideration of earthquake forces in structural design, city planning and infrastructure development is therefore a prerequisite for future disaster mitigation.
Unlike most natural disasters, earthquake affects millions of square kilometers in a very short time, which in most cases, is less than a minute. As it catches everybody in an unprepared state, earthquake tops the list of all natural disasters in producing damages and death. The 12` June 1897, Great Indian earthquake of magnitude 8.5 affected whole of Bangladesh and produced severe damage in northern, central and eastern parts of Bangladesh. The 15th January, 1934 Bihar Nepal earthquake affected only northern parts of Bangladesh where intensity of ground shaking was only VII on the MMI scale.

The historical seismicity data of Bangladesh and adjoining areas indicate that Bangladesh is vulnerable to earthquake hazards. As Bangladesh is the world's most densely populated area, any future earthquake shall affect more people per unit area than any other seismically active regions of the world. Both of the above factors call for evaluation of seismic hazard of Bangladesh so that proper hazard mitigation measures may be undertaken before it is too late.

3.1 Tectonics and Geology:

Tectonics and geology of Bangladesh and adjoining areas have been discussed in details by Guha, 1978; Matin et al., 1983; Sesoren, 1984; Bolt, 1985, 1987; and Khan, 1991; It is revealed in the above literatures that stratigraphy, structure and surface geology of Bangladesh are related to its tectonic evolution which started during late Cretaceous period when the northward moving Indian plate collided with the Eurasian plate. The collision caused the northern extremity of Bay of Bengal to separate into gulfs of Assam and Burma. During second collision at the end of Eocene time, the gulfs were shallowed. The third collision, which occurred in Middle Miocene, was intense due to which folding occurred in the sediments of Chittagong, Sylhet and Assam. The fourth and fifth collisions caused mainly vertical movements. The Shillong Plateau and Mikir Hills formed a horst and Dinajpur shield a graben during the fourth collision. The fifth collision uplifted the red clay tablelands.

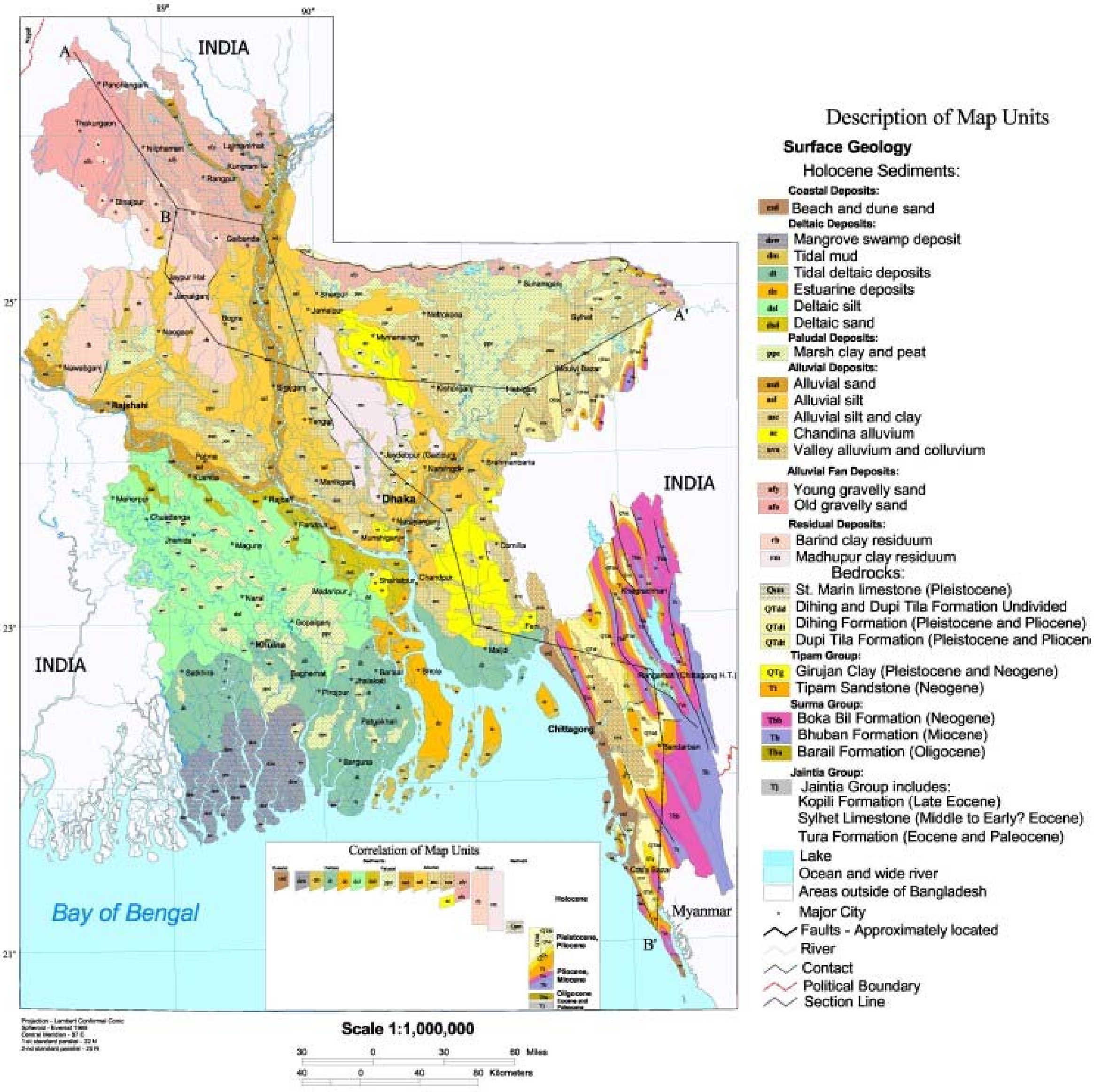


Source: Guha (1978), GSB (1990), Reimann (1993)

Fig-3.1: Tectonic Map of Bangladesh.

Geologically Most of West Bengal of India and whole of Bangladesh are occupied the Bengal Basin, where the Precambrian basement lies more than 3 km below mean sea level. The basin is bordered on the western side by the peninsula shield of India, and on the eastern side by the Shillong Massif.

The Precambrian rocks form the basement of all geological formations of Bengla Basin and shield areas. The surface geology of Bangladesh is essentially the geology of the sediments of only the Cenzoic Era. The geological succession of Bangladesh shows that the sub-surface stratigraphy includes, in addition to the continuation of the surface geological formations, the Precambrian, the *Permain Gondwana sediments, the upper Jurassic Volcanic* rocks, and a thin mantle of Cretaceous sedimentary rocks originating



GEOLOGICAL MAP OF BANGLADESH

Fig- 3.2: Geological Map of Bangladesh, *Source: BGS*

mainly from the deposition of the denuded volcanic. It also indicates that the Cenozoic sedimentary sequence is non-calcareous with sandstone, siltstone, sandy shale, shale and lignite comprising most of the deposits.

3.2 Structure and Seismicity

Geological framework of Bangladesh and adjoining areas is shown in Figure I which shows that it is surrounded by a number of tectonics blocks which have produced damaging earthquakes in recent times. To the east, the Tripura-Naga Orogenic belt is a zone of highly faulted tertiary deposits. In it and along the borders of the Shilong massif occurs a number of faults of which the Sylhet fault, the Kopili fault, and the Dauki fault are worth mentioning. The 180km long Sylhet lineanent passing in a NE-SW direction

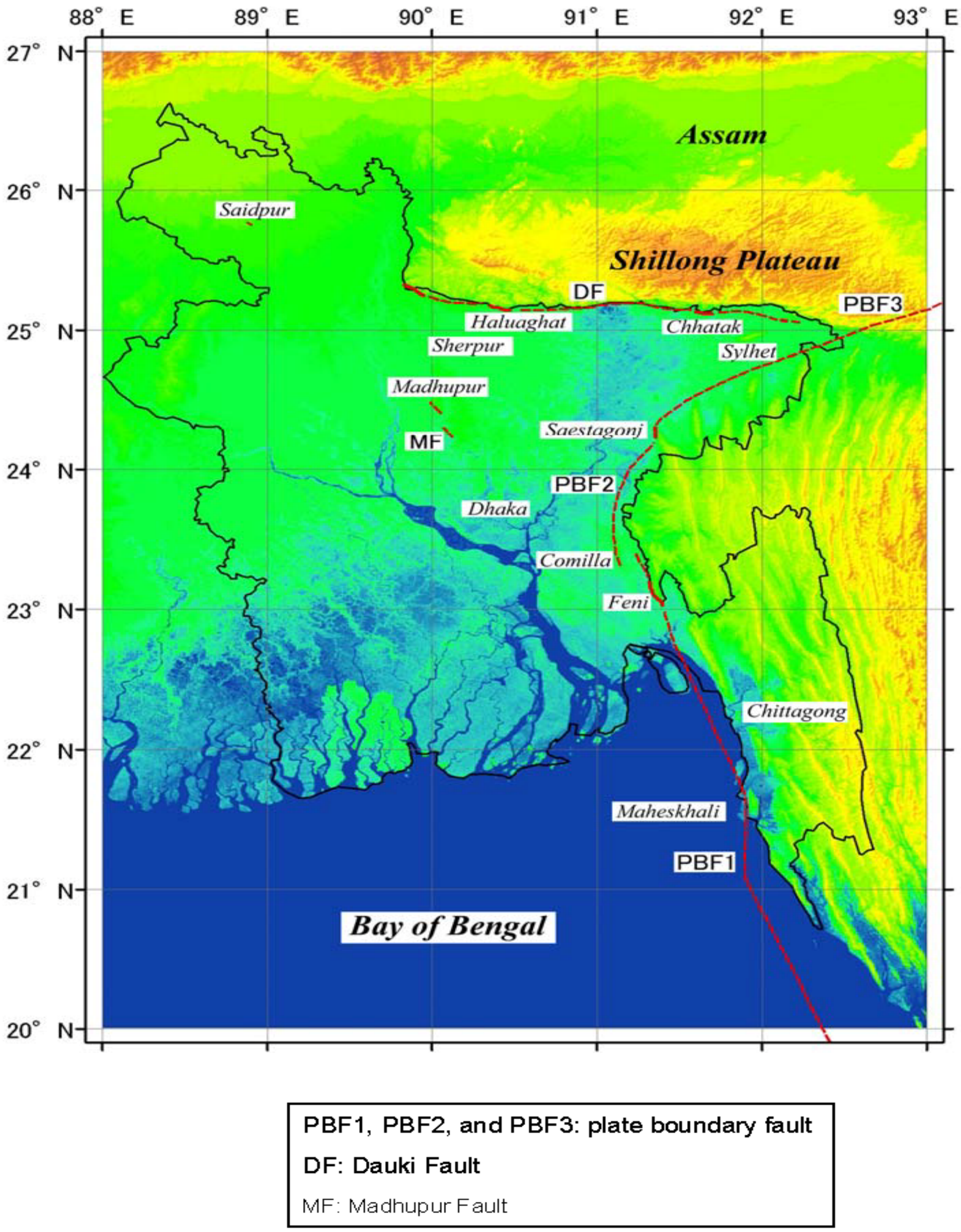


Fig-3.3: Fault Modelling Map, Source GSB.

across the Sylhet district forms the surface expression of a deep-seated, high angle reverse fault called the Sylhet fault. The fault has a dip of 70° towards South-East and is active seismically at present. The July 8, 1918 Srimangal earthquake located near the Sylhe fault originated due to subsidence along the southern side of a normal fault trending WNW-ESE through Balisera valley in Sylhet. The depth of hypocentre estimated for this earthquake was 15 km.

To the northwest part of Bangladesh a northeast-southwest tending fault called Bogra fault has recently been discovered. This fault is located to the west of the Jamuna River and south of Bogra town and is assumed to originate in the basement complex and

Fig-3.4: Fault Modelling with Google Image, Source, GSB.

extend into the Pleistocene layers up to depths of almost 300m. The Bogra fault system may be associated with flexure of the basin along its north western margin. Running in N-S direction through Longitude 90°E of the Jamuna lineament cuts through all eastern Himalayan structures. It is the surface expression of a deep-seated sub-vertical fault called Jamuna fault. This fault might have played active role towards the evolution of the Meghalaya plateau during recent times (Gupta and Nandy, 1982). To the north east of the country the Shilong plateau is separated from the Sylhet plain by E-W trending Dauki fault. Although a number of epicenters occur in the plateau proper, only a few epicenters appear on or close to the Dauki fault, including thereby that this fault is relatively inactive during the recent times. Maximum depth of hypocentre of earthquakes in the plateau is only 60 km. These earthquakes are caused by upward material transport from greater depth, which produces tensional stress in the crustal rocks.

Considering geology and tectonics of Bangladesh and neighborhood five tectonic blocks can be identified which have been active in producing damaging earthquakes. These are:

a. Bogra fault zone
b. Tripura fault zone
c. Sub-Dauki fault zone
d. Shillong plateau and
e. Assam fault zone

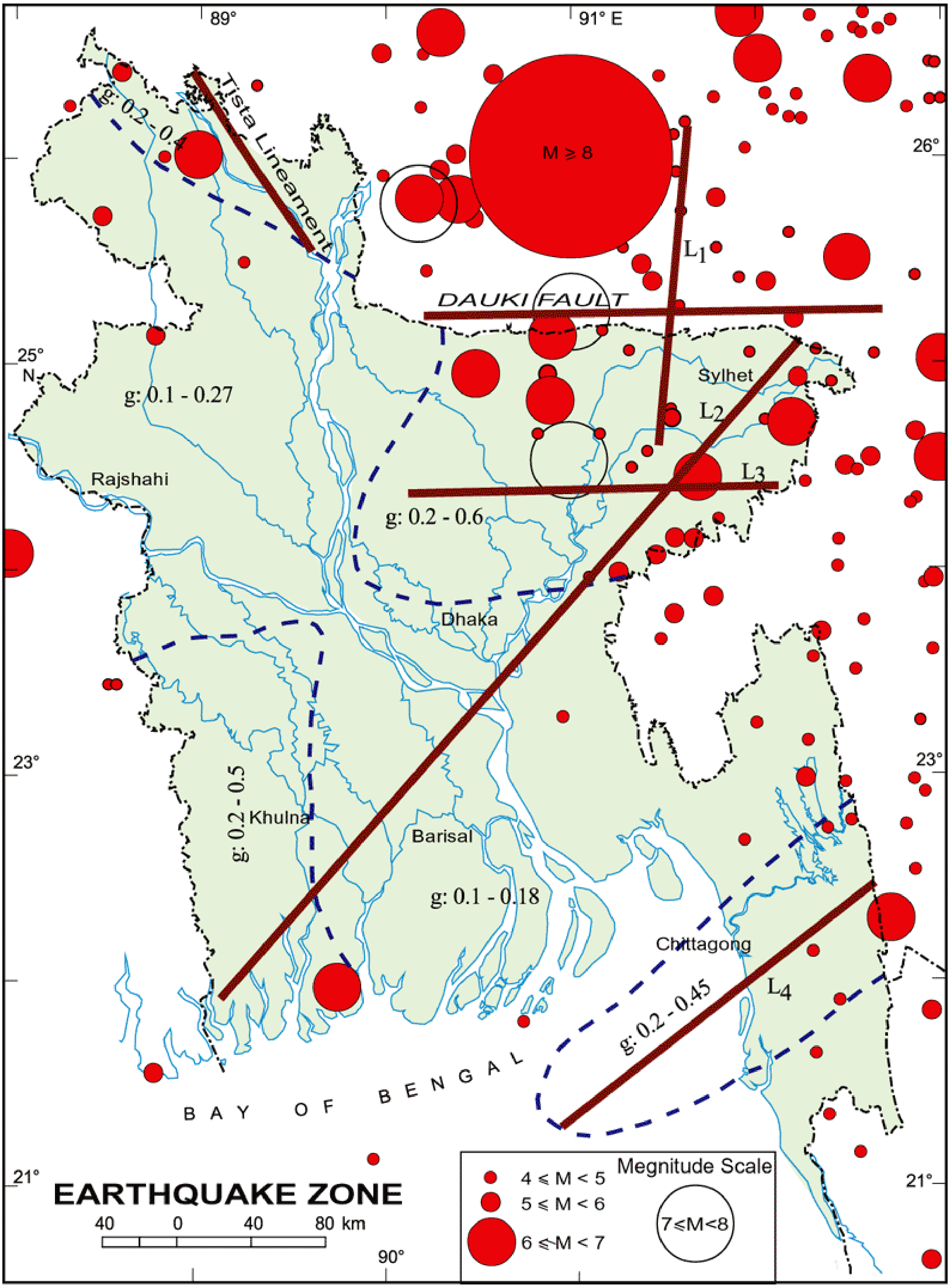


Figure-3.5: Earthquake Intensity in Different Faults.

Table-4: Maximum earthquake magnitude in different Tectonic blocks.

Sl. NO.	Tectonic block	Maximum Magnitude of Earthquake
1	Borga fault zone	7.0
2	Tripura fault zone	7.0
3	Sub Dauki fault	7.3
4	Shillong Plateau	7.0
5	Assam fault zone	8.5

3.3 Major Earthquakes Affecting Bangladesh

During the last 150 years, seven major earthquakes (with M > 7) have affected Bangladesh. Table 2 shows the date, magnitude for each earthquake. Out of the seven earthquakes, only two (viz. 1885 and 1918) had their epicenters within Bangladesh.

Table-4: Major earthquakes in Bangladesh during the, last 150 years.

Date	Name	Epicenter	Magnitude	Comment
October 11th, 1737	Kolkata	22.60N, 88.40E,	X (in MM)>7 M	India's deadliest earthquake.
January 10, 1869	Kachar	Jainati Hills 25.00 N 93.00 E	7.5, Depth 50 km.	Sylhet Town, area of 650, 000 square miles.
July 14, 1885	The Bengal Earthquake	Bogra Fault 24.00 N, 90.00 E	7.0	Damage within a 100 km radius of the epicenter, an area of 6,00,000 sqkm
June 12, 1897	The Great Indian	Shillong Plateau 26.00N, 91.00E	8.7	Dhaka-Kolkata.
July 8, 1918	Mymensingh	24.50 N, 91.00 E	7.4, 12 -14 km	Damage in a 100-kilometer radius of the epicenter
July 3, 1934	Dhubri	24.50 N, 91.00 E	7.1	Rangpur experienced severe tremor
January15, 1934	Bihar-Nepal	Darbhanga 26.50N, 86.50E	8.3	the Ganges Basin
August 15, 1950	Assam	Arunachal Pradesh	8.5	Felt throughout Bangladesh
23rd October, 1943	Dergaon Assam	26.80 N , 94.00 E	7.05	Felt throughout Bangladesh

Table-6: Recent Earthquakes in Bangladesh:

Date	Name	Epicenter	Magnitude	Comment
May 8, 1997	Indo-Bangla border	24.89N 92.25E, 34 km depth	6 Mb	Felt from Chittagong to Rangpur, also in Sylhet and Meghalaya, India.
November 21, 1997	Chittagong Indo-Bangladesh	22.21N 92.83E, 57 km depth	6 Mb	Felt throughout Bangladesh
July 22, 1999	Moheshkhali Island	21.47N 91.90E, 10 km depth	5.2 Mb	
December 31, 1999	Indo-Bangladesh Border Region	21.43N, 91.76E Near Sonadia	Mb - 4.3	Triggered a tidal surge that reached heights of 4 feet.
January 4, 2000	Bungtlang (Tripura), India	22.13N, 92.77E	Mb - 4.6	Southern Bangladesh epicenters about 150 km from Chittagong.
December 19, 2001	Kaliakoir, Dhaka	23.70 N 90.40 E (IMD)	4.2 IMD	Strong tremors (MM V-VI) in Dhaka City
June 20, 2002	Rajshahi	25.80N 88.86E (NEIC)	ML 4.6	Shook buildings for 39 seconds in Bogra and Syedpur.
March 25, 2003	Bhutan	27.260N 89.240E (NEIC)	M 5.1	Though the epicenter was in Bhutan
July 27, 2003	Barkal-Rangamati	22.85 N 92.31 E Depth–10 km	M 5.6	

Source: NEIC, USGS.

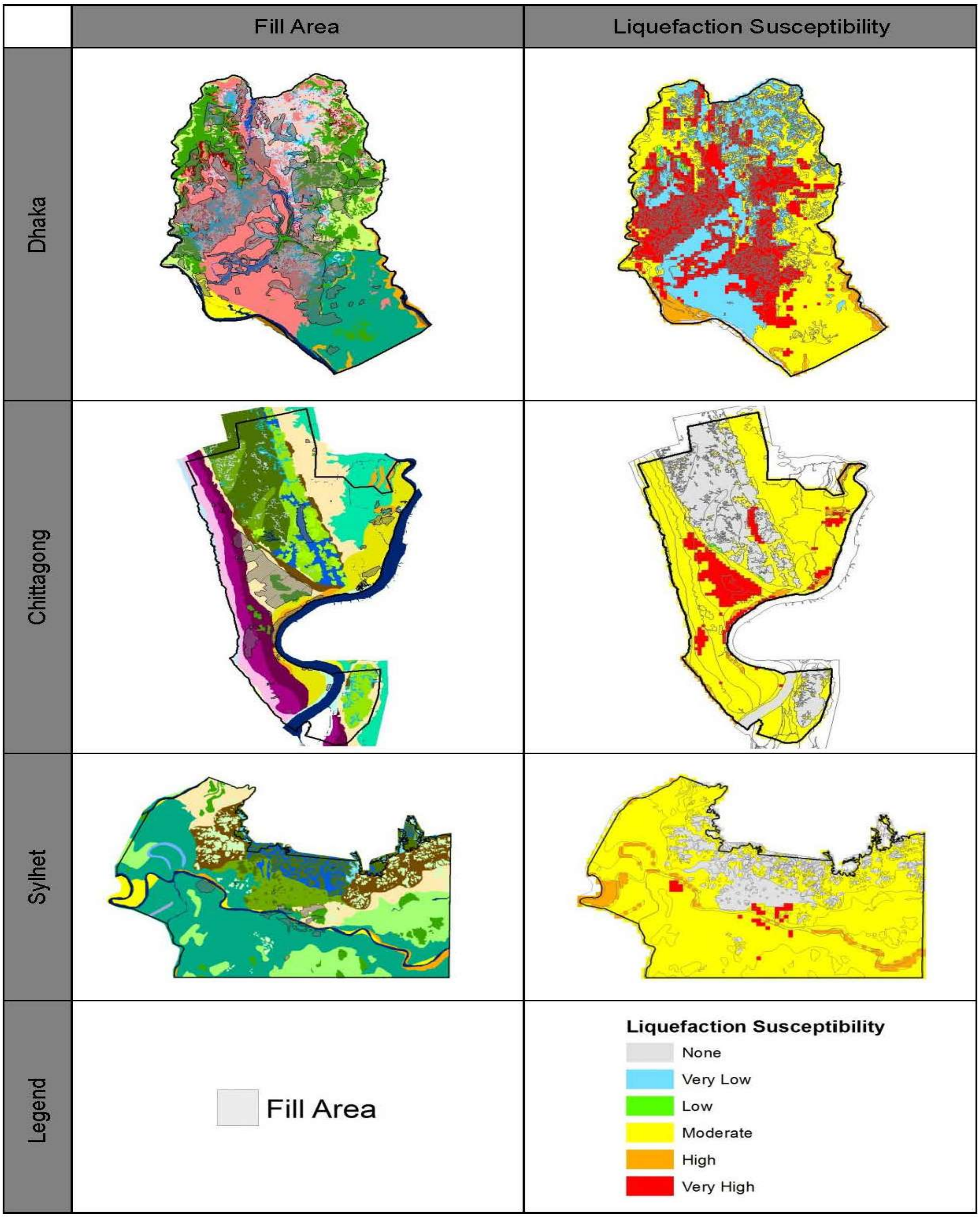
3.4 Vulnerability of Cities

By close examination of the seismicity maps presented shows that north-eastern cities of Bangladesh are more vulnerable to earthquake hazards than the central, eastern, southern, south western and western cities. The most vulnerable cities in the northeast are Mymensingh, Kishorognj and Sylhet. The north western, central and south-eastern cities which include Dinajpur, Rangpur Dhaka, Comilla, Chittagong and Cox's Bazar are comparatively less vulnerable than the afore mentioned cities. The south-western and western cities are the least vulnerable and include cities like Rajshahi, Faridpur, Khulna and Barishal etc.

Dhaka, the capital city of Bangladesh is one of the fast growing cities in the world. Since its independence, rapid urbanization turned Dhaka as one of the megacities of the world. The city had already become the eleventh largest city in the world in 2000 and is projected to be the sixth most populous city by 2010(Islam, 2005). In 2010, it becomes the 2nd worst city of the world. The rapid growth of Dhaka’s population forced haphazard & unplanned development and speedy construction of new buildings in any and every available space. Due to this, the capital city is now in a serious threat of upcoming massive disaster like earthquake. Some incidents of recent building collapse in and around Dhaka City have provided impetus of increasing concern about the seismic vulnerability of the built environment in Dhaka City. Bangladesh lies in a seismically active zone making the occurrence of major earthquakes a realistic possibility. Though Dhaka city lies in the moderate risk zone due to some others risk factor like high population density, unplanned urbanization and lack of open spaces, the city is most vulnerable than any other parts of Bangladesh.

3.4.1 Earthquake Seismic Hazard Assessment

Figure-3.6: Earthquake Seismic Hazard Assessment Map of the major Cities.



3.4.2 Earthquake Vulnerability Assessment:

Based on the developed database for the general building stock, vulnerability maps are created. Each map shows the ward-wise distribution of the following vulnerability factors including occupancy class, structural type, building age, visible physical condition, and population at risk. Moreover, the maps showing vulnerability of concrete buildings in the three cities are developed by using the statistics obtained from the field survey including presence of soft story, presence of heavy overhang, apparent building quality, presence of short columns, pounding possibility between adjacent buildings, and topographic effects. The significant findings from the building vulnerability assessment are concluded as followings:

1. Among occupancy classes in all city corporation areas, residential class is the major proportion. Their proportions are 81.3%, 81.7% and 85.2% in Dhaka, Chittagong and Sylhet, respectively.
2. Among structural type of non-engineered buildings from the survey results, BF (brick in cement mortar masonry with flexible roof) is the most common type in all cities. For engineered buildings, C3 (concrete frame with masonry infill walls) is the most common class.
3. From the survey results, age of buildings has been related to structural types. For example, it was found that most buildings with concrete slab-column frames (C4) are constructed less than 10 years. On the other hand, most masonry buildings with concrete floors (BC) ages more than 10 years. Also, light reinforced concrete buildings (LC) are found to be older than reinforced concrete buildings (RC).
4. As expected, all residential types have an average number of occupants per floor area in the daytime less than the nighttime; nevertheless, the other occupancy classes as commercial, industrial, government and education have the number of occupants in the daytime more than the nighttime.
5. The vulnerability factor which is the most common in Dhaka city is soft story (52%). The common vulnerability factor in both Chittagong and Sylhet city is heavy overhang (38% and 46%, consequently).

For Lifeline inventory, the database including transportation including highway, railway, bus and ferry and utility systems including portable water, waste water, natural gas, electric power and communication systems in the 3 city corporation areas were developed. This information was collected based on field surveying, data collecting from reliable sources and identifying of quickbird image. From the collected data and developed vulnerability map, the major findings are summarized as followings:

1. By defining road blockade potential as the building density (number of building per area) dividing by the total length in each ward. In Dhaka, this value is found to be the highest in southern part of Dhaka which is the old city.
2. About 51% of highway road in Dhaka, 3% of highway road in Chittagong and 13% of highway road in Sylhet is located in the soil with very high liquefaction susceptibility. It is noted that the liquefaction susceptibility depends on only geological characteristic and does not consider the effect of earthquake hazard, yet.
3. Most highway bridges in 3 city corporation areas are non-seismic design. The overlay map between liquefaction susceptibility and location of the bridge showed that there are 6 major highway bridges in Dhaka, 4 Bridges in Chittagong and 2 bridges in Sylhet which are located in moderate to very high liquefaction susceptibility area.
4. Two components of railway transportation system which are railway track and railway facilities were found in 3 city corporation areas. 70% of railway track in Dhaka, 92% of railway track in Chittagong and 84% of railway track in Sylhet are located in the moderate to very high liquefaction potential areas. From interviewing and expert judgment, it was found that most structure and its facility do not have a seismic design.

5. Most natural gas pipeline is 3 city coporation areas are arc-welded join steel pipe. 56% in Dhaka, 90% in Chittagong and 45% in Sylhet of this pipe is located in the moderate to very high liquefaction potential area.

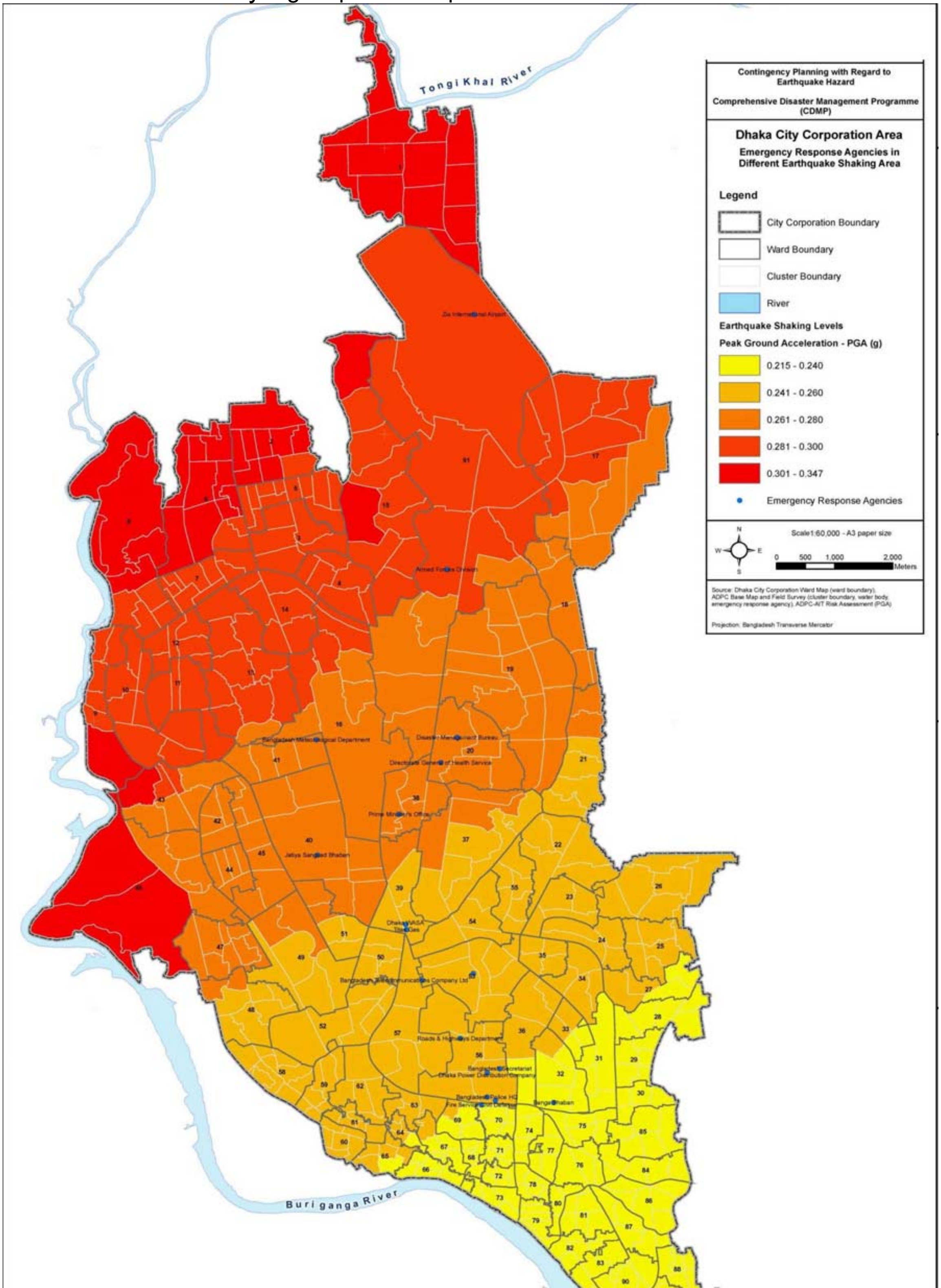


Figure-3.7: Earthquake shaking level of Dhaka City, Source, CDMP

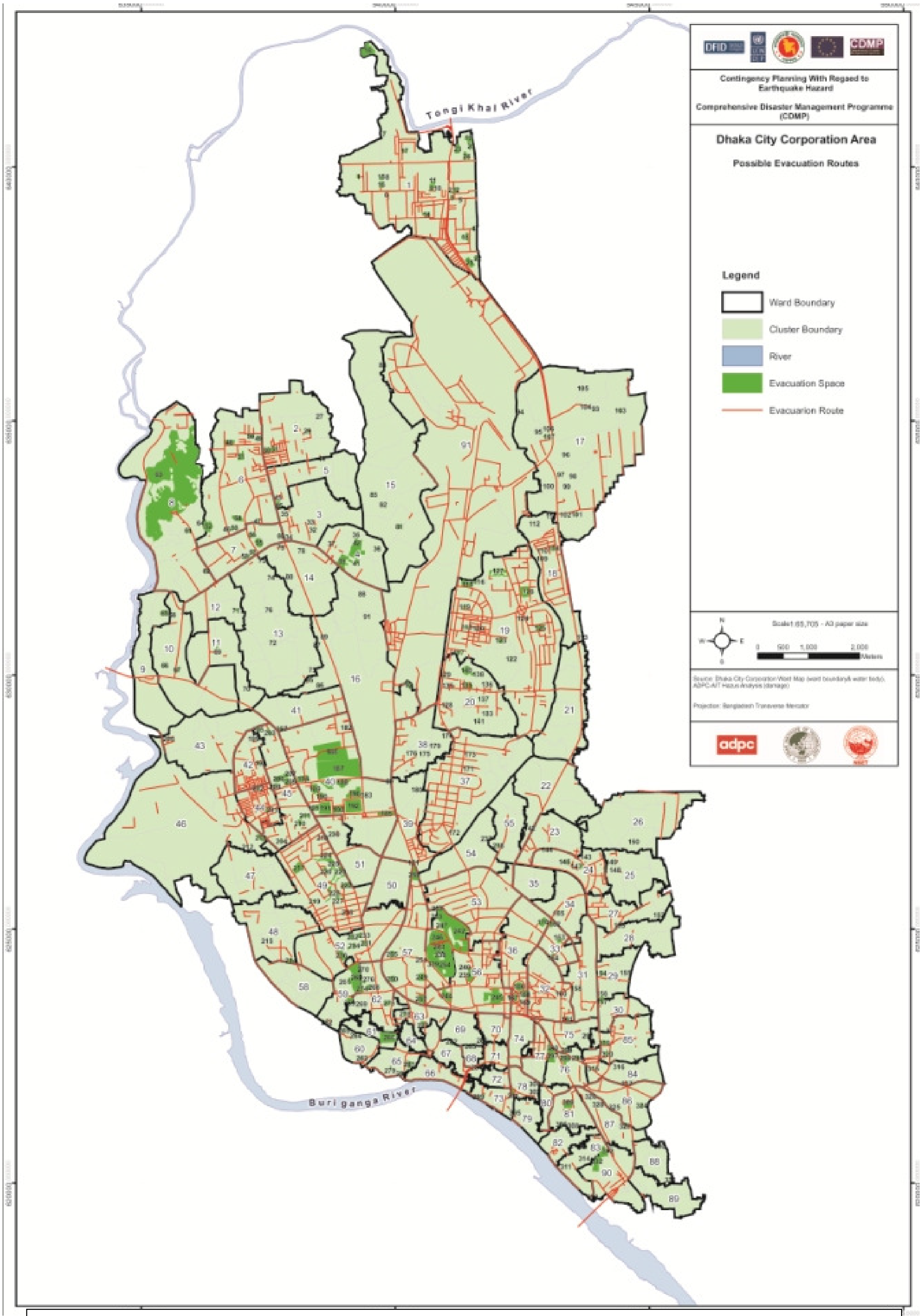


Figure-3.8: Earthquake Evacuation space of Dhaka City, Source, CDMP

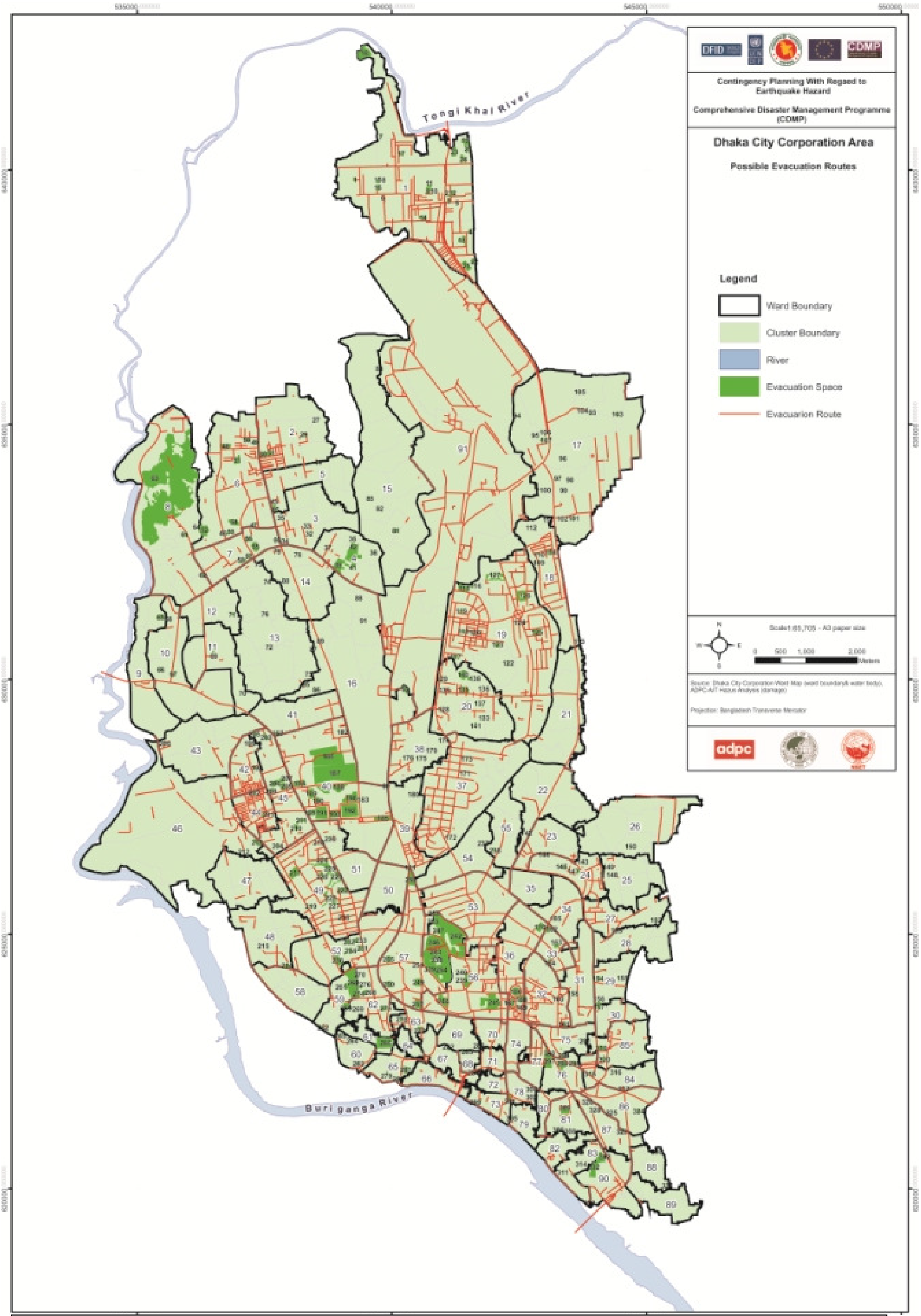


Figure-3.9: Possible Evacuation Route of Dhaka City, Source, CDMP

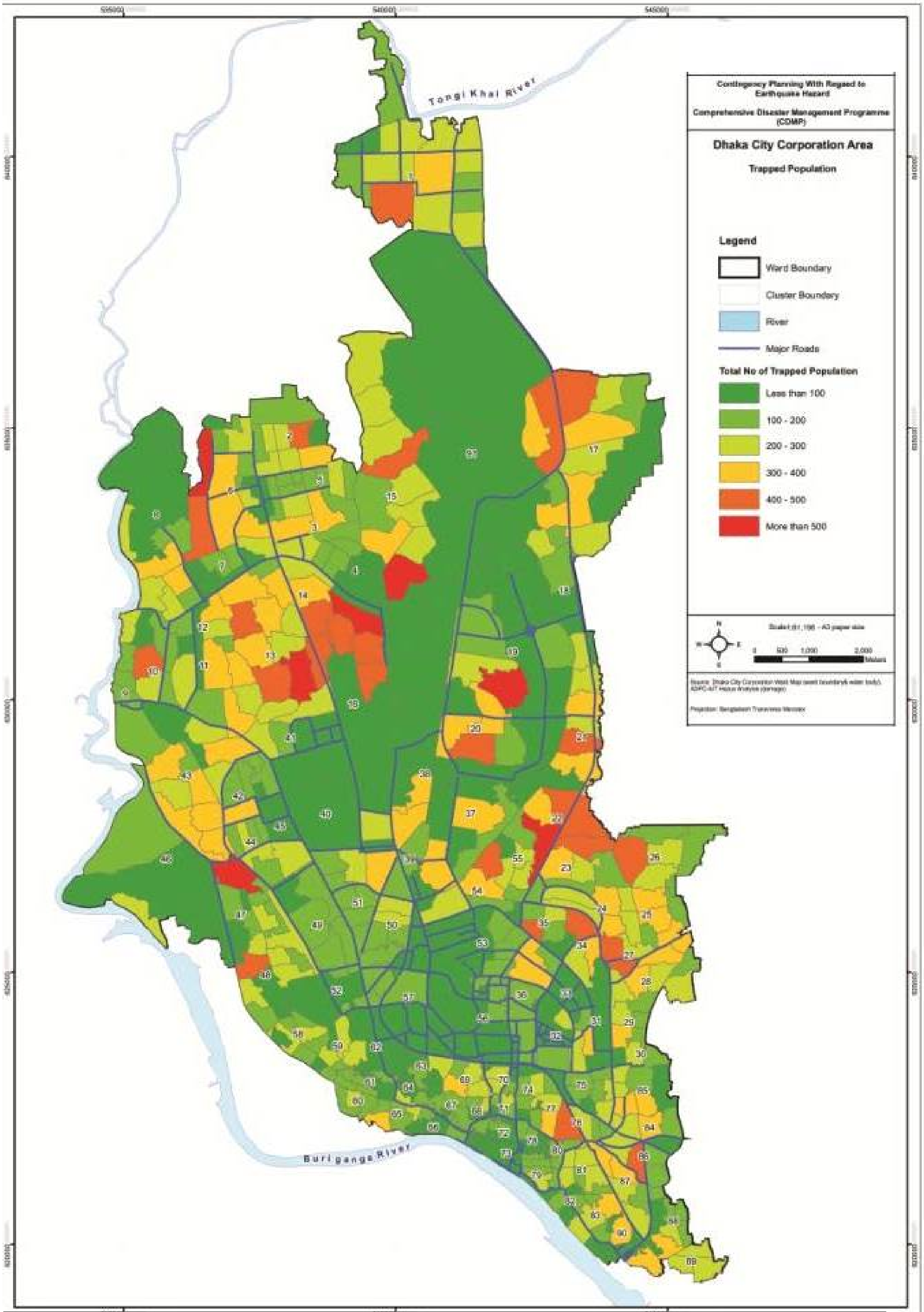


Figure-3.10: Trapped Population of Dhaka City, Source, CDMP

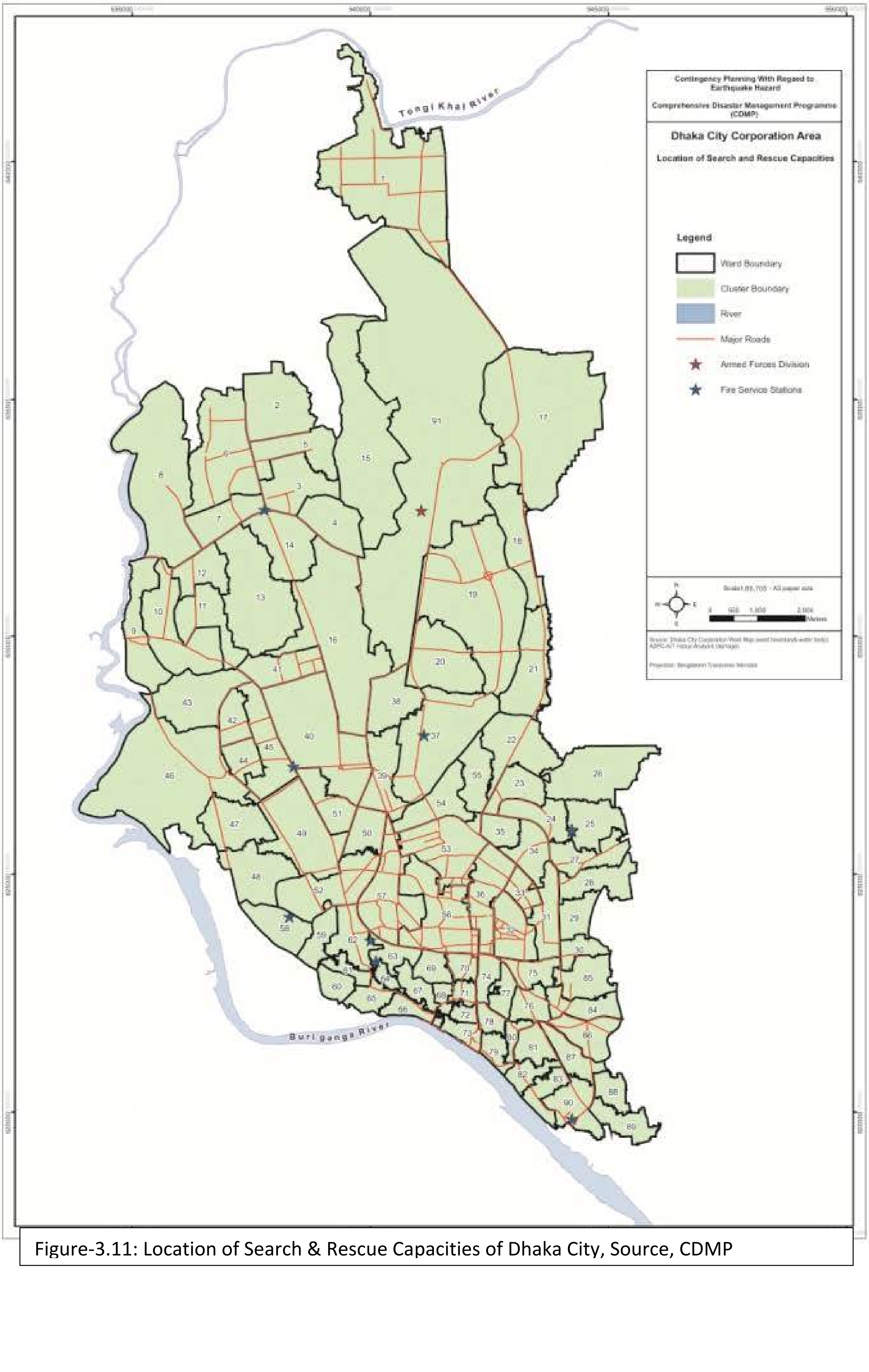


Figure-3.11: Location of Search & Rescue Capacities of Dhaka City, Source, CDMP

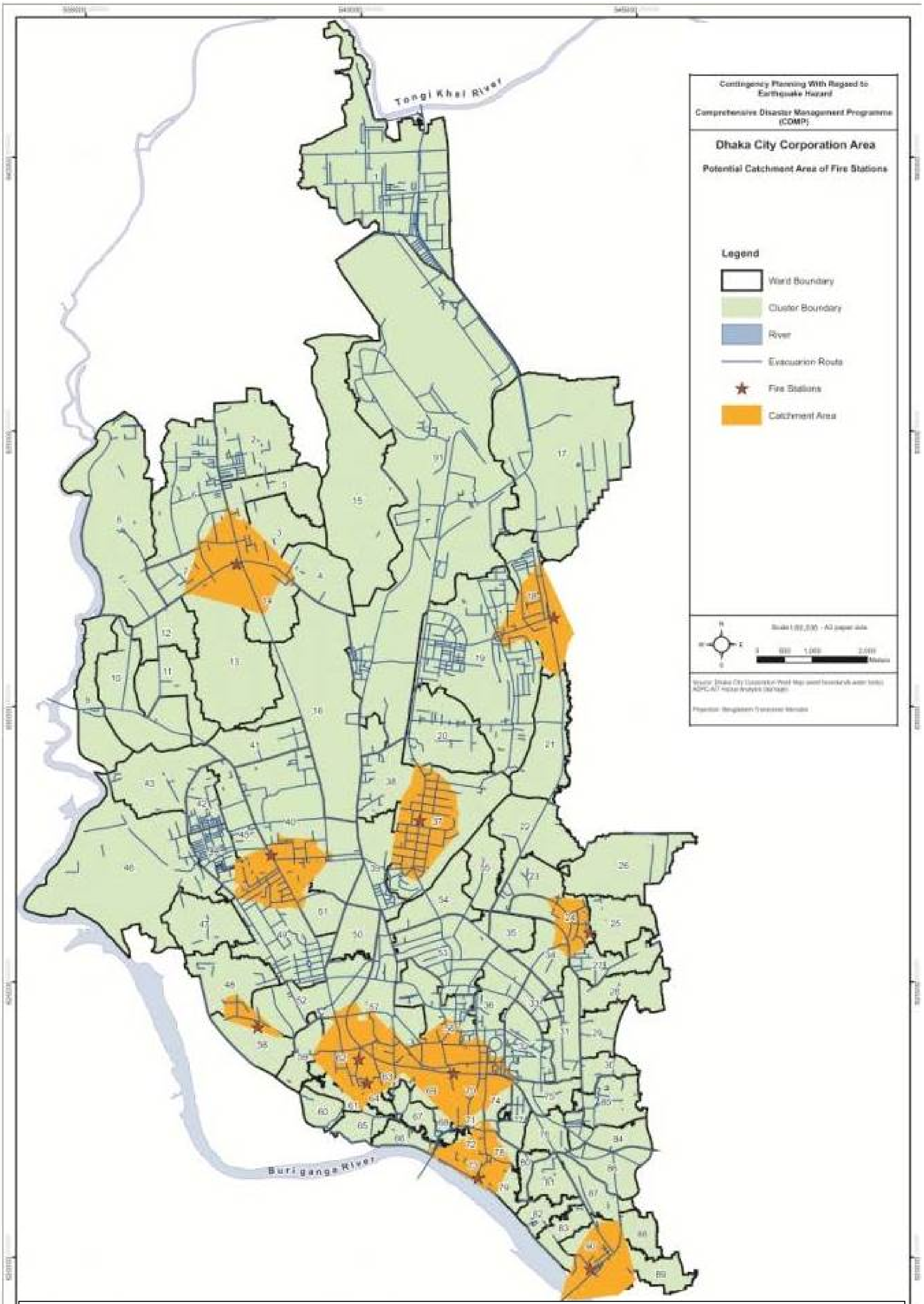


Figure-3.12: Potential catchment area of fire Station in Dhaka City, Source, CDMP

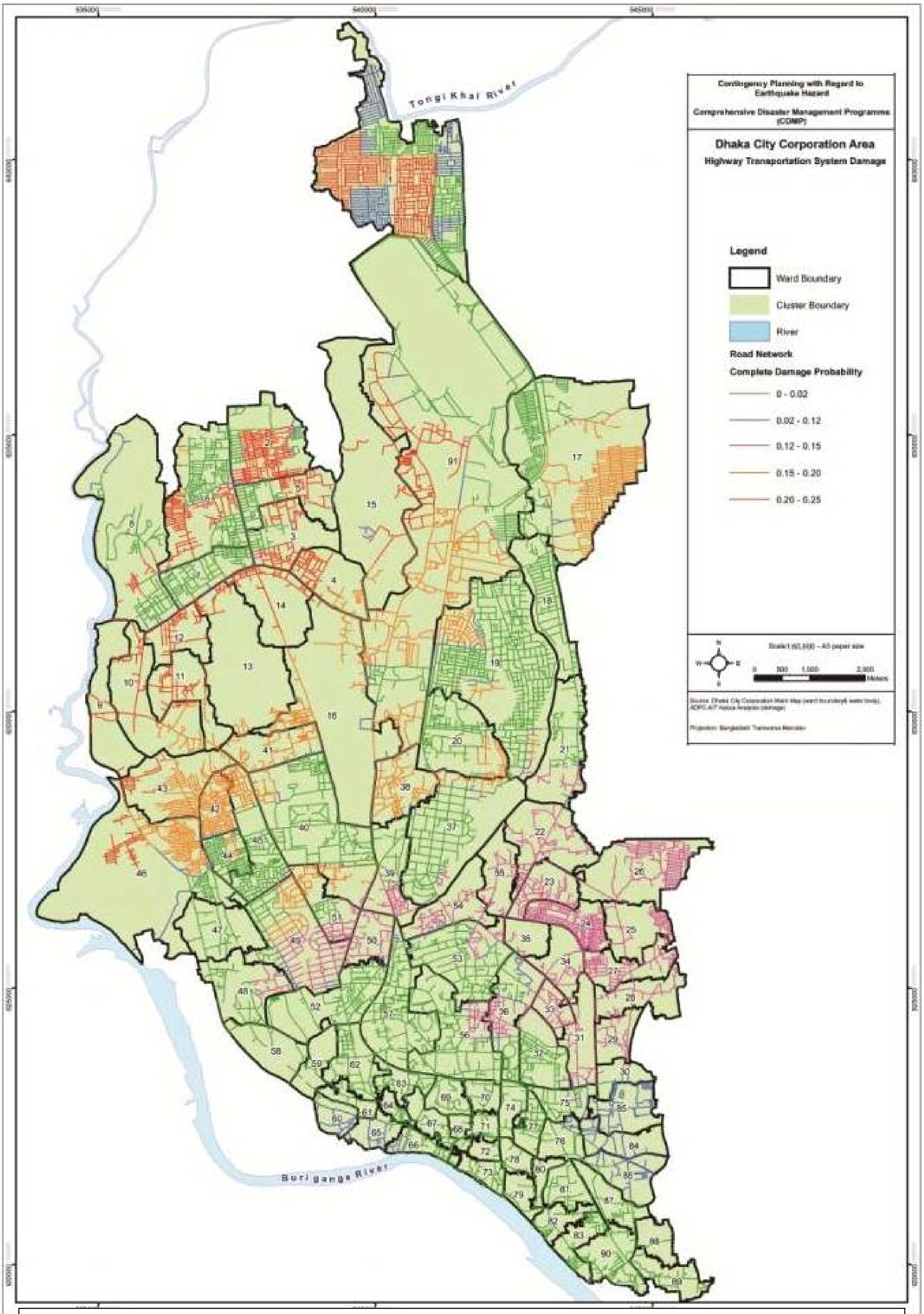


Figure-3.13: Highway Transportation System Damages of Dhaka City, Source, CDMP

3.4.3 Earthquake Risk Assessment:

An assessment presents the seismic risk of the buildings, essential facilities and lifelines based on a GIS database that was developed from existing secondary data and field survey in Dhaka, Chittagong and Sylhet City Coproration areas. The assessment provides forecasts of damage and human and economic impacts in those study areas that may result from an earthquake.

It is estimated that there are 326,000, 182,000, and 52,000 buildings in Dhaka, Chittagong, and Sylhet City Corporation Areas respectively, which have an aggregate total replacement value of 16,759 millions of dollars for Dhaka, 3,400 millions of dollars for Chittagong, and 940 millions of dollars for Sylhet. The total population of Dhaka, Chittagong and Sylhet are approximately 7.2, 2.3 and 0.4 millions respectively.
There are 600 hospitals, 2,737 schools, 10 fire stations, 62 police stations and 18 emergencies response agency offices in Dhaka City Corporation area. While in Chittagong, there are 162 hospitals, 1,033 schools, 12 fire stations, 11 police stations and 11 emergency response agency offices. And in Sylhet, there are 87 hospitals, 211 schools, 2 fire stations, 6 police stations, and 9 emergency response agency offices.

The lifeline inventory in Dhaka City Corporation area includes over 1,270 kilometers of highway road, 10 highway bridges, and 2,582 kilometers of potable water, waste water, and gas pipes. While in Chittagong, the lifelines include 639 kilometers of highway road, 4 highway bridges, and 792 kilometers of potable water and gas pipes. In Sylhet, the lifelines include 148 kilometers of highway road, 2 highway bridges, and 268 kilometers of potable water and gas pipes.

The earthquake in the worst case scenario will generate 72, 17, and 5 millions of ton of debris in Dhaka, Chittagong, and Sylhet respectively. It will also trigger 107 ignitions of fire following earthquake in Dhaka, 36 ignitions in Chittagong, and 13 in Sylhet. Before the earthquake, there are 59,849 hospital beds available for use in Dhaka City Corporation area. On the day of the earthquake with the worst case scenario, the model estimates that only 7,441 hospital beds (12%) are available for use by patients already in the hospital and those injured by the earthquake. While in Chittagong, there are 21,664 hospital beds available for use. With the worst case earthquake scenario, HAZUS estimates that only 923 hospital beds (4%) are available for use by patients already in the hospital and those injured by the earthquake. In Sylhet there are 8,722 hospital beds available for use, and in worst case earthquake scenario it is estimated that only 17 hospital beds (0%) are available for use by patients already in the hospital and those injured by the earthquake.

Regarding fatalities in the worst case scenario, it estimates the number of killed victims is 260,788, 95,183 and 20,708 for Dhaka, Chittagong, and Sylhet respectively if the earthquake occurs during night time (2:00AM). If the earthquake occurs during day time (2:00PM), the number of victims is 183,450, 73,213 and 14,276 for Dhaka, Chittagong, and Sylhet respectively. In the worst case scenario, estimated total building-related economic losses are 15,603 millions of dollars, 3,112 millions of dollars, and 1,105 millions of dollars in Dhaka, Chittagong, and Sylhet City Corporation areas respectively. While for the lifeline, the losses are 364, 244, and 117 millions of dollar in Dhaka, Chittagong, and Sylhet respectively.

3.5 Earthquake preparedness in Bangladesh:

It is evident from the past history of higher intensity earthquake in this region and the mild shakes experienced in recent dates as an initial call for earthquake in major cities of Bangladesh. The overall development of these cities has taken place without any caution for the earthquake. As such, it is feared that a high intensity earthquake in these cities may result in to serious devastation and collapse the cities. Thus, a well-designed and fully coordinated plan for optimum and efficient preparedness, response and early recovery, usually known as Contingency Plan, in a systematic manner so that their capacities and resources are best utilized to fulfill the need complimenting and supplementing other agencies. Realizing the need of coordinated and comprehensive emergency response, United Nations has been promoting its humanitarian response activities in a cluster approach. This approach is proved to be effective and efficient in responding to recent disasters, for instances, the response during the earthquake on 8 October 2005 in Pakistan. Hence, it has been decided that this concept of response operations in functional clusters be applied in Bangladesh also in case of possible earthquake disaster.

In this approach, under National Earthquake Contingency Plan, all response activities are grouped into nine relevant operational functional clusters based on the similarity of works normal and disaster time mandates of different relevant organizations and possible complementarily in the resources and capacities. The clusters are as follows:

1. Emergency Operations Cluster 1 – Overall Command and Coordination
2. Emergency Operations Cluster 2 – Search, Rescue and Evacuation
3. Health Cluster
4. Relief Services (Food, Nutrition and other Relief) Cluster
5. Shelter (Including Camp Management) Cluster
6. Water Supply, Sanitation and Hygiene Cluster
7. Restoration of Urban Services Cluster
8. Transport (Road, Rail, Air, Sea) Cluster
9. Security and Welfare Cluster

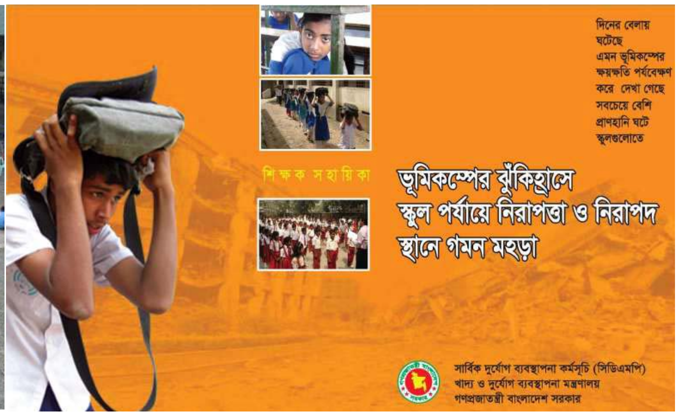
Considering the fact that people of Bangladesh did not have any living memories of major earthquake, it was a great challenge to motivate people with regard to preparedness for such a disaster. Therefore, with due respect to communities' physical vulnerability, the community people's response to this initiative was also given high importance.

CDMP works with the Partnership development among the DRR stakeholders, Community development through public awareness and participation and Urban Community Volunteerism. CDMP supports to develop 18000 urban volunteers for search rescue activities and CDMP officials currently conduct earthquake drills at 70,000 primary and secondary schools twice a year.

Bangladesh is working to enhance children's understanding of earthquake preparedness with the introduction of 10 new supplementary books for teaching the subject, which has been part of the education curriculum in primary and secondary schools since 2004. With these books, students will be taught about earthquake preparedness by rhymes and stories, so that they can understand the risks.

In the Bangladesh 2010 National Education Policy disaster preparedness is cited as a core area to be incorporated into the curriculum.

Earthquake Drills:



Chapter-4: Disaster Management in Japan:

Japan is particularly vulnerable to natural disasters because of its climate and topography, and it has experienced countless earthquakes, typhoons, and other types of disasters. A number of factors contribute to the high incidence of natural disasters in Japan. First, the country is subject to extreme climatic variations, such as seasonal rain fronts and typhoons, as well as heavy snowfall on the Sea of Japan side of the archipelago. Second, Japan's topography is rugged and there are many faults and steep inclines. Third, Japan is located in the Pacific earthquake belt and is frequently struck by earthquakes, while its complex coastline is vulnerable to tsunamis. And fourth, Japan is located in the circum-Pacific zone, in which almost all the volcanoes of the world are concentrated, and has 83 active volcanoes-one-tenth of the world total.

4.1 Disasters in Japan:

Every year there is a great loss of people's lives and property in Japan due to disasters. Up until the second half of 1950s, numerous large-scale typhoons and earthquakes caused extensive damage and thousands of casualties. However, with the progress of society's capabilities to address disasters and the mitigation of vulnerabilities to disasters by developing disaster management systems, promoting national land conservation, improving weather forecasting technologies, and upgrading disaster information communications systems, disaster damage has shown a declining tendency. In spite of such eff orts, in 1995, more than 6,400 people dies of the Great Hanshin-Awaji Earthquake. Also, in 2009, some 100 people died or went missing due to storms, flooding or heavy snowfall. There is also a high probability of the occurrence of large-scale earthquakes in the coming decades. As such, natural disasters remain a menacing threat to the safety and security of the country.

Earthquake:

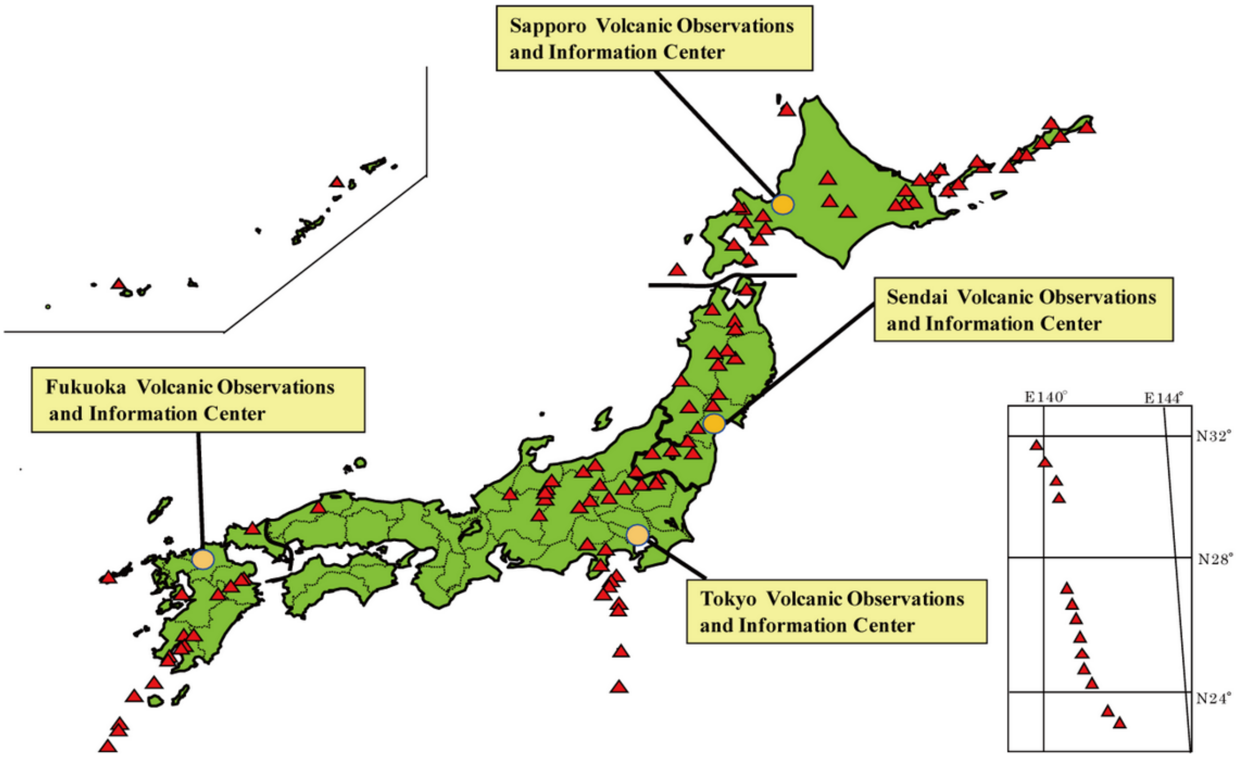
Japan is located at a point on the earth’s surface where four of more than 10 tectonic plates covering the globe are crushed against each other, making it earthquake prone. More than 20% of the world’s earthquakes (magnitude 6 or greater) have occurred in or around Japan. Japan is well acquainted with the massive inter-plate earthquakes produced by plate subduction (such as the Great Kanto Earthquake of 1923) and the inland crustal earthquakes caused by plate movements (such as the Great Hanshin-Awaji Earthquake of 1995)

Tsunami:

Surrounded by water on all sides with long andcomplex coastlines, Japan is highly vulnerable to earthquake-generated tsunamis. In reality, there has been severe damage caused by various tsunamis in the past, including the Meiji-Sanriku Earthquake Tsunami (1896), Nihon-kai-Chubu Earthquake (1983), and Hokkaido Nansei-oki Earthquake (1993).

Volcano:

There are 110 active volcanoes in Japan; on average, a total of 15 volcanic events (including eruptions) occur every year, some of which seriously hinder human life. To continuously monitor this volcanic activity, JMA deploys seismographs and related observation instruments in the vicinity of 47 volcanoes that are remarkably active.



Active volcanoes in Japan

Source: *Japan Meteorological Agency*

Storm and Flood:

Japan is prone to a variety of water and wind-related disasters including flooding, landslides, tidal waves and storm hazards, owing to meteorological conditions such as typhoons and active weather-front systems and geographical conditions such as precipitous terrains and steep rivers, as well as settlement conditions in which many of the cities are built on river plains. One-half of the population is concentrated in possible inundation areas, which account for about 10% of the national land. Although there has been a large reduction in the area inundated by floods owing to soil conservation and flood control projects over many years, the amount of general assets damaged in flooded areas has increased in recent years. Additionally, as a long-term trend, there is an increasing tendency of downpours throughout the country.

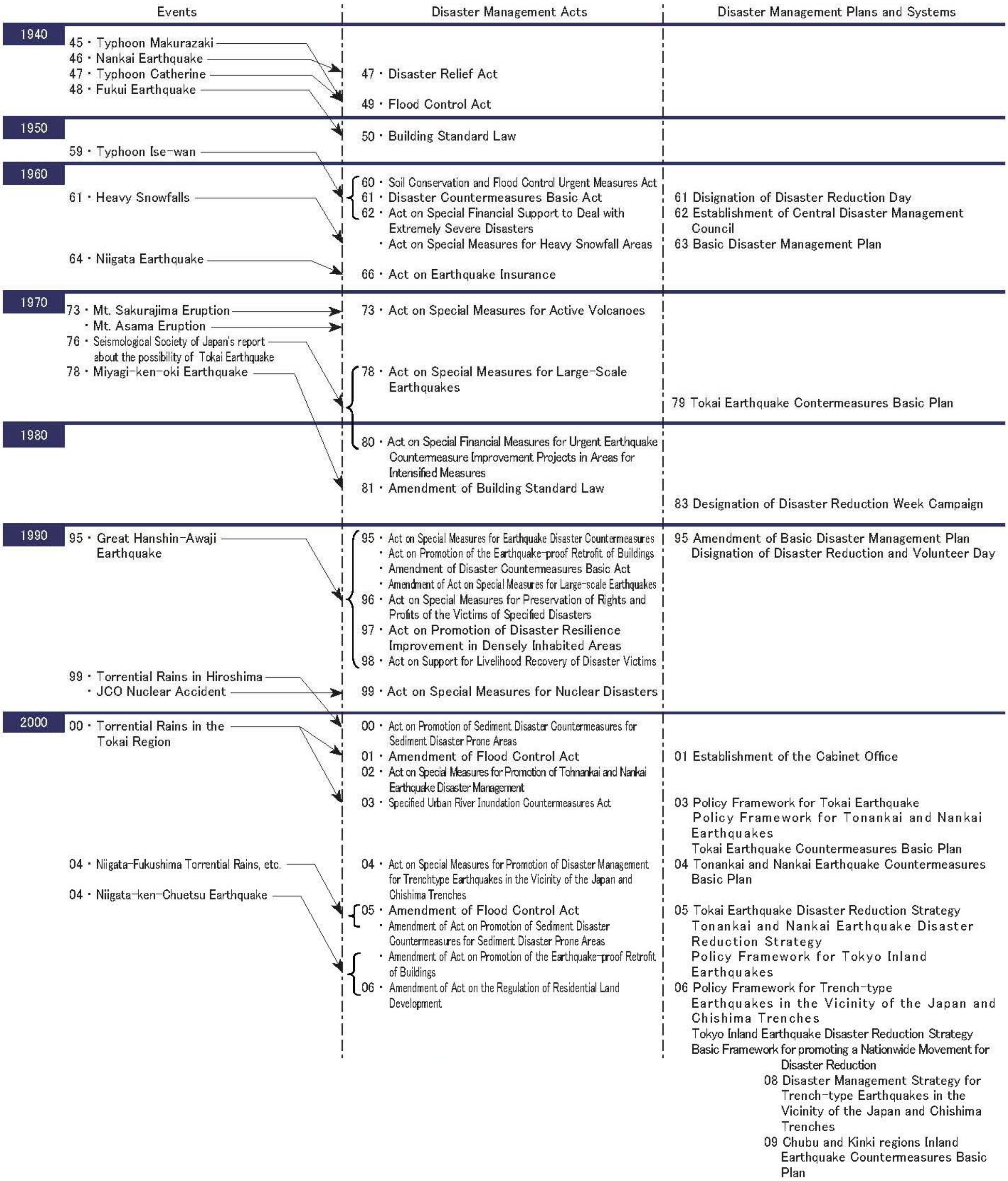
Snow:

Japan is a bow-shaped archipelago filled with steep mountain ranges. When cold winds blow in from Siberia in winter, the warm current flowing up the eastern coast from the south brings heavy snowfalls to the Sea of Japan side of the country. Among the seasonal problems that result every year are falls by people removing snow from their roofs, avalanches, and obstruction of traffic and city functions due to snow accumulation.

In the winter of 2005–06, ferocious winds brought tremendous snowfalls to every part of the Sea of Japan coastline. Many people were injured from falls as they cleared snow from their roofs, while others were pinned by snow falling from rooftops or even by collapsing roofs. The death toll reached 152—the second-worst total for snow-related deaths since the end of World War II. Fatal accidents continued in subsequent years, with 47 people perishing in the winter of 2006–07, 21 in 2007–08 and 56 in 2008–09.

4.2 Disaster Management Laws and Systems in Japan:

In Japan, the disaster management system has been developed and strengthened following the bitter experiences of large-scale disasters and accidents.



Source: Cabinet Office, Japan

Disaster countermeasures are taken based on the Disaster Countermeasures Basic Act and various disaster management related laws.

4.2.1 Basic Acts

1. Disaster countermeasures Basic Act (1961)
2. Act on Prevention of Marine Pollution and Maritime Disaster (1970)
3. Act on Disaster Prevention in Petroleum Industrial Complexes and other Petroleum Facilities (1975)
4. Act on Special Measures for Large-scale Earthquakes (1978)
5. Act on Special Measures for Nuclear Disasters (1999)
6. Act on Special Measures for Promotion of Tonankai and Nankai Earthquake Disaster Management (2002)
7. Act on Special Measures for Promotion of Disaster Management for Trench-type Earthquake in the Vicinity of the Japan and Chishima Trenches (2004)

4.2.2 Acts & Law related to Disaster Prevention and Preparedness:

1. Erosion Control Act (1897)
2. Building Standard Law (1950)
3. Forest Act (1951)
4. Act on Temporary Measures for Disaster Prevention and Development of Special Land Areas (1952)
5. Meteorological Services Act (1952)
6. Seashore Act (1956)
7. Landslide Prevention Act (1958)
8. Act on Special Measures for Disaster Prevention in Typhoon-prone Areas (1958)
9. Act on Special Measures for Heavy Snowfall Areas (1962)
10. River Act (1964)
11. Act on Prevention of Steep Slope Collapse Disaster (1969)
12. Act on Special Measures for Active Volcanoes (1973)
13. Act on Special Financial Measures for Urgent Earthquake Countermeasures Improvement Projects in Areas for Intensified Measures (1980)
14. Act on Special Measures for Earthquake Disaster Countermeasures (1995)
15. Act on Promotion of the Earthquake-proof Retrofit of Buildings (1995)
16. Act on Promotion of Disaster Resilience Improvement in Densely Inhabited Areas (1997)
17. Act on Promotion of Sediment Disaster Countermeasure for Sediment Disaster Prone Areas (2000)
18. Specified Urban River Inundation Countermeasures Act (2003)

4.2.3 Acts relating to Disaster Emergency Response

1. Disaster Relief Act (1947)
2. Fire and Disaster Management Organization Act (1947)
3. Japan Coast Guard Act (1948)
4. Fire Services Act (1948)
5. Flood Control Act (1949)
6. Police Act (1954)
7. Self-Defense Forces Act (1954)

4.2.4 Acts related to Disaster Recovery and Reconstruction

1. Forest National Insurance Act (1937)
2. Act on Temporary Treatment of Rental Land and Housing in Cities (1946)
3. Agriculture Disaster Compensation Act (1947)
4. Act on Interim Measures for Subsidizing Recovery Projects for Agriculture, Forestry and Fisheries Facilities Damaged Due to Disasters (1950)
5. Small-Medium Business Credit Insurance Act (1950)
6. Act on National Treasury Share of Expenses for Recovery Projects for Public Civil Engineering Facilities Damaged Due to Disasters (1951)
7. Public Housing Act (1951)
8. Fishing Boat Damage Compensation Act (1952)
9. Railway Improvement Act (1953)
10. Act on National Treasury Share of Expenses for Recovery of Public School Facilities Damaged Due to Disasters (1953)
11. Act on Interim Measures for Financing Farmers, Woodsmen and Fishermen Suffering from Natural Disasters (1955)
12. Airport Act (1956)
13. Small-scale Business Equipment Installation Financial Support Act (1956)
14. Act on Special Financial Support to Deal with Extremely Severe Disasters (1962)
15. Fisheries Disaster Compensation Act (1964)
16. Act on Earthquake Insurance (1966)
17. Act on Special Financial Measures for Group Relocation Promotion Projects for
18. Disasters Mitigation (1972)
19. Act on Payment of Solatia for Disasters (1973)
20. Act on Special Measures for Reconstruction of Disaster-stricken Urban Areas (1995)
21. Act on Special Financial Measures for Reconstruction of Jointly Owned Buildings in Disaster-stricken Areas (1995)
22. Act on Special Financial Measures for Preservation of Rights and Profits of Victims of Specified Disasters (1996)
23. Act on Support for Livelihood Recovery of Disaster Victims (1998)
24. The Japan Finance Corporation Act (2007)

4.2.5 Establishment of Comprehensive Disaster Management System: Disaster Countermeasures Basic Act

To protect national land as well as citizens' lives, livelihoods, and property from natural disasters is a national priority. The turning point for strengthening the disaster management system came after the immense damage caused by the Ise-wan Typhoon in 1959, and led to the enactment of the Disaster Countermeasures Basic Act in 1961, which formulates a comprehensive and strategic disaster management system. The disaster management system has been further strengthened following the lessons learned from large-scale disasters such as the Great Hanshin-Awaji Earthquake.

Japan’s disaster management system addresses all of the disaster phases of prevention, mitigation and preparedness, emergency response as well as recovery and rehabilitation. With clear roles and responsibilities of the national and local governments, the relevant stakeholders of the public and private sectors cooperate in implementing various disaster countermeasures.

4.2.6 Main Contents of the Disaster Countermeasures Basic Act

1) Definition of responsibilities for disaster management

2) Disaster management organizations

3) Disaster management planning system

4) Disaster prevention and preparedness

5) Disaster emergency response

6) Disaster recovery and rehabilitation

7) Financial measures

8) State of Disaster Emergency

4.3 Mission of the Cabinet Office:

Along with a series of reforms of the central government system in 2001, the post of Minister of State for Disaster Management was newly established to integrate and coordinate disaster reduction policies and measures of ministries and agencies. In the Cabinet Office, which is responsible for securing cooperation and collaboration among related government organizations in wide-ranging issues, the Director-General for Disaster Management is mandated to undertake the planning of basic disaster management policies and response to large-scale disaster, as well as conduct overall coordination.

Additionally, taking into account the lessons learned from the Great Hanshin-Awaiji Earthquake, the Cabinet Secretariat system was also strengthened, including the appointment of the Deputy Chief Cabinet Secretary for Crisis Management and the establishment of the Cabinet Information Collection Center, to strengthen risk management functions to address emergencies such as large-scale disasters and serious accidents. Thereby, the Cabinet Office has a role in supporting the Cabinet Secretariat regarding disaster management matters.

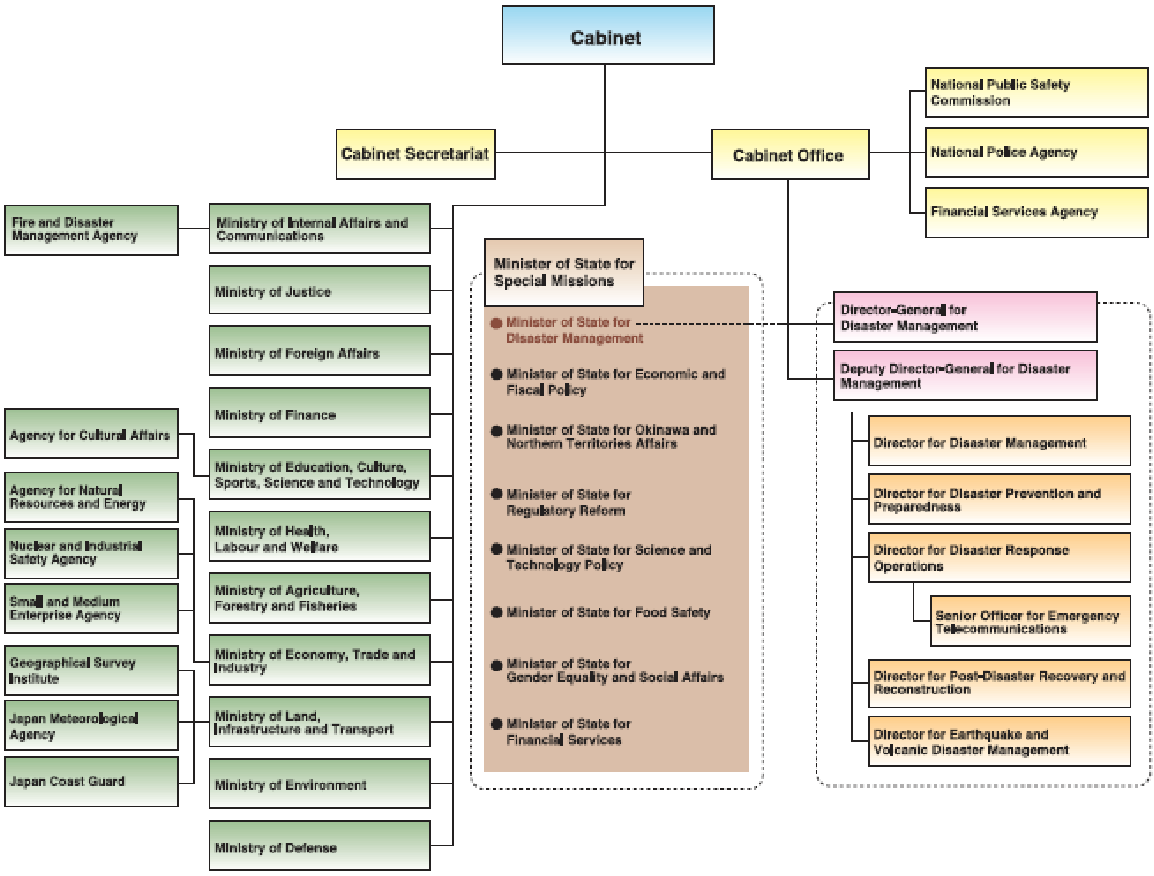


Figure 4.3: Organization of National Government and Cabinet Office (Disaster management)

Source: Cabinet Office, Government of Japan

4.4 Central Disaster Management Council

The Central Disaster Management Council is one of the councils that deal with crucial policies of the Cabinet, and is established in the Cabinet Office based on the Disaster Countermeasures Basic Act. The council consists of the Prime Minister, who is the chairperson, Minister of State for Disaster Management, all ministers, heads of major public institutions and experts. The council promotes comprehensive disaster countermeasures including according to requests from the Prime Minister or Minister of State for Disaster Management.

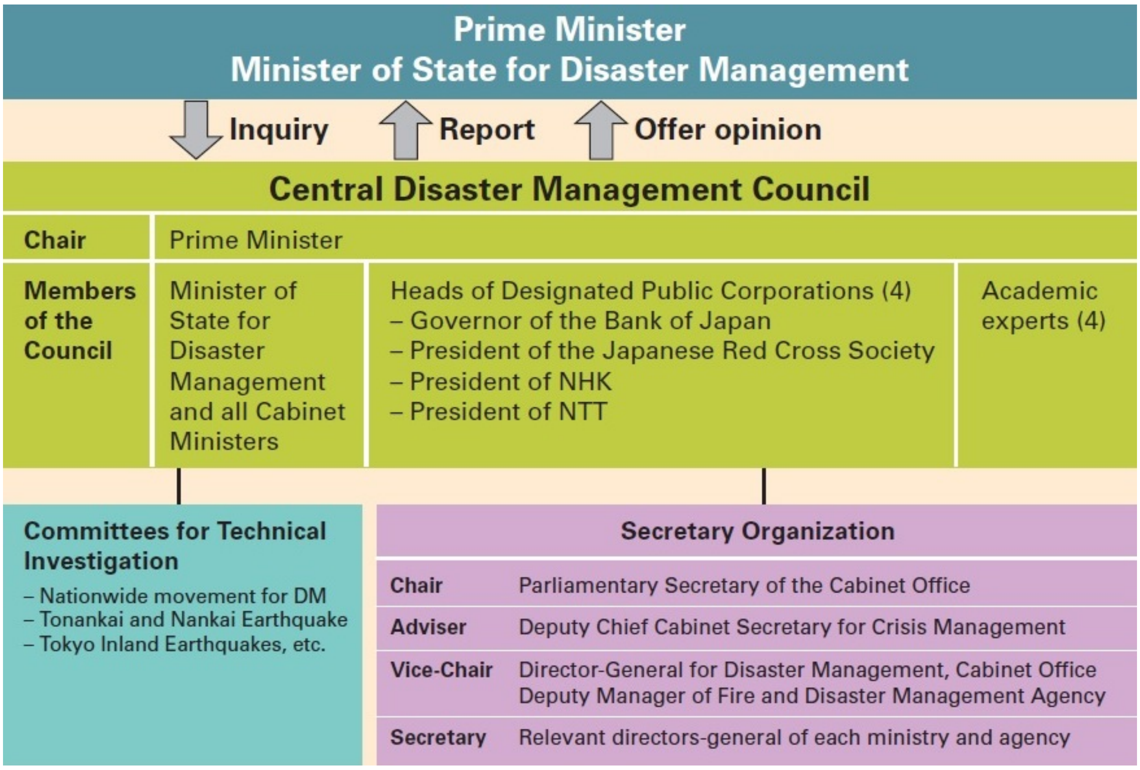


Figure 4.4: Structure of Central Disaster Management Council

Source: Cabinet Office, Government of Japan

4.5 Disaster Management Planning System

1) Basic Disaster Management Plan: This plan is a basis for disaster reduction activities and is prepared by the Central Disaster Management Council based on the Disaster Countermeasures Basic Act.

2) Disaster Management Operation: This is a plan made by each designated government organization and designated public corporation based on the Basic Disaster Management Plan.

3) Local Disaster Management Plan: This is a plan made by each prefectural and municipal disaster management council, subject to local circumstances and based on the Basic Disaster Management Plan.

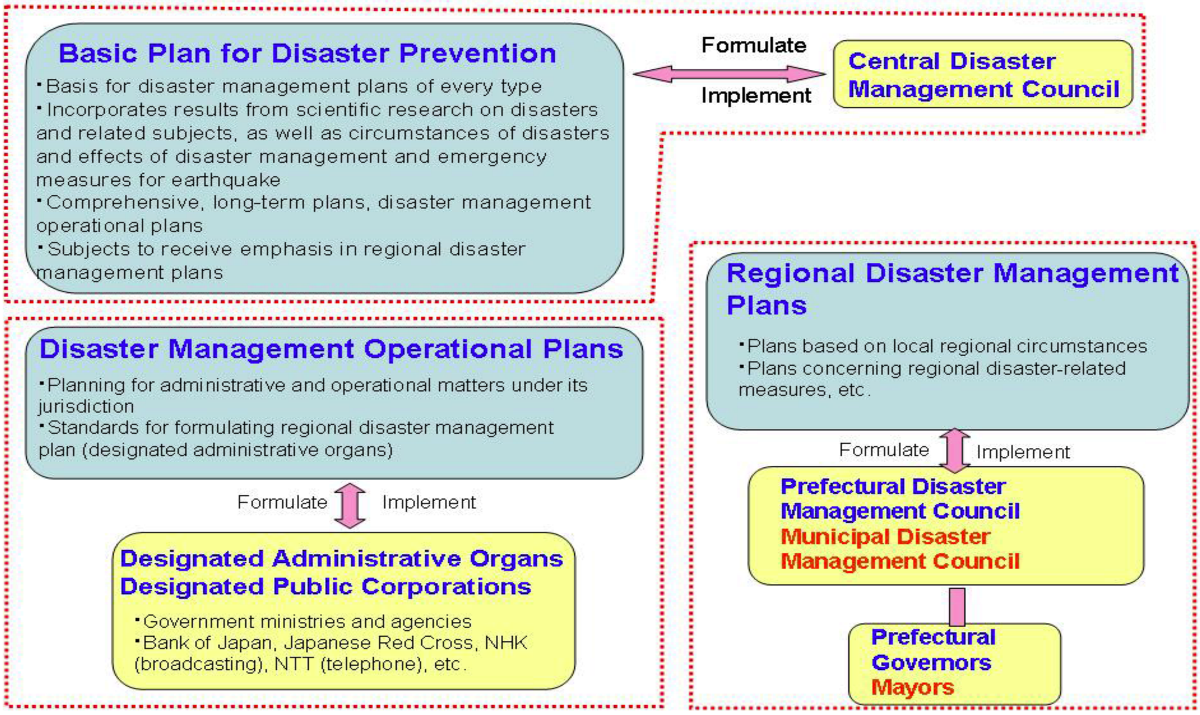


Fig-4.5: Disaster Management Plan.

4.5.1 Basic Disaster Management Plan

The Basic Disaster Management Plan states comprehensive and long-term disaster reduction issues such as disaster management related systems, disaster reduction projects, early and appropriate disaster recovery and rehabilitation, as well as scientific and technical research. The plan was revised entirely in 1995 based on the experience of the Great Hanshin-Awaji Earthquake. It now consists of various plans for each type of disaster, where tangible countermeasures to be taken by each stakeholder such as the national and local governments, public corporations and other entities are described for easy reference according to the disaster phases of prevention and preparedness, emergency response, as well as recovery and rehabilitation.

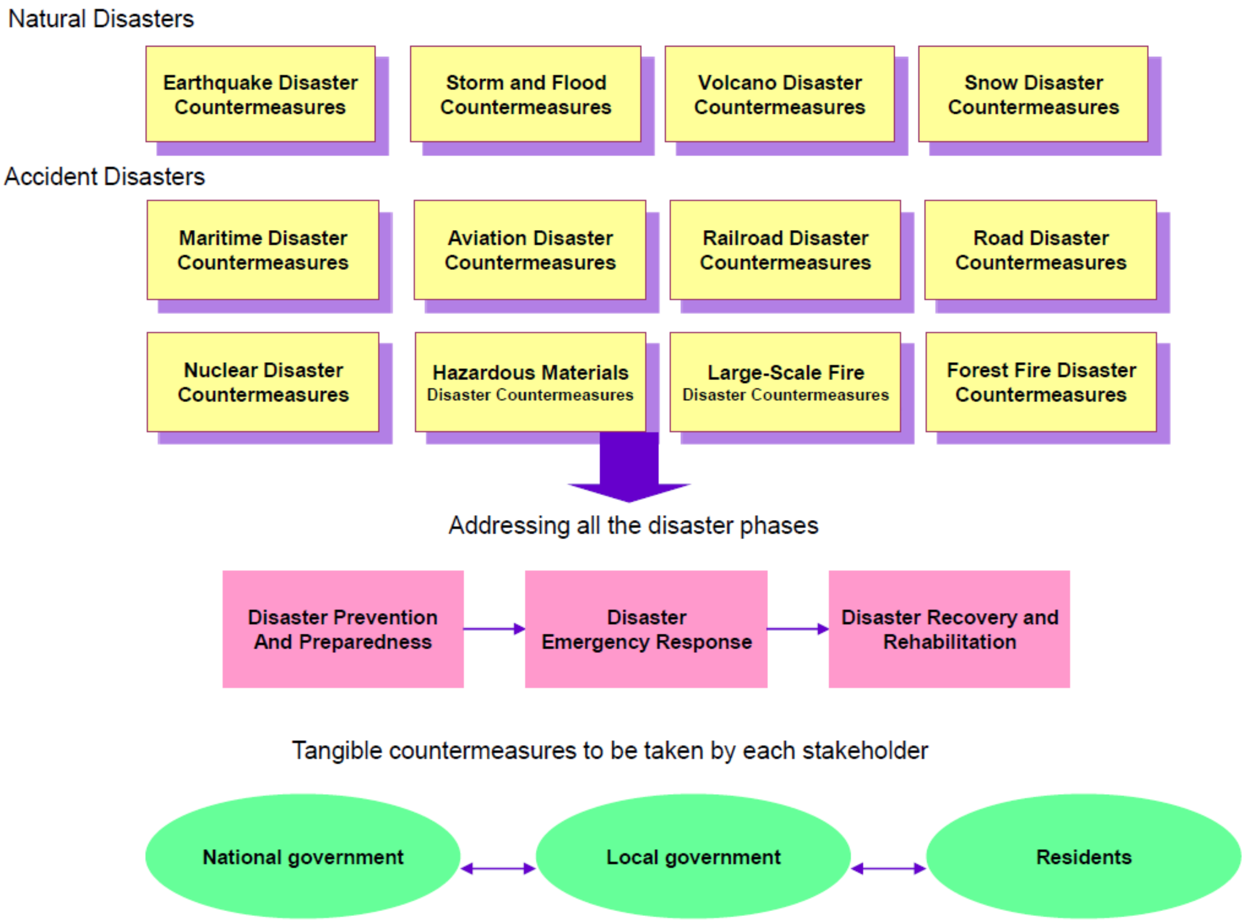


Figure 4.6 Structure of basic disaster management plan

Source: Book of disaster management in Japan

4.6 Disaster Management Structure

Disaster Management of Japan is categorized into 3 levels including national, regional and municipal level. The significance of each level is delineated as follows:

1) National Level: The Prime Minister is the National Commander through the National Disaster Management Council, and the designed government organizations (23 ministries and agencies), and designated public cooperation (63 organizations including independent administrative agencies, Bank of Japan, Japanese Red Cross Society, NHK, electricity and gas companies and NTT). In this connection, the national council is responsible for formulation and promoting the implementation of the Basic Disaster Management Plan. Meanwhile, the other two designed agencies of government and public cooperation are responsible for formulation and implementation of the Disaster Management Operation Plan.

2) Prefectural Level: The Governor is the commander ordering via the Prefectural Disaster Management Council, and designed government organization and public corporations in local. The prefectural council will conjunctionally work with the mentioned designed agencies to formulate and promote the implementation of Local Disaster Management Plan.

3) Municipal Level: In this level, the Mayor of City, Town and Village is the commander, as the same of Governor in prefectural level, will take function through Municipal Disaster Management Council to formulate and promote the implementation of Local Disaster Management Plan.

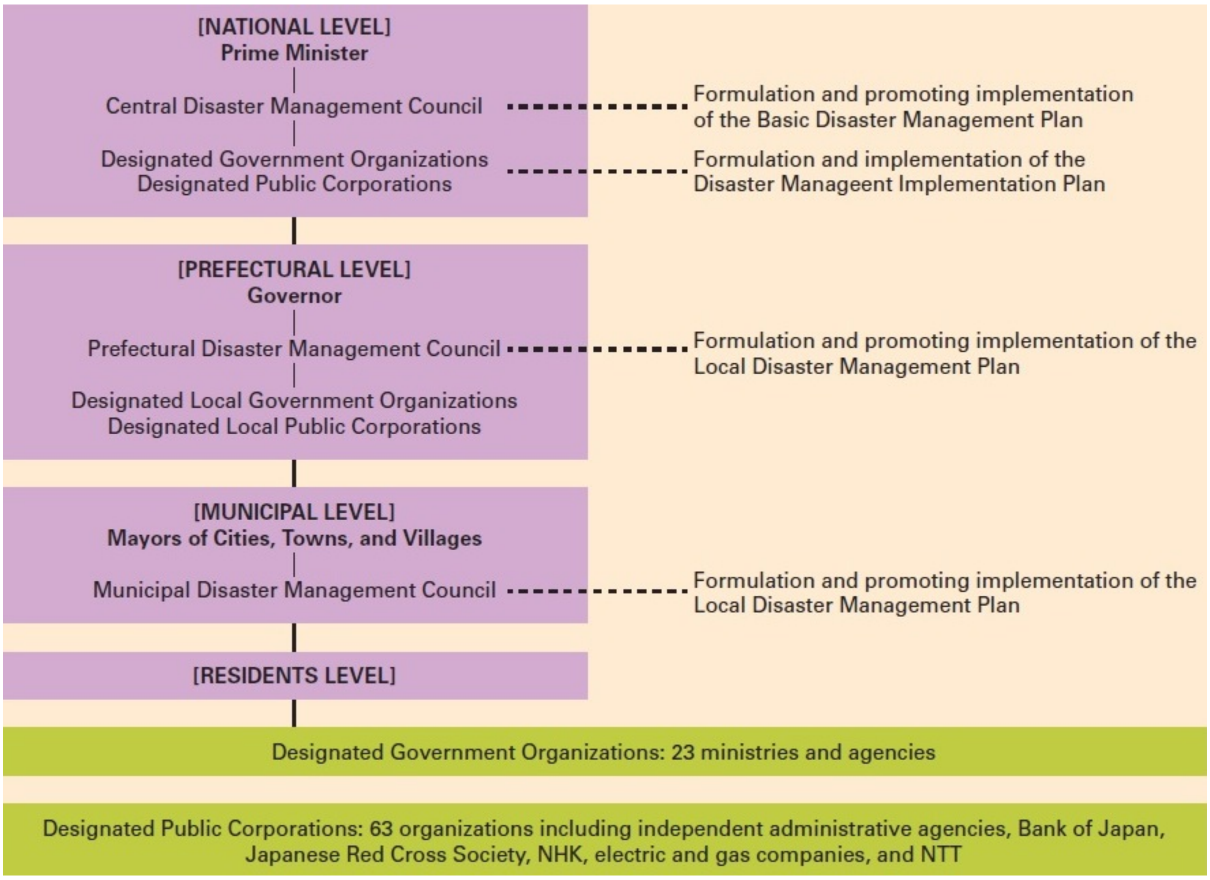


Fig-4.7: Disaster Management Structure, Source: Cabinet Office, Japan.

4.7 Disaster management Budget:

The National Budget for disaster management is approximately 1.2 trillion yen (Initial Budget 2010FY).

4.8 Research and Development:

(1) Scientific and Technological Research in Disaster Reduction:

The Basic Science and Technology Plan-Third Term (2006), which describes Japan's basic science and technology policies, sets a major goal of making Japan a country that can take pride in being safest in the world, and an intermediate goal of ensuring the security of national land, society and people's livelihoods. Based on this, the implementation strategy for the plan sets 10 important issues on disaster reduction.

(2) Utilization of Earthquake Early Warning Information:

Earthquake Early Warning (EEW) information announces the estimated hypocenter and magnitude of an earthquake as Well as the estimated arrival time of the S-Wave (the principal shock) of the earthquake and seismic intensity in each area. This information is made possible by detecting the P-wave near the epicenter and immediately processing the data since there is a difference in the speed of the P-Wave, which arrives faster and the principal shock which arrives later and causes more severely destructive phenomena. In the case of a large-scale ocean trench-type earthquake, there may be a time lag (several seconds to several tens of seconds) between the issuance of the EEW information and the start of severe shaking (When the S-Wave arrives). This can be a critical time to be used for mitigating damage by stopping trains and elevators, extinguishing flames or crawling under tables.

The issuance of EEW information by the Japan Meteorological Agency (JMA) began in October 2007. The JMA initiated the service to provide earthquake Warnings as mandated under a 2007 revision of the Meteorological Services Act.

4.9 Disaster Prevention and Preparedness

4.9.1 National Land Conservation

National land conservation projects such as river improvement, soil erosion control (sabo), and soil and coastline conservation are carried out strategically for protecting national land, citizens' lives and property from various disasters. Although long-term plans by field had been formulated in separate plans in the past, the Priority Plan for Social Infrastructure Development," set forth in 2002, integrated these plans. Additionally, the Forest Improvement and Conservation Works Master Plan" was formulated in 2003 to promote comprehensive and effective forestry improvement and soil conservation projects. A plan for the next five years, from 2009 to 2014, was adopted at a Cabinet meeting in April 2009.

4.9.2 Observing, Forecasting and Warning of Disaster Risks

Observation systems that can accurately detect disaster risks in real-time have been progressively improved for establishing early Warning systems, supporting the early evacuation of residents and response activities of disaster management organizations, and thereby reducing disaster damage. Organizations involved in disaster reduction, especially the JMA, use 24-hour systems to carefully monitor various natural phenomena and weather conditions. In addition to announcing observed information related to natural phenomena, the JMA issues a Wide range of forecasts, Warnings and advisories regarding earthquake-generated tsunamis and severe Weather events such as heavy rain.

4.9.3 Information and Communications Systems

The development of a quick and accurate communications system is essential for the effective use of disaster early Warning information. For this purpose an online, system has been built, linking the JMA with disaster management organizations of the national and local governments and media organizations. Disaster management organizations have also been developing radio communications networks exclusively for disasters: the Central Disaster Management Radio Communications System, which connects national organizations; the Fire Disaster Management Radio Communications System, which connects firefighting organizations across the country; and prefectural and municipal disaster management radio communications systems, which connect local disaster management organizations and residents.

The Cabinet Office has established the Central Disaster Management Radio Communications System to link with designated government organizations, designated public corporations and local disaster management organizations. providing communications by telephone, fax, data transmission, TV conferencing and transmission of pictures of disaster situations from helicopters. Furthermore, to provide backup for terrestrial communications services such as a satellite mobile- telephone communications system for municipal governments have been launched in 2011.

Simultaneous wireless communications systems using outdoor loudspeakers and indoor radio receivers are used to disseminate disaster information to residents. Tsunami and severe weather warnings are widely provided to citizens via TV and radio broadcasts.

4.9.4 Integrated Disaster Management Information System

Based on the experiences of the Great Hanshin-Awaji Earthquake, the Cabinet Office has been developing an integrated disaster management information system that helps to grasp the situation of the disaster early on and promotes information sharing among relevant organizations. thereby enabling quick and appropriate decision-making for emergency response operations.The main features of the Integrated Disaster Management Information System are as follows.

1. **Function for early assessment of damage from earthquakes:** The System receives information on earthquake intensity as observed by the JMA and automatically activated by an earthquake intensity level of 4 or greater. It has a feature that estimates the distribution of seismic intensity and scale of damage (human suffering and building damage) Within 10 minutes.
2. **Early damage assessment function using artificial satellites:** When large-scale disasters occur. this feature uses images from artificial satellites capable of Wide-area observation to provide early assessment of damage.
3. **Information sharing function:** This feature plots disaster information provided by disaster-management agencies to a map using GIS, so it can be freely accessed by all.

4.9.5 Main wide-area disaster-management base in the Tokyo Bay maritime area:

The first decision taken in the Urban Renewal Headquarters' Urban Renewal Project (June 2001) was to establish a core wide-area disaster-management base in the Tokyo Bay Waterfront area (the Ariake-no-Oka and Higashi-Ohgijima areas). The function of this base would be to secure a local headquarters for disaster-management activities in the event of a large-scale. wide-area disaster in the Tokyo area. If an earthquake strikes directly beneath Tokyo, a local disaster-management base is set up in the Ariake- no-Oka area to serve as the capital's Wide-area disaster- management headquarters, as well as a base camp for Wide-area support teams and a support base for disaster- relief medical care. During normal times, the site is used for the exchange of disaster-management information among related agencies and various training activities, to prepare for response in the event of disaster. The Higashi- Ohgijima area's role, in the event of an earthquake striking directly beneath Tokyo, is to coordinate the arrival of shipments of support materials from other locations in Japan and overseas; serve as a relay base for the shipment of these materials by sea, river and land; and to offer a temporary base camp for the mustering of wide-area support teams.

4.9.6 Issuing of Evacuation Order and Instruction:

When a disaster occurs or is imminent residents may start evacuating on their own, and the mayor of the municipality may also issue an evacuation advisory or order. It is effective for municipalities to prepare a manual explaining the criteria regarding disaster situations that require the issuance of evacuation advisories or orders thereby helping the mayor’s quick decision. The Cabinet Office, in cooperation with relevant ministries, published the "Guidelines for Producing a Decision and Dissemination Manual for Evacuation Advisories and Orders” in 2005, and is promoting its implementation. Disasters that occurred in 2009 pointed up the need for a new approach to evacuation. When heavy rainfalls and sediment disasters struck that year, residents were unable to carry out appropriate evacuation procedures, and disaster information was not transmitted properly. To examine all aspects of the evacuation issue, a Committee on Disaster Evacuation was established (decision of the Central Disaster Management Council, April 21. 2010).

4.9.7 Measures for People Requiring Assistance during Disaster

In recent storms and floods, it was observed that most of the victims were elderly people aged 65 years and over. When these disasters occur, many older people are unable to escape by themselves. Establishing a framework through which neighbors can support and assist the elderly and disabled is therefore an issue of vital importance for minimizing injury and loss of life. To guide this process, the Cabinet Office formulated the Guidelines for Evacuation Support of People Requiring Assistance During a Disaster in March 2005. This publication was followed in March 2007 with the preparation of Measures for Supporting Persons Requiring Assistance During a Disaster. a guidebook filled with case studies from recent disasters. The Cabinet Office continues to support municipal governments in producing overall plans (plans outlining policies for providing disaster support to persons requiring assistance).

4.9.8 Disaster Reduction Drills and Exercises

Disaster reduction drills and exercises are good opportunities to review the effectiveness of disaster management systems to ensure quick and appropriate emergency operations, and to enhance public awareness through wide-ranging stakeholders' participation. The Disaster Countermeasures Basic Act stipulates the obligation to conduct disaster reduction drills. In order to promote various drills and exercises nation-wide, the Central Disaster Management Council sets forth an annual Disaster Reduction Drills Plan which stipulates the basic principles for executing the drills and outlines the comprehensive disaster reduction drills carried out by the national and local governments and relevant organizations.

On September 1st, Disaster Reduction Day, wide- area, large-scale disaster reduction drills are conducted in every region across the country in collaboration with disaster related organizations. Additionally, drills based on the experiences of the past disasters are conducted in every region throughout the year. In recent years, practical disaster reduction drill methods such as mapped- put role-playing systems have been introduced, in which participants are not given any information beforehand and are required to make decisions and respond to the situation based upon the information provided after the drill starts.

4.10 Disaster Response:

4.10.1 Outline of Disaster Response

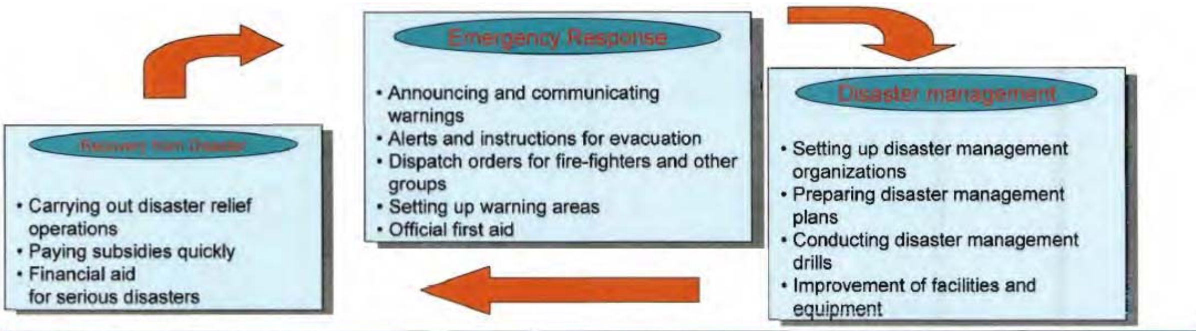
The national and local governments need to quickly collect and share disaster and damage information, and secure communications so that they can carry out effective emergency activities such as search and rescue and medical operations. Based on such information, local governments set up a disaster management headquarters and related organizations establish their own operations mechanism.

The national government collects disaster information at the Cabinet Information Collection Center 24 hours a day. When a large-scale disaster strikes, an emergency team composed of the director generals of the respective ministries and agencies gathers immediately at the Crisis Management Center in the Prime Minister's Office to grasp and analyze the disaster situation, and report the results to the Prime Minister. Inter-ministerial meetings at the ministerial or high-ranking senior-official level are held to decide basic response policies if necessary. According to the level of damage, the government may establish a Headquarters for Major Disaster Management (headed by the Minister of State for Disaster Management) or a Headquarters for Extreme Disaster Management (headed by the Prime Minister). Additionally a government investigation team headed by the Minister of State for Disaster Management may be dispatched, or an onsite response headquarters may be established.

4.10.2 Wide-area Support System

In the case of large-scale disasters that exceed the response capabilities of the affected local government, various Wide-area support mechanisms are mobilized by the National

Police Agency (Inter-prefectural Emergency Rescue Unit), Fire and Disaster Management Agency (Emergency Fire Rescue Team), and Japan Coast Guard. Furthermore, the Self-Defence Forces can be dispatched for emergency response activities upon request from the governor of the affected prefectural government. Also, the disaster medical assistance teams (DMATS) will be dispatched to provide Wide-area medical-transport services. These teams transport severely injured persons via Self-Defence Forces vehicles to hospitals outside the stricken zone.



Local municipality level	Prefecture level	National level
•Making local disaster management plan •Responsible for first response to disasters 1 Setting up disaster management headquarter 2 Release of evacuation alert 3 Mobilization of fire fighting units	· Supporting municipalities` response · Coordination between municipalities` level and national level	•Making basic disaster management plan •National support to local governments •Dispatch of ERT and SDF in a large-scale disaster

Fig-4.8: Emergency Disaster Response.

4.11 Disaster Recovery and Rehabilitation:

4.11.1 Outline of Recovery and Rehabilitation Measures:

In rebuilding and recovering from disasters, the aim is not merely to restore public buildings to their original state. Rather. these efforts encompass a more comprehensive range of measures, including legal, tax-related and budgetary measures. Among other objectives, these measures are taken to create the basic conditions for regional recovery, with greater consideration of safety issues; to effect recovery in disaster-stricken zones in a planned manner; to rebuild disaster victims' ability to live autonomously; to provide disaster victims with shelter; and to effect recovery in the regional economy.

In the case of the Great Hanshin-Awaji Earthquake in 1995, to achieve smooth and rapid reconstruction and recovery from disaster, the Headquarters for Re-construction of the Hanshin-Awaji Area (headed by the Prime Minister) was established, followed by the Inter-Ministerial Committee for Reconstruction of the Hanshin-Awaji Area. In the cases of the Mt. Usu Eruption in 2000 and the Niigata-ken-Chuetsu Earthquake in 2004, inter-ministerial recovery and rehabilitation committees were established. As such, ministries and agencies work together on disaster recovery and rehabilitation, taking into account the opinions of those in the disaster-stricken area.

4.11.2 Disaster Victims Livelihood Recovery Support System

The Disaster Victims Livelihood Recovery Support System is based on the Act on Support for Livelihood Recovery of Disaster Victims. which was enacted in 1998 following the Great Hanshin-Avvaji Earthquake of 1995. Under this system, a “livelihood recovery support payment for disaster victims" is disbursed to persons whose livelihoods are severely damaged by disasters. The purpose of this system is to support victims in recovering their normal lives, bring stability to the lives of residents, and facilitate the quick recovery of disaster-stricken areas.

Specifically, the livelihood recovery support payment for disaster victims is disbursed to households whose homes are completely destroyed in disasters of a certain scale or greater, up to a maximum of three million yen.

4.11.3 Contents of Disaster Recovery and Rehabilitation Measures:

1. **Disaster Recovery Project:** The recovery of damaged public infrastructure facilities, educational facilities, welfare facilities and agricultural, forestry and fishery facilities is either conducted directly by the national government or put into practice by the local government with subsidies from the national government.

2. **Disaster Relief Loans:** Persons engaged in the agriculture, forestry or fishery industries, small and medium enterprises and low-income people Who incurred damage are eligible for a variety of low-interest loans with rather generous conditions as compared to normal ones.

3. **Disaster Compensation and Insurance:** Affected persons engaged in the agriculture, forestry or fishery business can obtain compensation for disaster losses. Earthquake insurance system has been established by the national government.

4. **Tax Reduction or Exemption:** For affected persons, measures are taken for the reduction, exemption and postponed collection of income and residential taxes.

5. **Tax Allocation to Local Governments and Local Bonds:** For affected local governments measures such as delivery of special tax allocations and permission to issue local bonds are taken.

6. **Designation of Extremely Severe Disaster:** When a disaster causes extremely severe damage, it is designated an “extremely severe disaster." Various special measures are to be taken for disaster recovery projects.

7. **Assistance for the Rehabilitation Plan:** Assistance is provided, when necessary, for local government rehabilitation plans, which should be quickly and accurately formulated and implemented.

8. **Support for the Livelihood Recovery of Disaster Victims:** Assistance is provided for victims to support their self-supportion efforts through disaster solatia, money for support of livelihood recovery of disaster victims and loans such as disaster relief funds and livelihood welfare funds.

Chapter-5: Earthquake Prevention Experience in Japan

Japan locates the peripheral part between oceanic plate (Pacific Plate and Philippine Sea Plate) and inland plate. Pacific Plate sinks under inland plate and Philippine Sea Plate at Chishima Trough, Japan Trough and Izu-Ogasawara Trough. Also Philippine Sea Plate sinks under inland plate at south-western trough, Nankai Trough, Suruga Trough and Sagami Trough. This indicates that Japan, locating on the complex crust structure, has more earthquakes comparing with other countries and have much damage from past earthquakes. The earthquakes over 6 minus of earthquake intensity in Japanese scale happened 13 times (25 times when each aftershock was counted from the Hyogoken Nambu Earthquake in 1995 to the Noto Hanto Earthquake in 2007). There are two types of large-scale earthquakes which heavy damages were brought. One is the type that occurs near the boundary of plate, and this is divided into the type occurred between the plates and the type occurred within oceanic plate. The typical example of earthquake occurred between the plates was the Kanto Earthquake in 1923 and the Nankai Earthquake in 1946. This kind of earthquake occurs when the deformation recovers after the deformation with plate's sinking in reaches its limit. Its frequency is generally said every several hundred years. The Tokai, the Tonankai and Nankai Earthquake occurred in near future are predicted as this type. The other type is the one in inland shallow area that strain energy is accumulated by deformation of inland plate resulted from plate's sinking in and the energy is released by the disruption of underground fault. The typical example of this kind of earthquake was the Hyogoken Nambu Earthquake in 1995, the Niigataken Chuetsu Earthquake in 2004, and the Noto Hanto Earthquake in 2007.

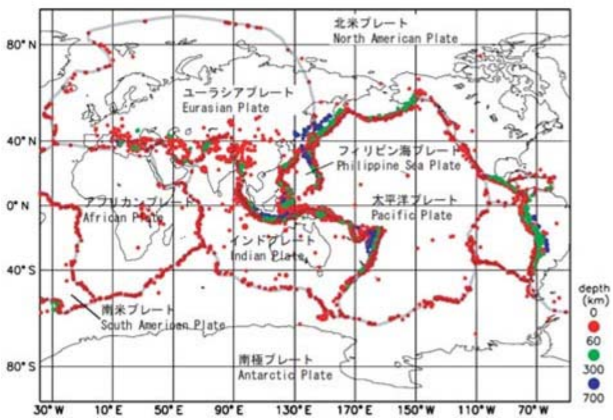


Fig-5.1: Earthquake Focus Distribution Magnitude 6.0 or Greater

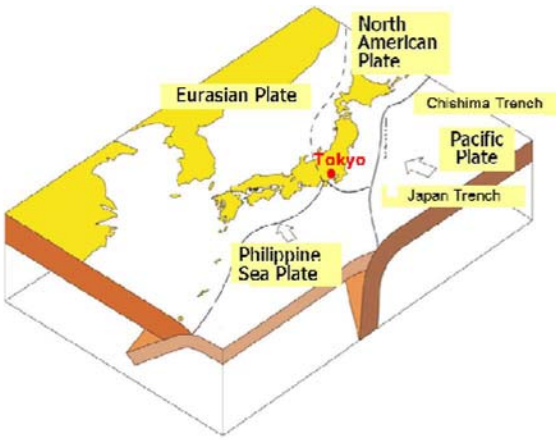


Fig-5.2: Plates around Japan

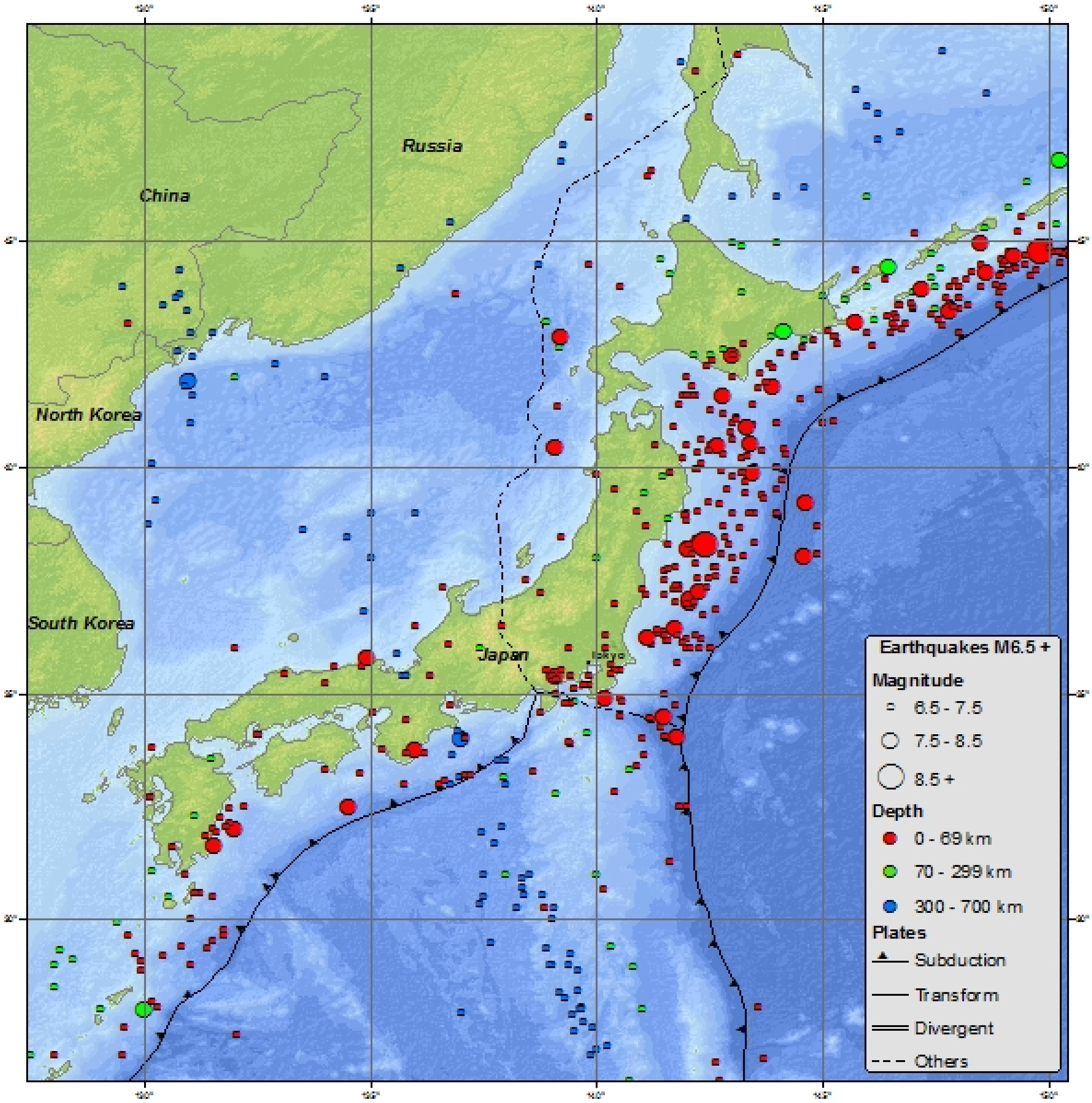


Fig-5.3: Seismicity Map (1900 to 2012) of Japan, *source: USGS.*

5.2 Earthquake Disaster Mitigation Policy in Japan:
5.2.1 Observation system

In order to constantly monitor seismic activity, the Japan Meteorological Agency ((JMA) and other relevant organizations install and maintain seismometers that are used for estimating the location of the epicenter and magnitude of an earthquake as well as for tsunami warnings, and seismic intensity meters that measure the intensity of ground motion, in numerous places nationwide. As soon as an earthquake occurs in or around Japan, the JMA analyzers P-wave at seismometers placed close to the hypocenter. If an earthquake of intensity 5 or greater is forecasted, Earthquake Early Warning (EEW) information is issued. Within about two minutes, it issues a seismic intensity information report for earthquakes of intensity 3 or greater, and within about five minutes issues an earthquake information report indicating the epicenter and magnitude of the earthquake and the seismic intensity in the municipalities where strong shaking was observed.

To monitor earthquakes, JMA operates an earthquake observation network comprised of about 200 seismographs and 600 seismic intensity meters. It also collects data from over 3,600 seismic intensity meters managed by local governments and the National Research Institute for Earth Science and Disaster Prevention (NIED).

When an earthquake occurs, JMA immediately issues information on its hypocenter, magnitude and observed seismic intensity.

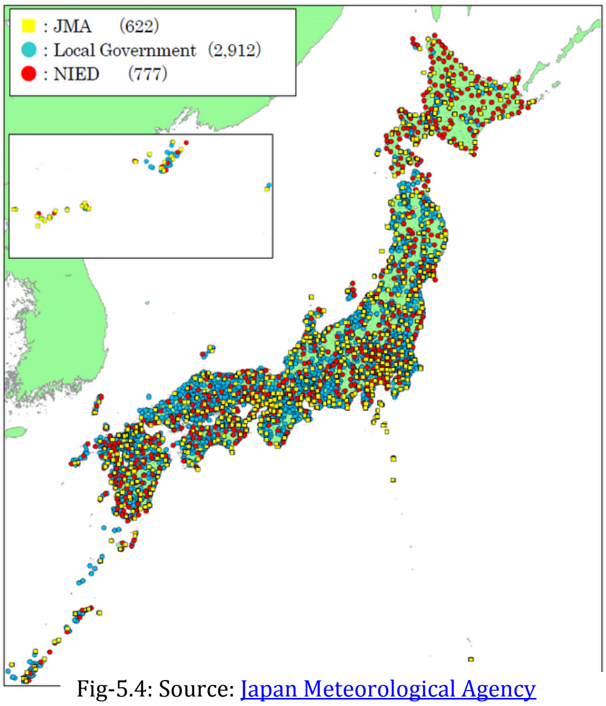


Fig-5.4: Source: Japan Meteorological Agency

(as of January 5, 2012)

5.2.2 Dissemination of Forecast and EW:

In order to prevent and mitigate damage caused by natural disasters and support prompt disaster prevention activities, JMA disseminates weather information and warnings via various channels to government disaster prevention agencies, local governments, the mass media and the public. An outline of EWS in Japan is given in figure 5. For this purpose, the Agency maintains direct communication links with meteorological offices and central/local governments. Strong communication with municipal governments that play direct roles in disaster management and mitigation in affected areas is essential. Such communication is ensured via various channels for information dissemination, such as prefectural governments, NTT (Nippon Telegraph and Telephone Corporation), J-ALERT (an instant information broadcasting system introduced by the Fire and Disaster Management Agency (FDMA) and the Internet. To support prompt disaster mitigation activities by local governments, the Agency has introduced a new information provision system called the Information Network for Disaster Prevention (INDiP), which enables effective and rapid dissemination of data in both text and graphic form. INDiP connects disaster prevention agencies and local governments with JMA headquarters via the Internet and provides detailed weather information and warnings tailored to individual municipalities. Information for maritime users is transmitted via the JMH radio facsimile broadcast service operated by JMA and fishery radio communications services. Such information is also disseminated within the framework of the

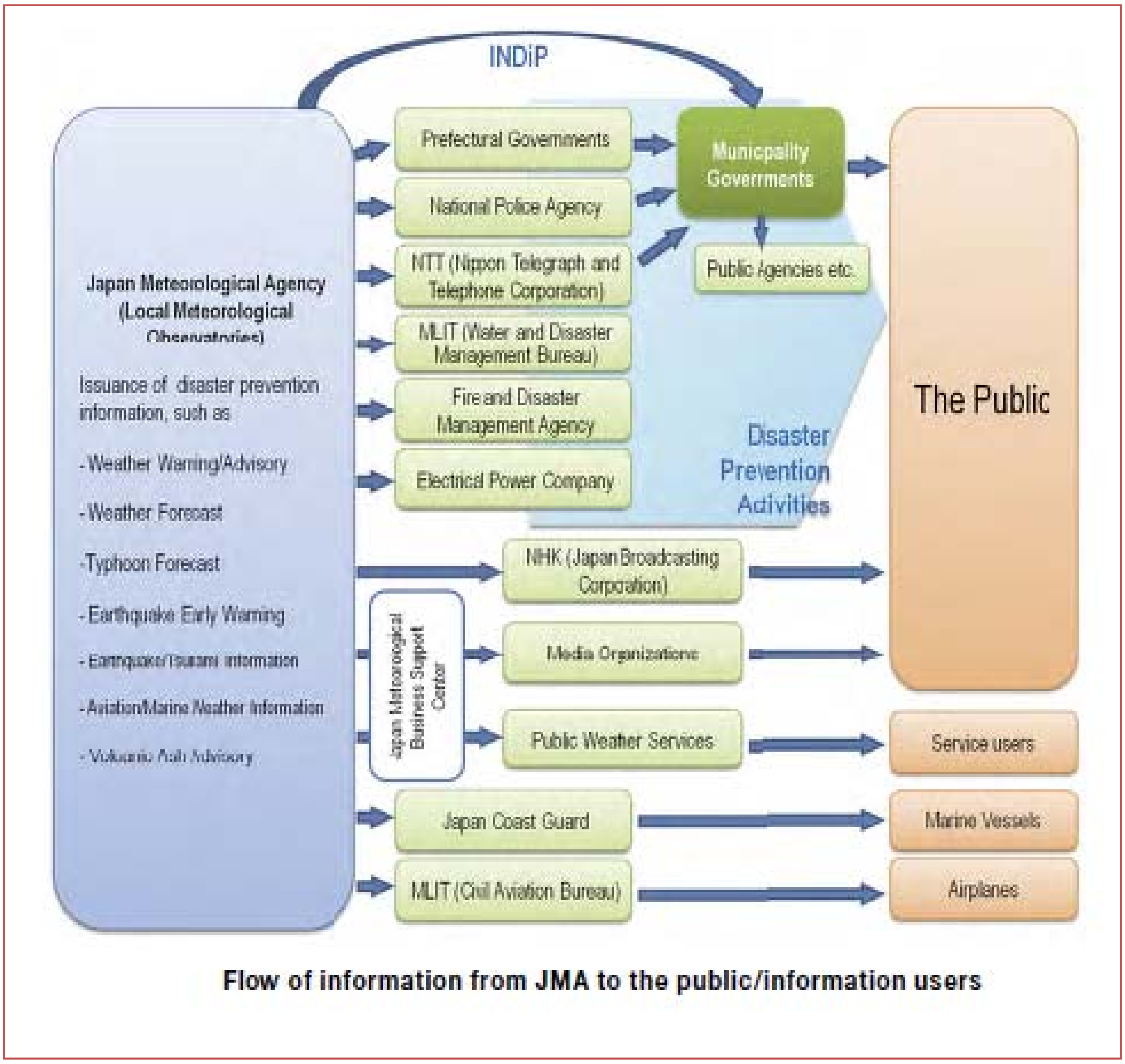


Figure 5.5: INDiP Network (Source: JMA)

Global Maritime Distress and Safety System (GMDSS), i.e. via the NAVTEX broadcast service of the Japan Coast Guard for seas in the vicinity of Japan, and via the Safety-Net broadcast service for ships in the high seas via the maritime satellite INMARSAT. Nowadays, the Internet plays a vital role for JMA in the public dissemination of a wide range of meteorological information not only on forecasts but also on historical and current observation data.

J-Alert System - J-Alert is the system to immediately transmit emergency information such as Emergency Earthquake information, tsunami warning, information of ballistic missiles, which people have no enough time to deal with, is transmitted to the municipalities by using satellite (via the Fire and Disaster Management Agency, the Cabinet Secretariat, and JMA). It became operational on 09 February 2007 and on 01 October 2007 started sending the emergency earthquake information. As of first March 2010, 344 municipalities have introduced this system. Among them, automatic activation system of radio broadcasting and community FM has been introduced to 282 municipalities. The J-Alert framework has been given in figure 5.6.

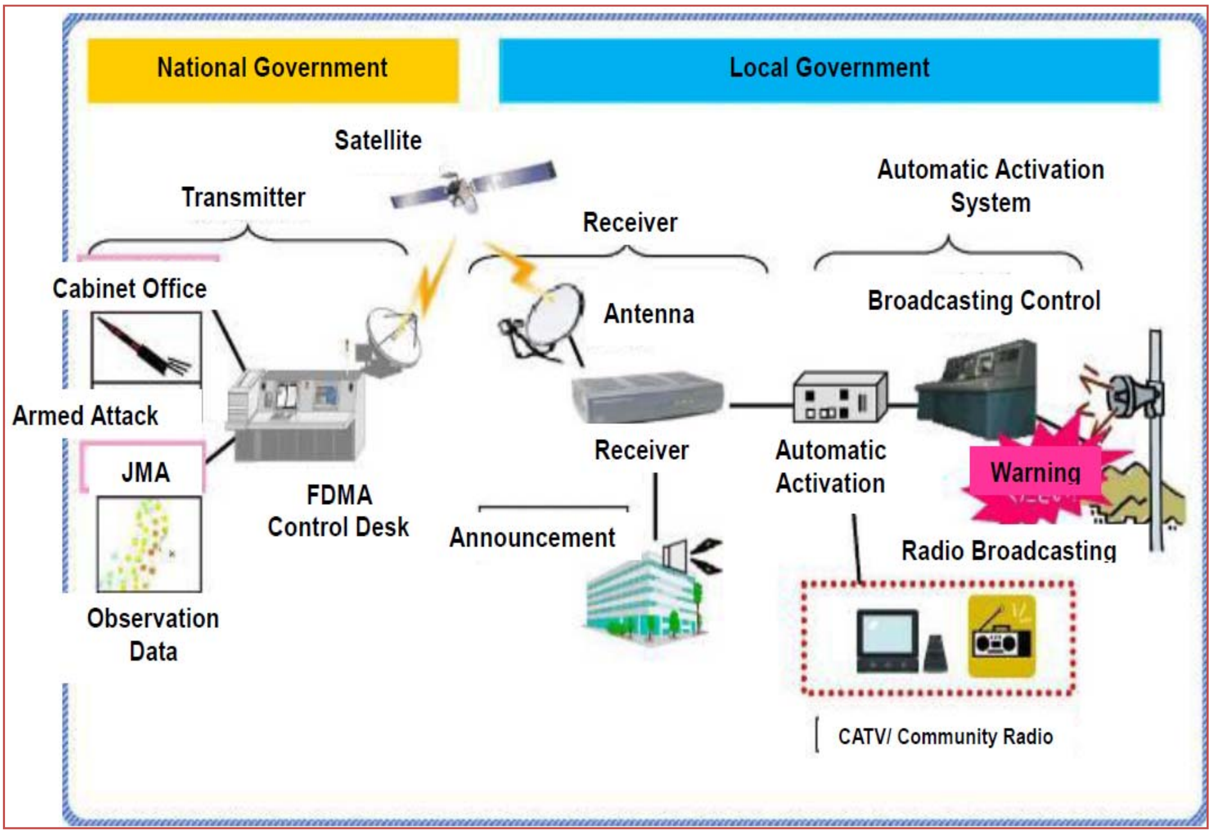
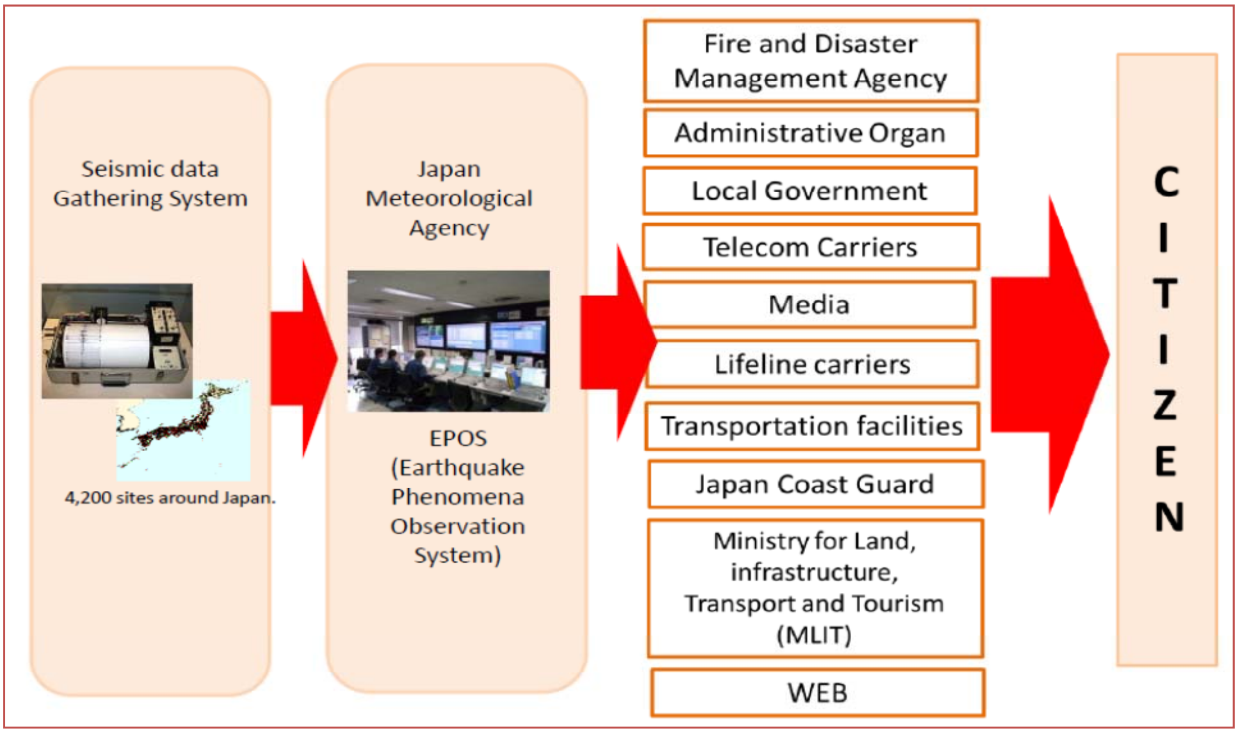


Figure-5.6: Framework of J-Alert System, source:JMA

5.2.3 Utilization of Earthquake Early Warning Information

Earthquake Early Warning (EEW) information announces the estimated hypocenter and magnitude of an earthquake as well as the estimated arrival time of the S-wave of the earthquake and seismic intensity in each area. This information is made possible by detecting the P-wave near the epicenter and immediately processing the data since there is a difference in the speed of the P-wave, which arrives faster, and the S-wave, which arrives later and causes more severely destructive phenomena. In the case of a large-scale ocean trench-type earthquake, there may be a time lag (several seconds to several tens of seconds) between the issuance of the EEW information and the start of severe shaking (when the S-wave arrives). This can be a critical time to be used for mitigating damage by stopping trains and elevators, extinguishing flames or crawling under tables. Research and development has been promoted by the JMA in cooperation with related organizations, and the provision of the EEW information to specific entities such as railway companies began in 2006. Earthquake or tsunami warnings are instantly delivered to central & local governments, broadcasters, telecom carriers. After receiving this warning, local government delivers alarm through their sirens or microphones. The flow of information in EEWS has been given in figure 5.7 and use of this alert by train services in figure 5.10.

Figure-5.7: Outline of Earthquake Early warning Information (Source: MIC, Japan)



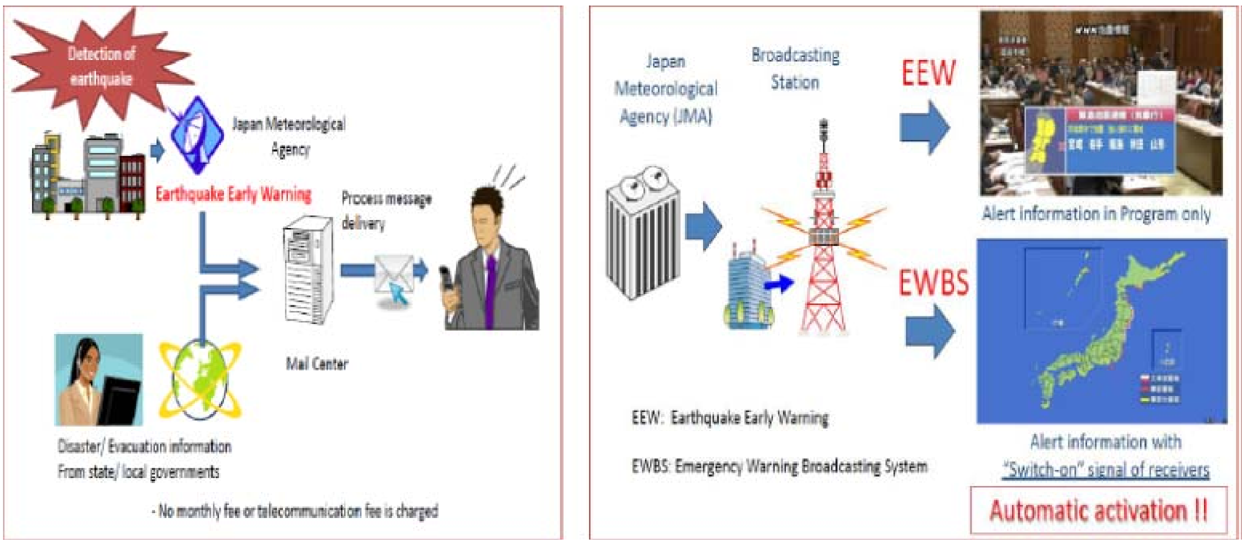


Figure-5.8: An outline of Earthquake Early warning Information to community (Source: MIC, Japan)

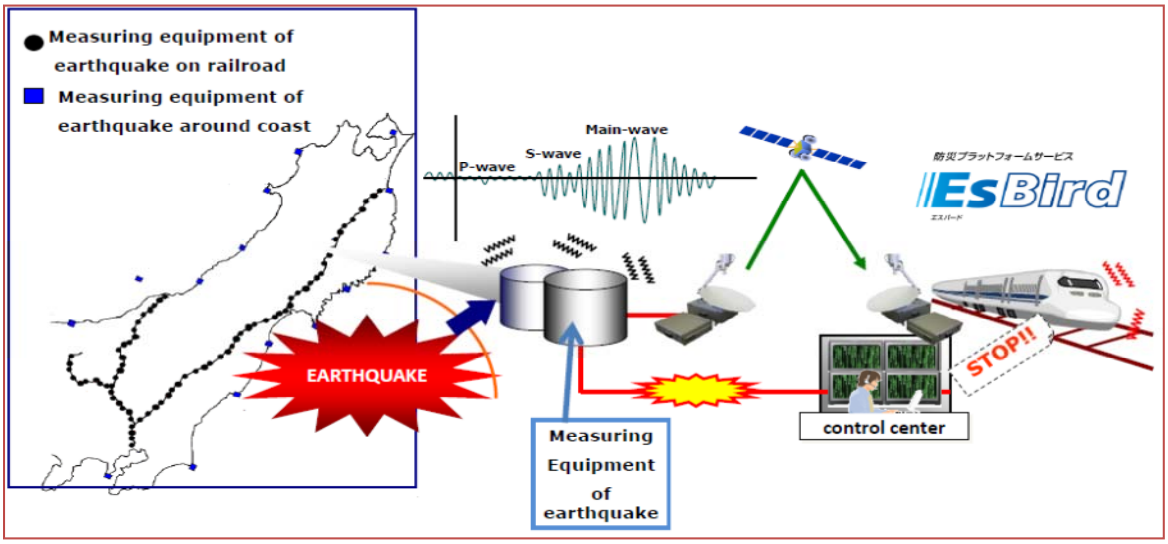


Figure 5.10: An outline of Earthquake Early warning Information used to stop high speed trains (Source: MIC, Japan)

5.3 Countermeasures against Large-scale Earthquakes:

It has been pointed out with a great sense of urgency that Japan can be struck by large-scale earthquakes in the next few decades, in areas such as Tokai, Tonankai, Nankai, the Japan and Chishima Trenches, and directly below Tokyo and the Chubu and Kinki regions. Regarding trench-type earthquakes, based on the related laws and regulations, appropriate actions where various countermeasures need to be strengthened, the reinforcement of observation systems, and the formulation of a plan of action by relevant government organizations and private corporations. In addition, preparations such as improvements in evacuation sites and firefighting facilities are being promoted based on laws specifying special financial measures. With regard to each large-scale earthquake, including the Tokyo Inland Earthquake, the Central Disaster Management Council has conducted examinations to clarify the characteristics of the earthquake, estimate the damage and identify necessary countermeasures. The following set of plans and strategies for each large-scale earthquake are now being developed: the “Policy Framework,” a master plan that includes a range of activities from preventive measures to post-disaster response and recovery; the “Earthquake Disaster Reduction Strategy, ”to determine an overarching goal of damage mitigation and strategic targets based on the damage estimation; and the “Guidelines for Emergency Response Activities,” which describes the actions to be taken by related organizations. It is necessary to keep working on countermeasures nationwide, as has been witnessed by the examples of the major earthquakes of Hanshin-Awaji and Niigata-ken-Chuetsu, because such a disaster can occur anywhere in Japan. Committee on Earthquake Disaster Reduction in Local Cities is examining possible countermeasures.

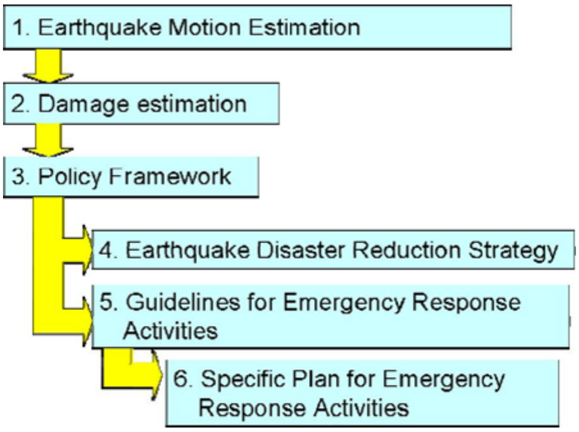


Fig-5.11: Flowchart of Formulation of Countermeasures against Large-scale Earthquakes

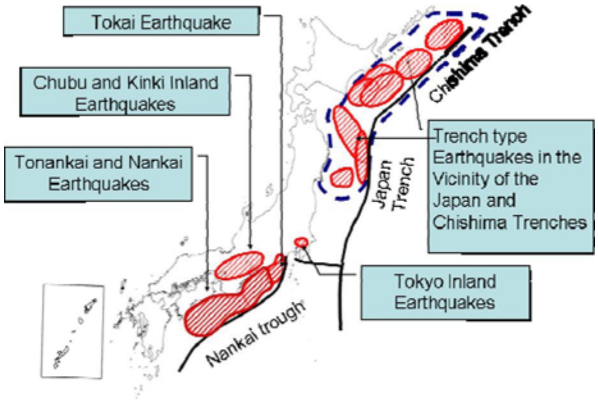


Fig-5.12: Large-scale Earthquakes

Countermeasures against disasters in Japan can be broadly classified into;

a. research into the scientific and technical aspects of disaster prevention;
b. the reinforcement of the disaster prevention system, its facilities and equipment, and other preventive measures;
c. construction projects designed to enhance the country's ability to defend against disasters;
d. emergency measures and recovery operations and
e. the improvement of information and communication systems.

5.3.1 Countermeasures against Tokyo Inland Earthquakes: A case study

It is believed that in the capital area (Tokyo), massive trench-type earthquakes with a magnitude of 8 or greater, like the Great Kanto Earthquake (1923), will occur at intervals of 200-300 years. Additionally, it is presumed that several Tokyo Inland Earthquakes of M7 scale will occur before a M8 scale earthquake, and the imminent possibility of such an event in the first half of this century has been pointed out.

Many types of Tokyo Inland Earthquakes are assumed due to various possible epicenters and the complicated mechanism of the occurrence. The Central Disaster Management Council has carried out damage estimations for 18 types of Tokyo Inland Earthquakes, and assumed extensive damage including a death toll of approximately 11,000 people, total collapse of 85,000 buildings and a maximum economic loss of 112 trillion yen in the earthquake with an epicenter in the northern part of Tokyo Bay (assumed scale of M7.3).

In 2005, the Council established the Policy Framework for Tokyo Inland Earthquakes, with the main items being to secure the continuity of the capital functions and countermeasures to reduce massive damage. In 2010, this policy framework was revised to include specific

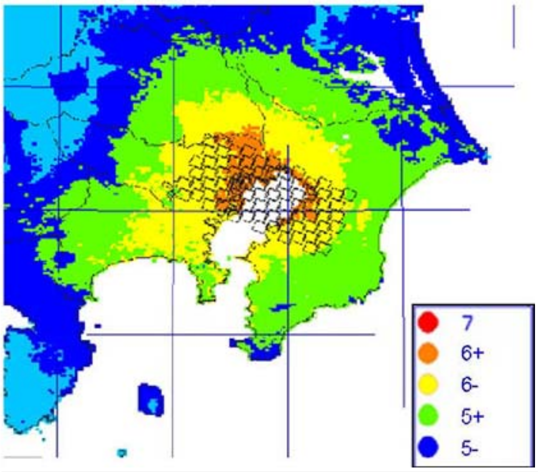


Fig-5.13: Seismic Intensity Tokyo Inland Earthquake

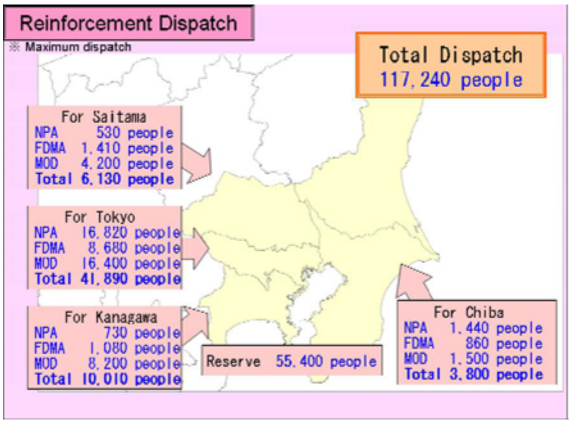
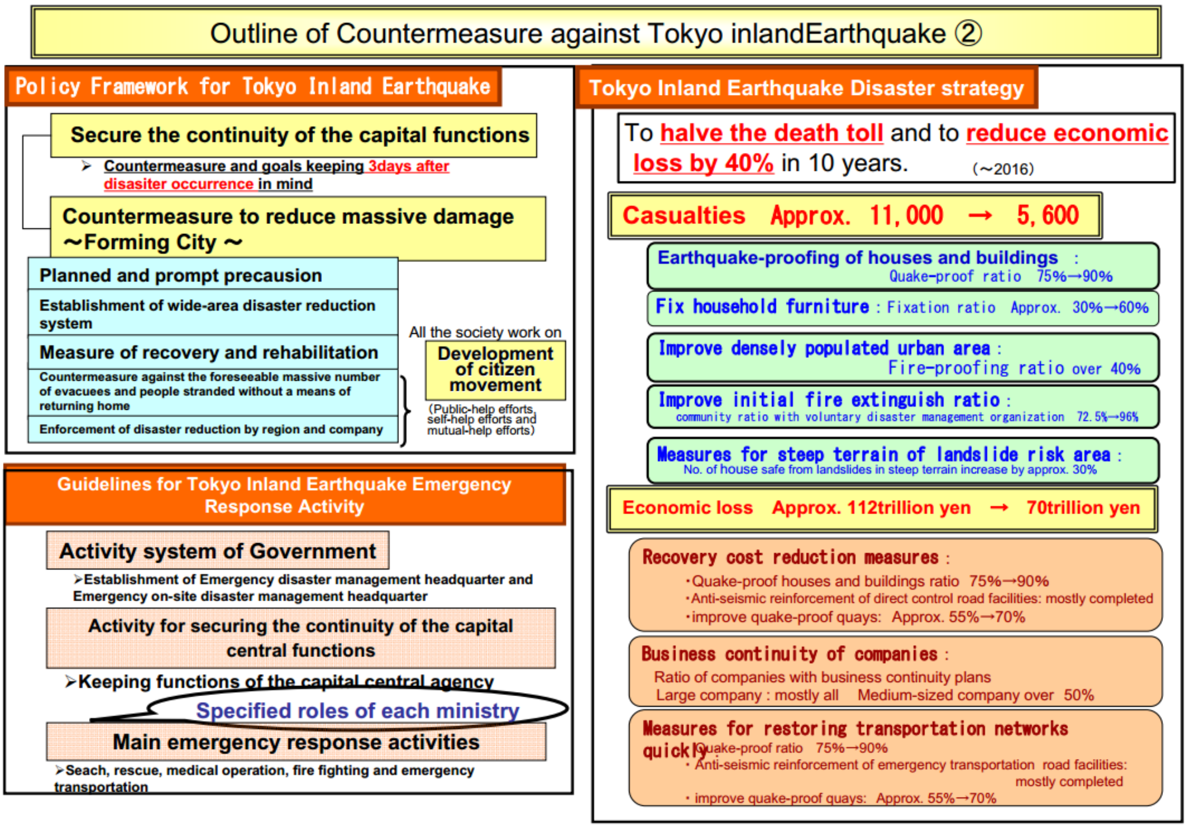


Fig-5.14: Reinforcement Dispatch Plan

measures to handle large numbers of evacuees or travelers unable to return to their homes. Additionally, in 2006, the council drafted the Tokyo Inland Earthquake Disaster Reduction Strategy, with general goals of halving the death toll and reducing the economic loss by 40%, as well as strategic goals such as increasing the proportion of earthquake-resistant houses and buildings to 90% of total housing stock and increasing the fixed furniture rate to 60% within 10 years.

Fig-5.15: Source: Book of disaster management in Japan



That same year, the Council also drafted the Guidelines for Tokyo Inland Earthquake Emergency Response Activities. Plans specifying specific activities were then drawn up on the basis of these guidelines.

5.4 Earthquake Disaster Management Strategy:

In March 2005, disaster mitigation objectives were determined. These set forth specific objectives, including timeframe, regarding the mitigation of human and economic damage from a large-scale earthquake. An earthquake disaster management strategy was then formulated that presents in ordered form those items that should be addressed selectively and strategically in order to meet the mitigation objectives.

The earthquake disaster management strategies formulated on that occasion have to do with the Tokai Earthquake and the Tonankai and Nankai Earthquakes. In every case, they set disaster mitigation objectives that call for reducing fatalities and economic damage by one half in the coming decade. They also set specific objectives by which to achieve that goal, such as aiming for a rate of earthquake proofing of 90% for residences, and drawing up tsunami hazard maps for all coastal municipalities. Disaster mitigation objectives of this kind are not only for the national government, but are meant to be shared by society at large, including local governments, related organizations, and local residents. The local governments concerned have therefore been requested to formulate their own regional objectives in light of the earthquake disaster management strategy. Follow-up surveys will be conducted at three-year intervals to check on the status of progress. There are plans to formulate earthquake disaster management strategies in stages for other large-scale earthquakes, as well, including major earthquakes centered in Tokyo.

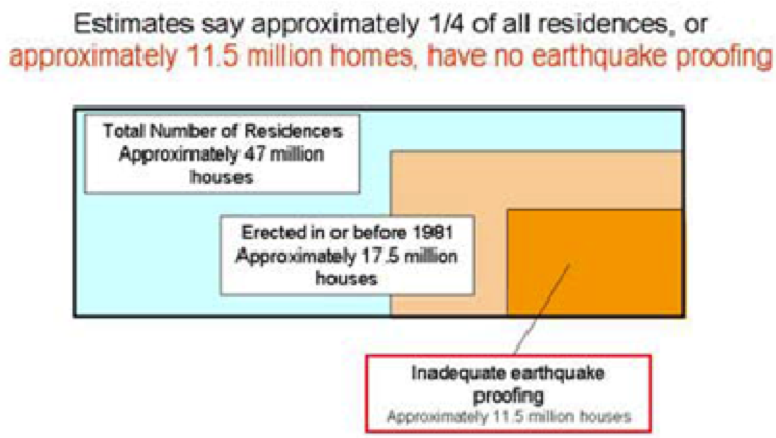
Like the Niigata Chuetsu Earthquake, earthquakes could occur anywhere in Japan. Consequently, local governments should make provisions for earthquakes other than the large-scale kind addressed by the earthquake disaster management strategy. They are being required to come up with damage scenarios in light of their regional characteristics, formulate disaster mitigation objectives accordingly, and promote effective and efficient earthquake countermeasures.

5.4.1 Earthquake-proofing of Houses, Buildings and Infrastructures

Approximately 80% of the people who died in the Great Hanshin-Awaji Earthquake were suffocated or crushed when they were trapped in collapsing homes and other buildings. The standards for earthquake proofing of buildings today were revised in 1981 in light of experience from the Miyagi-Ken Oki Earthquake of 1978, and the majority of buildings that collapsed during the Great Hanshin-Awaji Earthquake predated the 1981 standards. In 1995, therefore, the Act for Promotion of the Earthquake Proof Retrofit of Buildings was enacted to promote earthquake proof reinforcement of existing buildings. (Subsequent progress in earthquake proof retrofitting was inadequate, and this law was amended to better promote such retrofitting in a special Diet session in 2005.)

The current state of earthquake proofing of buildings in Japan is estimated as follows: Approximately 25% of residences (approximately 11.5 million out of some 47 million houses) are thought to have inadequate earthquake proofing, while the corresponding figure for buildings other than residences is approximately 35% (approximately 1.2 million out of 3.4 million buildings).

Figure-5.16: Number of Residents Urgently Requiring Earthquake Proofing



1998 Housing and Land Statistical Survey (Management and Coordination Agency), Ministry of Land, Infrastructure and Transport estimates

To raise the rate of earthquake proofing of residences, individual homeowners must be made more aware of preparation for earthquakes, and their houses must be evaluated for earthquake resistance. Efforts must also be made at the regional level to promote earthquake proofing of residences as part of urban planning efforts to make towns and cities safer in disasters.

Meanwhile, procedures such as evaluation for earthquake resistance, earthquake proof retrofitting, and rebuilding impose a commensurate financial burden. The national government has therefore sought to promote those activities by making active use of subsidy systems, financing systems, and so on. A tax plan to encourage earthquake proof retrofitting is slated to be created in fiscal 2006.

It will be necessary to undertake these various approaches in combination. They include, for instance, the widespread awareness and use of hazard maps, the development of techniques that allow people to do earthquake proof retrofitting of their residences while living in them, the development of low-cost earthquake proof retrofitting methods, and the creation of arrangements to heighten the asset value of safe buildings by explaining their earthquake proof quality at the time of sale. Damage to buildings is the principal cause of fatalities. It is also a causal factor in the outbreak of fires, the spread of fires, the creation of evacuees, the obstruction of rescue activities, the creation of rubble, and other forms of extended damage. The national and local governments should work together and with local

residents on earthquake-proofing buildings in a selective and focused manner. This would be the most valuable earthquake countermeasure we could take at this time.
In view of this situation, the Central Disaster Management Council drafted the “Urgent Countermeasures Guideline for Promoting the Earthquake-resistant construction of Houses and Buildings” in 2005, which stipulates that earthquake-resistant construction throughout the country should be urgently and strongly enforced in close cooperation with related ministries as a national priority.

In line with this, the Act on Promotion of the Earthquake-proof Retrofit of Buildings was amended to strengthen measures such as the development of a promotion plan for improving earthquake-resistant construction by local governments. Additionally, the subsidy system that provides financial support to promote earthquake-resistance diagnosis and retrofit has been expanded, and tax reduction measures to promote earthquake-resistant retrofit of residences and commercial buildings have been established.

The Cabinet Office has released the “Map of Weak Subsurface Layers Nationwide,” indicating weakness against earthquake tremors in 1km2 blocks throughout Japan. It has also summarized a method for each municipality to produce an “Earthquake Disaster Hazard Map” that indicates subsurface layer weakness in 50m2 blocks and the danger of building collapse, and is working on disseminating this method.

Hyogo Earthquake Engineering Research Center:

Construction of this facility began in 1999 and will be completed in 2005. Therefore, this facility will begin to make its contribution ten years after the Hyogoken Nanbu (Kobe) Earthquake.

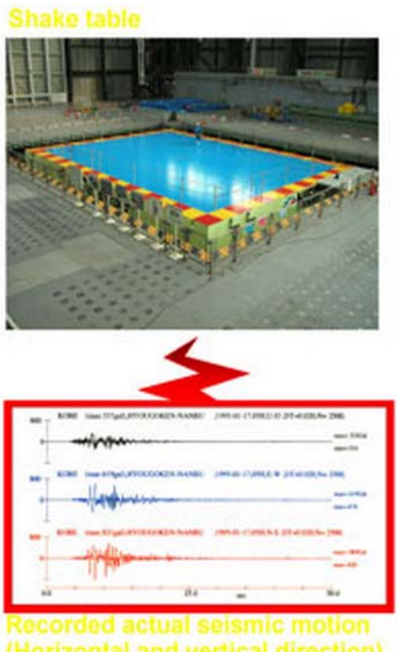


Table Size	20m x 15m	
Payload	12MN(1200tonf)	
Driving Type	Accumulator Charged/Electro-Hydraulic Servo Control	
Shaking Direction	X, Y - Horizontal	Z - Vertical
Max. Acceleration (at Max. Loading)	900cm/s²	1500cm/s²
Max. Velocity	200cm/s	70cm/s
Max. Displacement	±100cm	±70cm
Max. Allowable Moment	Overturning : 150MN-m	Yawing : 40MN-m

The world's largest shaking table, which can simulate high level ground motions, is taking shape in Japan. The opportunities and challenges provided through this facility are great. It will be a focus of full-scale testing of structures due to high-intensity earthquakes.

Emergency Response and Communication System of Osaka Gas Engineering Co. Ltd., Japan

Osaka Gas Engineering Co. Ltd. supplies gas in Kansai region of Japan which comprises of six prefectures namely Hyogo, Osaka, Kyoto, Nara, Wakayama and Shiga consisting of 6.3 million households/customers. The company ensures safety in areas heavily damaged by earthquakes by stopping city gas supply. The intelligent gas meters installed at each customer's location automatically shut off at 200 (gal). Furthermore, low pressure gas supply is automatically shut off in earthquakes capable of damaging pipelines and structures by an automatic shut-off system installed at medium pressure governor B. Moreover, in extreme cases (widespread damage), city gas supply can be shut off remotely from the Central Control Center and Back-Up Center. A diagrammatic presentation of the emergency shut off system is given in the figure 5.17.

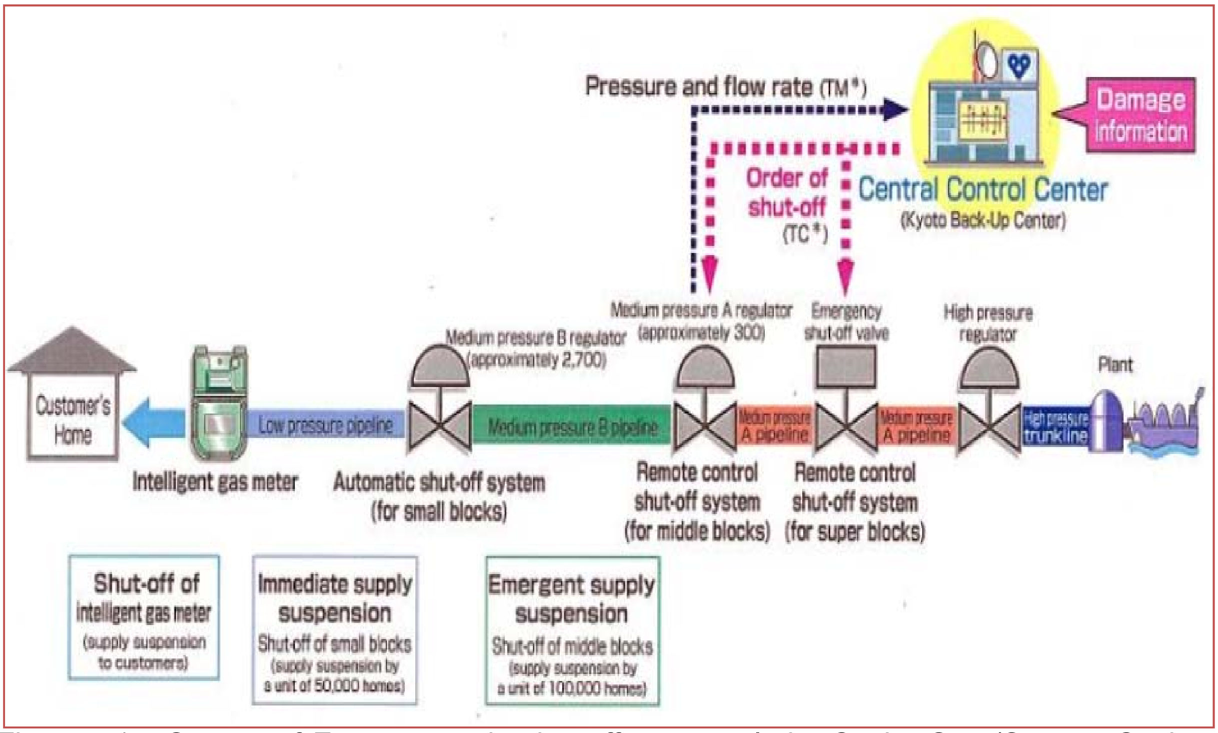


Figure-5.17: System of Emergency shutting off gas supply by Osaka Gas (Source: Osaka Gas Co. Ltd.)

In-house radio network - In order to smoothly produce and supply city gas, Osaka Gas remotely monitors and controls city gas supply 24-hours a day. Because around-the-clock operation is necessary as much in an earthquake as on a regular basis, Osaka Gas introduced a radio network that works by radio waves and satellite. System of radio network operated by the company is given in the figure 5.18.

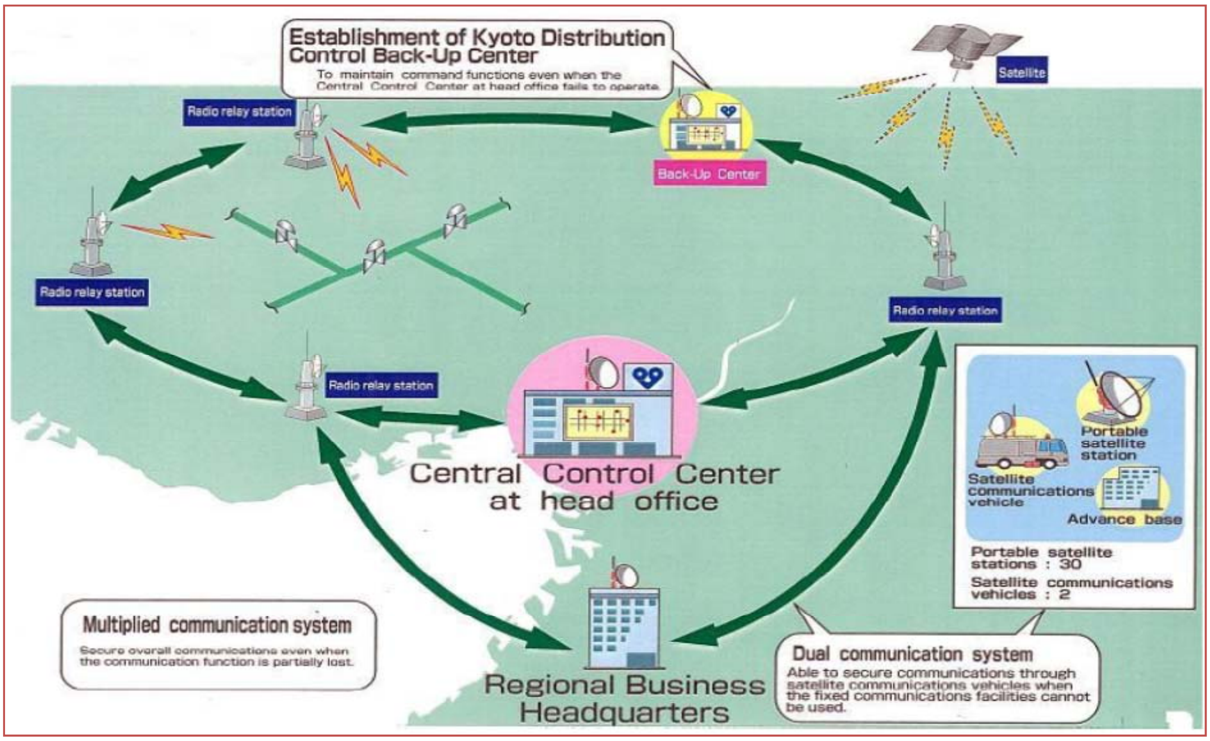


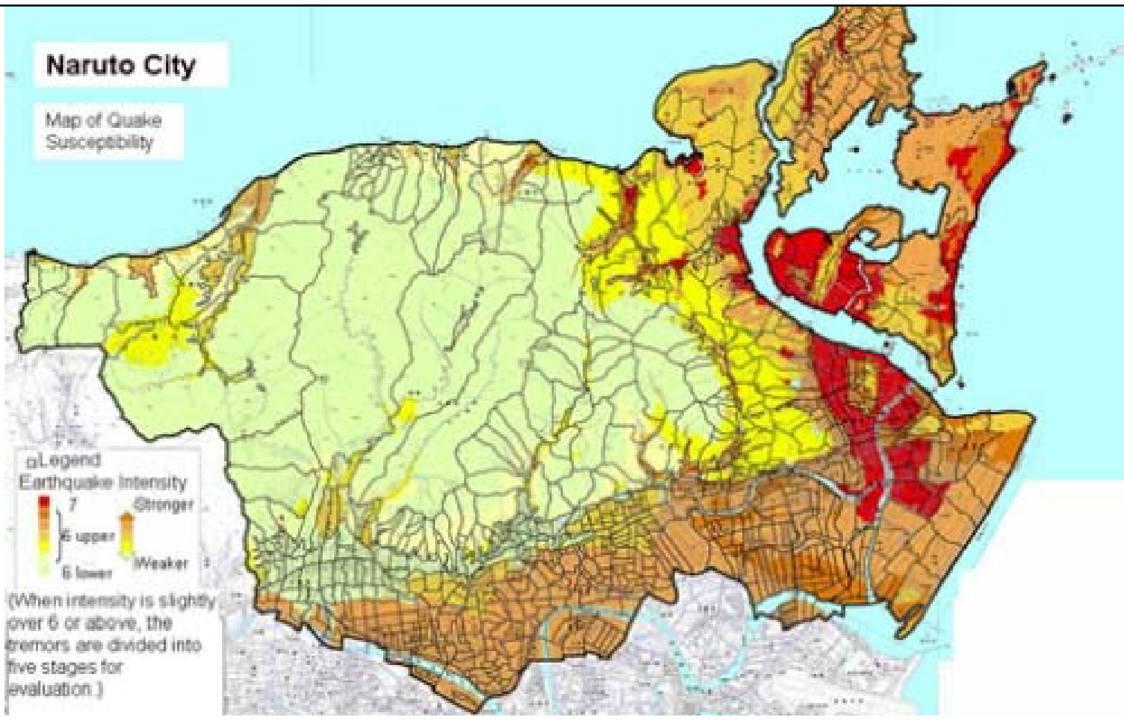
Figure-5.18: Radio Communication System of Osaka Gas (Source: Osaka Gas)

5.4.2 Utilization Hazard Maps To Promote The Earthquake-Proofing Of Buildings:

One means of informing local residents about the risks of earthquakes that could occur is to use maps that project damage scenarios by locality. It is important for people to know what areas face greater risks of casualties due to building collapse, or what areas are expected to be more liable to damage from spreading fires. These maps are an effective means for making people aware of such factors.

Examples of the creation of earthquake hazard maps at the local government level include the cities of Tokyo and Yokohama. The creation of hazard maps has occasioned progress in earthquake proofing in Yokohama, which has a good record of performance in this regard. National and local governments can create and publicize earthquake disaster prevention maps that are detailed enough to allow people to identify individual neighborhoods. This is one means of raising awareness of disaster management among residential and other property owners, and it is an effective method to make the public better understand for the necessity of earthquake-proofing. The Cabinet Office is therefore creating a manual instructing people how to make earthquake disaster prevention maps that show the risk of building collapse in familiar locations close to home.

Figure-5.19: Example of Earthquake Disaster Management Map (Naruto City, Tokushima Prefecture)

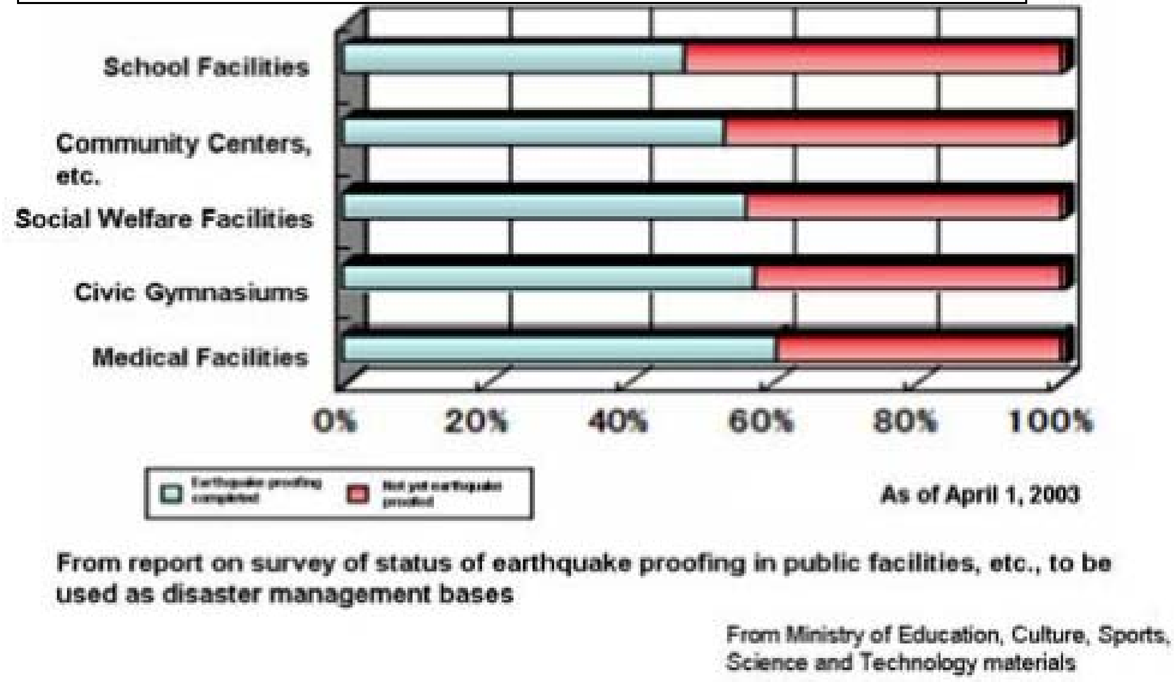


5.4.3 Earthquake-proofing of disaster management bases (schools and other institutions) and key infrastructure:

A survey by the Ministry of Education, Culture, Sports, Science and Technology showed that approximately 68,000 of the some 130,000 non-wooden buildings at public elementary and lower secondary schools throughout Japan had been confirmed earthquake resistant. That amounts to no more than approximately 52% (as of April 2005). School facilities are expected not only to assure the safety of children and other people when disaster strikes, but also to serve as emergency evacuation sites for local residents. As a matter of earthquake disaster management and countermeasures, therefore, it is particularly important that these buildings be earthquake resistant.

Also an urgent issue is the earthquake proofing of certain key buildings and infrastructure. Hospital facilities, for example, must hold inpatients and other people with special needs, and also provide treatment for people who are injured in a disaster. Government offices, local government facilities, and other public facilities must serve as centers for emergency activity (Figure 11). The earthquake proofing of roads, airports, harbors, and other such critical infrastructure must also be facilitated.

Figure-5.20: Status of Earthquake Proof Reinforcement of Public Facilities

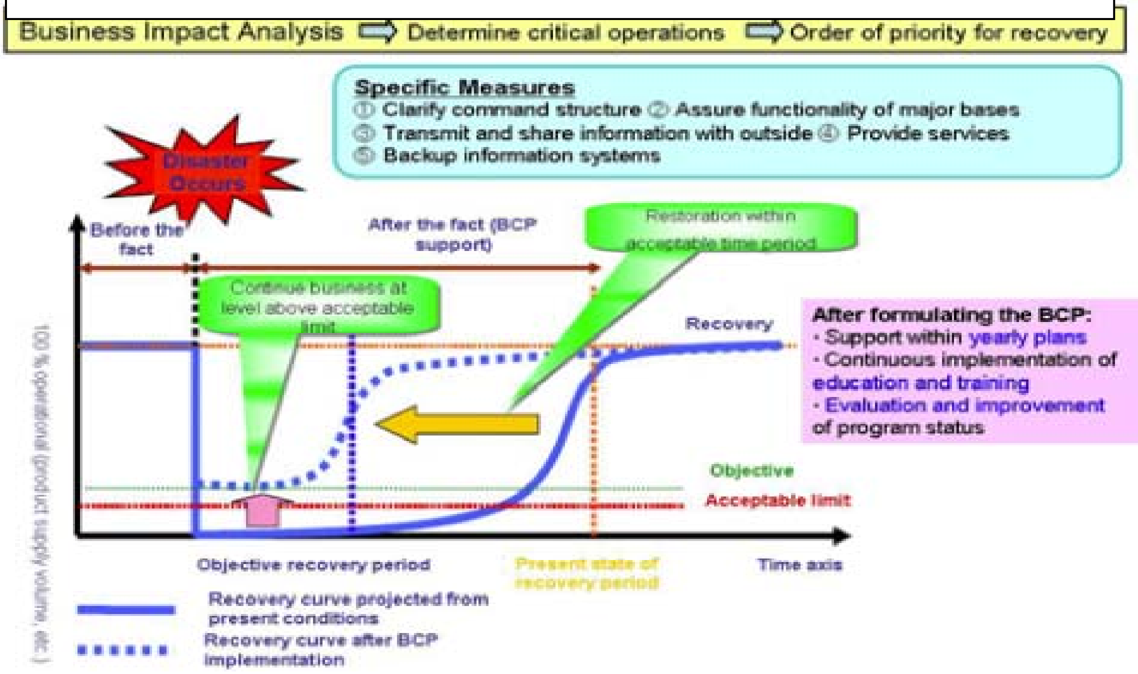


5.4.4 Business continuity plans for companies

Measures for disaster management by companies are also essential in order to mitigate damage. If companies are able to carry on their own business when disaster strikes, so that they keep up employment in the affected area and maintain the supply chain from procurement of raw materials through to marketing, then their activities will tend to mitigate the damage to the regional economy and society.

For this reason, guidelines to support companies in formulating business continuity plans (BCP) were compiled in August 2005 (Figure 12). Business continuity measures for a company should be seen essentially as a management strategy for protection of that company. It provides for the continuation of important operations to the maximum extent possible during a disaster, and for prompt recovery of the company's level of operation. It also protects against the loss of clients and business to competing companies while operation is suspended, the decrease of market share, and the decline in the company's reputation. Specific measures include preparing backup computer systems, securing reserve office space, assuring the ready availability of key personnel, and so on. These are all typical approaches. In Europe and America, companies that prepare for possible disaster in a systematic, organized manner have gradually come to be highly appreciated by their business connections and by the market.

Figure-5.21: Business Continuity Plan (BCP)



Certain business continuity measures require particularly urgent facilitation. These are measures to address a major earthquake centered in Tokyo, which is envisioned to cause economic damage amounting to approximately 112 trillion yen. That would be 1.4 times the national budget. Japan's core economic functions are to a very high degree centered in metropolitan Tokyo, and if such a disaster were to occur there, the impact would not be limited just to those areas directly affected by the earthquake. The wider effects are likely to extend throughout the country, and even overseas. In the context of advancing economic globalization, and in the interest of increasing confidence in Japan's security, among other reasons, the public and private sectors must act together on measures that would hold such effects to the minimum.

5.4.5 Improvement of evacuation areas

Recent disasters in general, not limited to earthquakes or storms and floods alone, have found the majority of victims among elderly people, the disabled, foreigners, and other such people with special needs. Indeed, consideration for these people with special needs has become an important issue in disaster management. Plans have therefore been made to improve support systems in a variety of ways, including efforts to ascertain where people with special needs can be found under normal conditions and to formulate individual Evacuation Support Plans for people with special needs.

It would be desirable to improve systems intended to prevent and ameliorate problems for people living as evacuees. This would include, for example, the early detection of any deterioration of vital functions among evacuees, and particularly of inactive life diseases (disuse syndrome). It would also be desirable to study schools and other evacuation facilities under normal conditions in light of actions that will enable their smooth operation as evacuation sites when disasters do occur. Measures should be taken, for instance, to promote the stockpiling not only of food, heating equipment, fuel, and so on, but also of partitions to allow privacy among evacuees, portable toilets, eating utensils, and other such goods that will effectively help evacuees to maintain healthy lives.

Settlements in hilly and mountainous areas and at coastal locations that are likely to become isolated are required to build up stockpiles on an appropriate scale. These should include water, food, and other everyday goods, medical supplies, portable toilets, fuel for emergency generators, and so on. Power sources that can supply electricity within each settlement will be studied for feasibility, to include solar power generation and wind power generation. It will be necessary to study how essential services may be provided, according to the circumstances, not on a network model but rather by the use of propane gas, joint septic tanks, and so on, and even by the improvement of independent facilities for each household.

5.4.6 Effects of long-period seismic waves on structures:

Ocean trench earthquakes and other such enormous earthquakes have very large source regions. For this and other reasons, the movement of such an earthquake tends to include many seismic wave components with a rather long period of 2–20 seconds that cause buildings to sway slowly.

In a basin like the Kanto Plain that is covered by a thick layer of sedimentary deposits, these long-period seismic waves form as surface waves. Depending on the soil structure, the amplitude of the waves may grow even larger and their duration may also become longer.

Studies and research must therefore be conducted regarding the effects on structures, and especially on high-rise buildings and other large structures, of these long-period seismic waves, which are still not adequately understood. The necessity for new countermeasures also requires study. Concrete studies of these matters are presently being carried on in coordination with the Japan Society of Civil Engineers and the Architectural Institute of Japan.

Chapter-6: A Comparative Study of Earthquake Management System between Japan and Bangladesh

No.	Parameters of Comparison	Japan	Bangladesh
1	**Legal Frameworks**	**Act & Laws related to:** - Disaster Countermeasures Basic Act - Disaster Prevention and Preparedness - Disaster Emergency Response - Disaster Recovery and Reconstruction **Disaster Management Planning:** - Basic Disaster Management Plan - Disaster Management Operation - Local Disaster Management Plan	- Disaster Management Act - National Plan for Disaster Management - Standing Order on Disasters (SOD)
2	**Institutional Frameworks**	**Central Disaster Management Council comprises with:** - 23 Govt. ministries and agencies - 63 designated public cooperation including independent administrative agencies, Bank of Japan, Japanese Red Cross Society, NHK, electricity and gas companies and NTT. **Prefectural Disaster Management Council:** - Designed government organization and public corporations in Prefecture level. **Municipal Disaster Management Council:** - Designed government organization and public corporations in the local City, town and village level.	**National Disaster Management Council (NDMC):** Headed by Prime Minister with 15 ministries and armed forces. **Inter-Ministerial Disaster Management Co-ordination Committee (IMDMCC):** 31 ministries and Govt. agencies. **District Disaster Management Committee:** With district level all govt. and local govt. organizations. **Disaster Management Committees** in the Upazilla, Union, City Corporation, Paurashava and Village level comprises with respective govt. and non-govt. organizations.
3	**Earthquake Observations**	▪ **To monitor earthquakes, JMA operates** an earthquake observation network with 200 seismographs and 600 seismic intensity meters. It also collects data from over 3,600 seismic intensity meters managed by local governments and the National Research Institute for Earth Science and Disaster Prevention (NIED). ▪ **Estimation of Earthquake P-Wave and S-Wave.**	**No system for earthquake observation**
4	**Early Warning**	**According to the Meteorological Services Act:** Japan Meteorological Agency (JMA) issues EEW information to mitigate the damage by stopping trains and elevators, extinguishing flames or crawling under tables and get opportunity to take immediate safety measures by people. ▪ **Introduction of J-Alert System.** ▪ **Earthquake of intensity 5 or greater is disseminated by Forecast and EW by JMA.**	**No system for Early warning**
5	**Information &**	▪ **When an earthquake occurs**: JMA	**After shock, Bangladesh**

	Communications	immediately issues information on its hypocenter, magnitude and observed seismic intensity. ▪ JMA maintains direct communication links with meteorological offices and central/local governments. ▪ JMA disseminates weather information and warnings via various channels to government disaster prevention agencies, local governments, the mass media and the public. ▪ J-Alert System - J-Alert is the system to immediately transmit emergency information such as Emergency Earthquake information. ▪ Introduction of Information Network for Disaster Prevention (INDiP).	**Meteorological Department disseminate the magnitude.**
6	**Emergency Response**	**An emergency team composed of the director generals of the respective ministries and agencies During large scale disaster to grasp and analyze the disaster situation, and report the results to the Prime Minister. Inter-ministerial meetings are held to decide basic response policies.** **A government investigation team may be dispatched.** **Wide-area support mechanisms are mobilized by:** - the National Police Agency (Inter-prefectural Emergency Rescue Unit) - Fire and Disaster Management Agency (Emergency Fire Rescue Team) - Japan Coast Guard. **The Self-Defence Forces can be dispatched for emergency response activities upon request from the governor of the affected prefectural government.** **The disaster medical assistance teams (DMATS) are dispatched to provide Wide-area medical-transport services.** **SAR Operations:** Fire and Disaster Management Agency (FDMA) is responsible for SAR operations in Japan. SAR operations begin at the local level, conducted mainly by fire services, both professional and volunteer fire fighting fighters, and the police. **Japan Disaster Relief (JDR) Search and Rescue Team.**	**According to Standing Orders on Disaster, Department of Disaster Management is responsible to emergency response by Civil Defence and Fire Service and Urban Volunteers.** **Capacity Building Programme for Search & Rescue.**

7	**Building & Infrastructures**	**Act & Laws related to:** - Building Standard Law - Housing Quality Assurance Act. - Act for Execution of Defect Warranty Liability under Housing Quality Assurance Act. - Act on Promotion of the Earthquake-proof Retrofit of Buildings. **Assistance Scheme for Building Quake Proofing:** - Tax deduction for Residential Building Quake Proofing - Tax exemption for commercial building quake. - Public School Quake-proofing. - Hospital Quake-proofing. - Earthquake Insurance System. **Emergency Response and Communication System by Life line infrastructures like Osaka Gas Engineering Co. Ltd.**	**National Building Code.**
8	**Recovery & Rehabilitation**	**Disaster Recovery Project:** The recovery of damaged public infrastructure, educational, welfare, agricultural, forestry and fishery facilities. **Disaster Relief Loans:** Persons engaged in the agriculture, forestry or fishery industries, small and medium enterprises and low-income people **Disaster Compensation and Insurance:** Affected persons can obtain compensation Earthquake insurance for disaster losses. **Tax Reduction or Exemption for affected persons.** **Tax Allocation to Local Governments and Local Bonds:** For affected local governments. **Financial Support for the Livelihood Recovery of Disaster Victims.**	**Providing of Disaster relief for affected person:** - Financial grants. - CI Sheet - Vulnerable Group Feeding Programme - Blanket
9	**Education & Research**	**Basic Education on Disaster:** - Guide book and Sub Text book - Video for disaster risk education - Instruction based on manuals - Lesson and experiment by experts of disaster prevention - Earthquake experience by utilizing special cars - Drill for disaster prevention - Student's activities on Skill improvement, survival at camping, Volunteerism etc. - First aid in time of disaster - Visit to disaster prevention centre and fire station **Highly Prioritise Scientific and Technological Research in Disaster Reduction.** **High quality educational and training institutions.**	▪ Earthquake education has incorporated into the curriculum for school children. ▪ Supplementary books for primary and secondary education level. ▪ Research on Earthquake has been prioritising for grants in the higher education institutes.
10	**Community**	**Utilization Hazard Maps to Promote The**	▪ Try to develop community

	Awareness and Preparedness	**Earthquake-Proofing Of Buildings.** **Integrated Disaster Management Information System.** **Earthquake-Proofing of disaster management bases (schools and other institutions) and key infrastructure.** **Issuing of Evacuation Order and Instruction.** **Disaster Reduction Drills and Exercises:** the Central Disaster Management Council sets forth an annual Disaster Reduction Drills Plan which stipulates the basic principles for executing the drills and outlines the comprehensive disaster reduction drills carried out by the national and local governments and relevant organizations. **Countermeasures against Large-scale Earthquakes.** **Improvement of evacuation areas** **Business continuity plans for companies.**	participation and awareness to reduce the vulnerability. ▪ About 18000 urban volunteers. ▪ Earthquake Drills and Activities: earthquake drills at 70,000 primary and secondary schools twice a year. ▪ Community awareness through media campaign, workshop and seminar.
11	**Geo-databases & Maps**	▪ **Geo-database on Earthquakes parameters.** ▪ **Seismic Intensity Mapping.** ▪ **Vulnerability Mapping.** ▪ **Risk Mapping.** ▪ **Models and Integrations related to earthquakes.** ▪ **Hazard Mapping.** ▪ **Remote sensing using satellite image.** ▪ **Early damage assessment function using artificial satellites.**	**Earthquake Vulnerability, Mapping, Risk Mapping and Seismic Hazard Mapping under Comprehensive Disaster Management Programme (CDMP).**
12	**Budget**	**The National Budget for disaster management is approximately 1.2 trillion yen (Initial Budget 2010FY).**	**National Budget for Disaster management is about 625 million USD.**

Chapter-7: Observation and Findings of the research:

Key Factors	Observations	Findings
Preparedness and response	The nation of Japan organizes a massive, speedy response. The Japanese people demonstrated a "culture of preparedness.	Robust catastrophic planning, preparedness, and mitigation make a society more resilient to disaster.
Communicating the risk	Japan relied heavily on formal early warning systems, evacuation plans, and alerts to limit loss of life.	Communications that effectively identify risks to the public by promoting measures and behaviours that avoid, minimize, prepare for, or respond to threats.
Sustainable Structure	Japan ensures enforcement of legal framework to develop sustainable structure.	Developed methods and capabilities to ensure sustainable structure.

Chapter-8: Recommendations

- Incorporation of earthquake countermeasures acts in the Legal frameworks to enforce structural sustainability.
- Establish Emergency Disaster Management Force under Ministry of Disaster Management and Relief for professionalizing the search and rescue operation.
- To ensure integrated disaster management system in the city planning.
- To develop contingency plan for earthquake prevention by Ward level.
- To raise massive public awareness through mass media and community campaign.
- Monitor and ensure enforcement of building code and soil testing
- Enhancement of response capacities of the responsible departments
- Arrange training on first aid, search and rescue for community people.
- To strengthen more effective public–private partnerships to build the business continuity plan for earthquake prevention.

- To develop sufficient open spaces in the cluster level for emergency evacuation.

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