ROLE OF ICT IN NATURAL DISASTER MANAGEMENT OF BANGLADESH

A Dissertation for the Degree of Master in Disaster Management

By

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ABSTRACT

Bangladesh being world's eighth-most populous country is highly vulnerable to recurrent natural hazards due to its location and topography. It regularly experiences floods, droughts, tornadoes and cyclones. Being located in a tectonically active zone, Bangladesh has a long history of seismic tremors as well. During disasters information is as much a necessity as water, food and medicine. ICT is thus among the lifelines which helps to save lives, livelihoods and resources. Responding effectively to disasters demand rapid access to reliable and accurate data. Information sharing and integration of communication is critical which is time demanding as well.

Globally there is a growing awareness of the importance of ICT for Disaster Risk Reduction (DRR). A natural disaster may have discrete origins but its effects propagate and interact in such a way that intensifies the complexity and uncertainties. Thus each type of natural disaster presents a particular context for ICT use. Data need to be acquired and analysed under severe time pressure. ICT can potentially play a pivotal role in DRR. Beside the traditional ICT media (radio, television, etc); rapid advancement in ICT in the form of Internet, GIS, Remote Sensing and satellite-based communication can help a great deal in planning and implementation of DRR. These technologies are playing a major role in designing early warning systems, catalysing the process of preparedness, response and mitigation.

Bangladesh ICT Policy 2009 stated to protect citizens from natural disasters through ICT based disaster warning and management technologies. DRR through the use of ICT is among the objectives set under the ICT Policy. ICT has played a significant role to bring paradigm shift in disaster management from conventional response and relief practice to a more comprehensive risk reduction culture in Bangladesh. However, for effective DRR an integrated communication system is indispensable. Besides, there is eminence of obstacles for ICT and emergency communication when a natural hazard strikes Bangladesh. Although a good ICT infrastructure is in place in Bangladesh, yet scopes exist in diversifying ICT applications uses to enhance integrated information management for minimizing hazard specific risks in a timely manner.

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CHAPTER 1: INTRODUCTION

1.1 Background of the Study

Bangladesh being world's eighth-most populous country is highly vulnerable to recurrent natural hazards due to its location and topography (Global Population Census Country rank, 2014). It regularly experiences earthquakes, floods, droughts, tornadoes and cyclones. Being located in a tectonically active zone, Bangladesh has a long history of seismic tremors. Major cities such as Dhaka, Chittagong and Sylhet are extremely vulnerable to earthquakes due to high population density and unplanned growth over the years (Shaw, Mallick and Islam, 2013). Rapid, unplanned urbanization exponentially increases the number of people and property at risk. Total global annual average loss (AAL) for earthquakes is estimated at more than US$100 billion where Bangladesh AAL is projected between 100 to 1000 million US$ (Global Assessment Report on Disaster Risk Reduction, 2013). The country is prone to floods and cyclones almost at a regular interval where it has the highest number of people exposed to flooding in the world (Global Assessment Report on Disaster Risk Reduction 2011). The impacts are becoming more visible at the local level, with greater impacts on poor and vulnerable communities.

During disasters, information is as much a necessity as water, food and medicine. ICT is thus among the lifelines which helps to save lives, livelihoods and resources. Responding effectively to disasters demand rapid access to reliable and accurate data (Yap, 2011). Thus, speedy communication to appropriate stake holders is essential in order to organize and mobilize resources and coordinate response activities among agencies involved. Therefore, information sharing and integration of communication is critical which is time demanding as well (Wattegama, 2007).

At present there is a growing awareness of the importance of ICT for Disaster Risk Reduction (DRR) (UNAPCICT, 2010). DRR through ICT aims to reduce the damage caused by natural hazards like earthquakes, floods, droughts and cyclones by an ethic of prevention.[1] Recent literatures and reports supported the accelerated paradigm shift from response activities to DRR practice in different countries. United Nations International Strategy for Disaster Reduction (UNISDR) has also promoted the integrated concept of DRR through five priority areas, known as Hyogo Framework for Action (HFA 2005–2015) (UNISDR, 2005).

Risk reduction and management relies on large amount of statistically processed data. The emergency activity depends on fast response, reliable access to existing data, up-to-date field information, integration and distribution of information among various stake holders. Many applications of risk reduction are hazard specific. Thus, it is difficult to consider only one type of hazard as often one hazard is triggered by another. Floods near industrial areas may cause technological hazards like explosions, fires, etc. Earthquakes may provoke subsequent landslides, liquefaction, tsunami etc. In this context, disasters triggered by a primary hazard and developing to a secondary hazard should also be considered as likely. Therefore, DRR is often mentioned in a multi-hazard context where ICT can play a vital and integrating role (Zlatanova, 2015).

ICTs have become an integral part of operations for disaster preparedness, mitigation, response and recovery. Although they have been around for three decades and are widely used, several new trends origin great enhancement as follows:

- Increases in accessibility, connectivity, usability and open-source technology.
- Blending of networks, hardware, applications, social media and mapping platforms.

Utilising ICT tools, disaster-affected communities can be engaged directly in dialogue and two-way communication. This will rapidly improve humanitarians understanding of their needs in the local context which will ultimately enable communities to build their own response. We cannot stop disaster but we can minimize risk. Impact of disaster can be alleviated (Yap, 2011).

[1] http://www.unisdr.org/who-we-are/what-is-drr

Communities are now becoming more engaged in humanitarian actions than ever before. Simultaneously, the rise in use of ICT also provides unique abilities to coordinate humanitarian action and be more accountable to local communities. Moreover, it provides unique tools to mobilize financial support and volunteer communities. Emergency response is a kind of dependency. If the community can be empowered to be resilient to disaster only then DRR can be achieved in true sense (IFRC, 2014).

Bangladesh ICT Policy 2009 (strategic theme 9.3) stated to protect citizens from natural disasters through ICT based disaster warning & management technologies (ICTD, 2009). Consequently, minimizing DRR through the use of ICT is among the objectives set under the ICT Policy (BTRC, 2012). ICT has played a significant role to bring paradigm shift in disaster management from conventional response and relief practice to a more comprehensive risk reduction culture in Bangladesh (Azad, Bahauddin and Himel, 2013). DRR has become a major development agenda since 2002 in Bangladesh. The global knowledge on "Reducing Risk" has also become very popular in Bangladesh not only because Bangladesh is a disaster-prone country but also it has contributed in shaping the knowledge about disaster risk. There is a history of strong "disaster preparedness" backbone in Bangladesh, which earned justified attention of the world in shaping the knowledge and paradigm in disaster management discipline (Shaw, Mallick and Islam, 2013).

Although a good ICT infrastructure is in place in Bangladesh, there is yet no comprehensive well-defined system in the country to designate the institutions and their responsibilities for emergency communication in a post-disaster situation (UNAPCICT, 2010). Standing Orders on Disasters have not also clearly defined the aspect of ICT and emergency telecommunication (DMB, 2010). However, for effective DRR an integrated communication system is indispensable (Aizu, 2011). Thus, scopes exist in diversifying ICT applications uses to enhance integrated information management for minimizing hazard specific risks in a timely manner.

Besides, there is eminence of major obstacles for ICT and emergency communication when a natural hazard strikes Bangladesh (UNAPCICT, 2010). Firstly, the heavily damaged or destroyed communication networks will lead to a complete communication blackout in the affected areas. Secondly, even if part of the existing communication system is operational, they may quickly become oversubscribed by increasing traffic volume at the time of the disaster, making communication difficult. Thirdly, in an event of a major earthquake in Bangladesh particularly in large cities, there is high possibility of a severe breakdown in power supply in and around the affected areas. Furthermore, during disaster events, one of the most common problems for the telecommunication operators (both public and private) is power failure, which hampers the delivery of services and disruption of communication. Most of the mobile phone network operators have limited power back-ups, especially in remote areas (UNAPCICT, 2010).

The role of ICTs in community and national adaptation strategies to the long-term impacts of natural disasters has been reviewed in several recent publications (Yap, 2011). Though limited studies and systematic impact analyses were performed for ICT's role as contributing to more effective and efficient DRR, yet those were not sufficient as they could not incorporate integrated ICT tools for DRR.

This dissertation focuses on the role of ICTs in minimizing and managing the impacts from acute natural disasters events within a broad spectrum, where actual ICT applications in natural hazards will be described in determining the tools to integrate ICTs for effective DRR in the context of Bangladesh. Prevailing natural hazards in Bangladesh with special reference to earthquake, flood, cyclone and tornado is identified in chapter 2, where risk reduction approaches in disaster management is explored at the end viewing the importance of a people-centered approach. Then, the role of ICTs in disaster management practices is described in Chapter 3, showcasing the critical role in enabling communities to prepare for and cope with the impacts of extreme natural hazard events. Chapter 4 presents the current state of ICTs in Bangladesh highlighting on its limitations. Subsequently, in Chapter 5 some reflections on the potential of ICTs in DRR are narrated. Thereafter, Chapter 6 identifies means to integrate ICT tools suggesting how it could be utilized for more effective DRR in Bangladesh. Finally, the dissertation concludes viewing the importance on use of ICTs in DRR in a developing country like Bangladesh.

1.2 Objective of the Study

The study was carried out for the fulfillment of the following objectives:

a. To analyze the usefulness of ICT elements in disaster management practices of Bangladesh.

b. To investigate the challenges in maintaining ICT connectivity in disaster scenario at community level in Bangladesh.

c. To assess the integrated ICT tools for DRR practices in Bangladesh.

The study aimed to determine the factors responsible for associated management of ICT connectivity in disaster scenario for Bangladesh at present. This also helped in identifying underlying causes for potential disruption and limitations under different natural hazard scenarios which provided significant information base for suggested planning of effective tools for integrated ICT to address DRR practices of Bangladesh.

1.3 Methodology

The research approach of the present study was analytical and exploratory using qualitative methodology. The study followed mostly the descriptive type of research where secondary data was used extensively. This study covered some sequential steps including conceptualization of the problem and identifying the study area. Primary and secondary sources were utilized for data collection. Thereafter the analysis and arrangement of the information and data was sequenced and sifted according to the study objectives. Finally, the study output was formulated for suggesting tools to integrate ICTs in different natural hazard scenarios for effective DRR practices in Bangladesh.

Information and data related to ICT was collected from Ministry of Information, ICT Division, SPARRSO, other relevant government and private sector organizations. Meteorological data was collected from Bangladesh Meteorological Department (BMD). For secondary data sources; related published books, journals, publications, research works, articles, newspapers and web resources were adequately consulted.

1.4 Study Area

1.4.1 Geological Location and Setting

The study area is Bangladesh in a broad spectrum of Asia-pacific region. Bangladesh is a low-lying, riverine country located in South Asia with a largely marshy jungle coastline of 710 km on the northern littoral of the Bay of Bengal. Formed by a deltaic plain at the confluence of the Ganges, Brahmaputra and Meghna Rivers and their tributaries, Bangladesh's alluvial soil is highly fertile but extremely vulnerable to hydro-meteorological hazards like flood and drought (URL 3). Hills rise above the plain only in the Chittagong Hill Tracts in the far southeast and the Sylhet division in the northeast. Straddling the Tropic of Cancer, Bangladesh has a tropical monsoon climate characterized by heavy seasonal rainfall, high temperatures and high humidity. The country occupies major part of the bengal delta, one of the largest in the world (URL 4).

The broad geological features of the Bengal Basin and its prominent tectonic elements are Indian platform, Bengal foredeep[2], Arakan Yoma folded system, and the Sub-Himalayan foredeep. The country has an area of 147,570 square kilometers and extends 820 kilometers north to south and 600 kilometers east to west. Bangladesh is bordered on the west, north, and east by a 4,095 kilometers land frontier with India and in the southeast, by a short land and water frontier of 193 kilometers with Myanmar. On the south is a highly irregular deltaic coastline of about 580 kilometers, crisscrossed by many rivers and streams flowing into the Bay of Bengal.

This complexity of environment and utilization patterns has important implications for the vulnerability and depletion of the natural resource base which is often further threatened by natural hazards. Rapid urbanization without considering the geological aspects has brought significant changes in the geo-environment of Bangladesh (URL 5).

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[2] Foredeep is a basin adjacent to a craton which is filled with a thick accumulation of sediment derived from an orogenic belt during uplift. Source: www.encyclopedia.com/doc/1O13-foredeep.html

Figure 1.1: Map of Bangladesh (Study Area)

(Source: http://travel.nationalgeographic.com/travel/countries/bangladesh-guide)

1.4.2 Climatic Condition

Bangladesh has a subtropical monsoon climate characterized by wide seasonal variations in rainfall, high temperatures and humidity. In general, maximum summer temperatures range between 30°C and 40°C. April is the warmest month in most parts of the country. January is the coldest month, when the average temperature for most of the country is about 10°C. Heavy rainfall is characteristic of Bangladesh. Under the Koppen climate classification[3], Bangladesh has a tropical savanna climate. Increasing air and water pollution emanating from traffic congestion and industrial waste coupled with erosion of natural habitats are serious problems affecting public health and the quality of life which ultimately threatens to destroy much of the regional biodiversity.

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[3] Koppen Climate Classification, developed by German Climatologist Wladimir Koppen. Source: http://www.britannica.com/EBchecked/topic/322068/Koppen-climate-classification

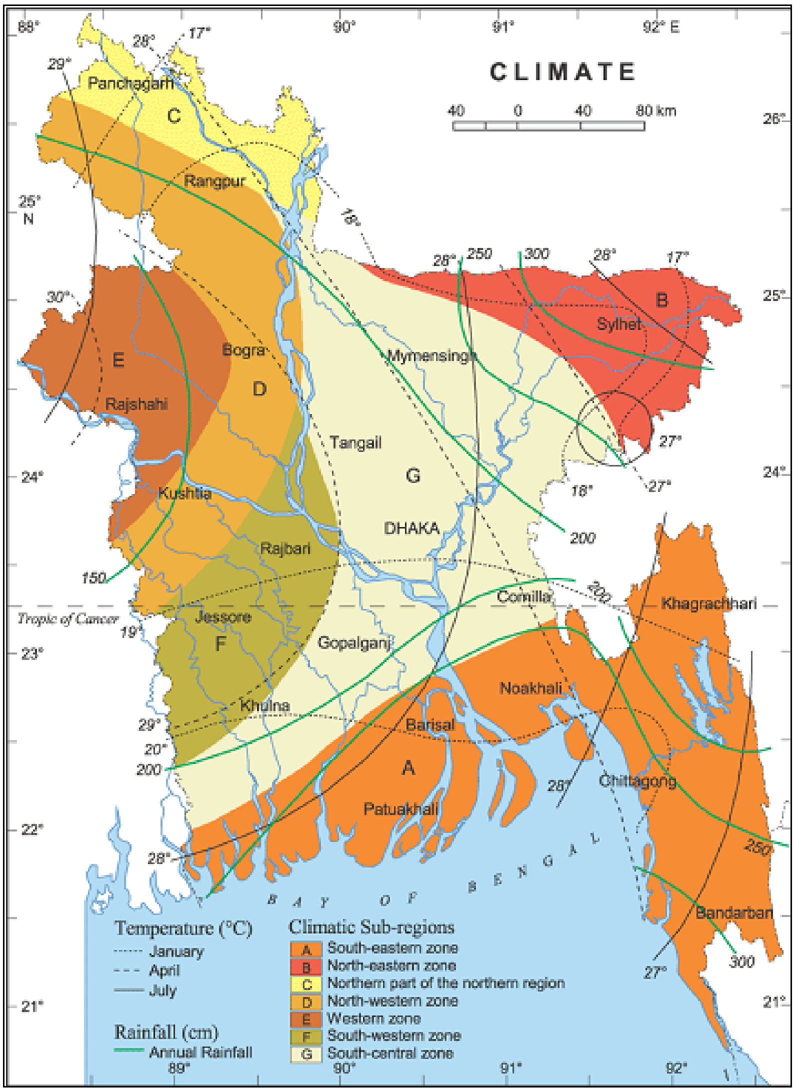

Figure 1.2: Climate of Bangladesh

(Source: http://www.adrc.asia/countryreport/BGD/2013/BGD_CR2013B.pdf)

1.4.3 Demographical Features

Bangladesh is largely ethnically homogeneous, and its name derives from the Bengali ethno-linguistic group which comprises 98% of the population with many dialects of Bengali spoken except those in Chittagong and Sylhet which are particularly distinctive. In 2013 the population was estimated at 160 million. About 90% of Bangladeshis are Muslims, followed by Hindus (9%) and others (1%).

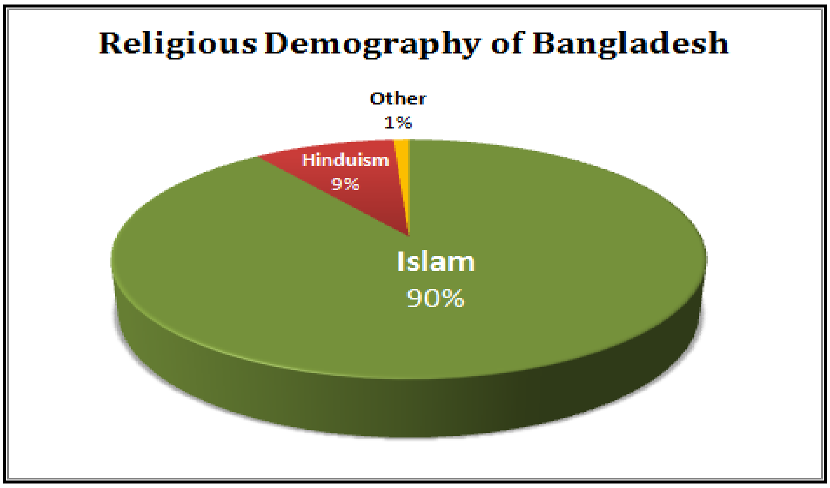

Figure 1.3: Demography of Bangladesh

(Source: http://en.wikipedia.org/wiki/Demographics_of_Bangladesh)

Bangladesh has the highest population density in the world, excluding few city-states like Malta and Hong Kong. Bangladesh had high rates of population growth in the 1960s and 1970s. Due to reduction in its total fertility rate, over a period of three decades it dropped from almost 7 to 2.4 in 2005-2010. The sprawling mega-city of Dhaka has a huge population, but the majority still live in rural areas. Country's urban population is 27% of total population (2009 est.) and rate of urbanization is 3.5% (2005-2010 est.).

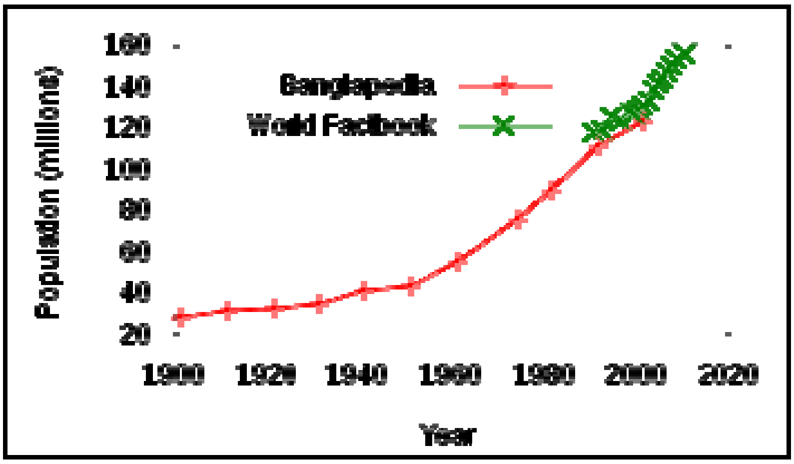

Figure 1.4: Demographic Evolution of Bangladesh (1900-2010)

(Source: http://en.wikipedia.org/wiki/Demographics_of_Bangladesh)

1.5 Limitations of the Study

The report was formulated principally on the secondary data sources. Thus with the progression of report in some areas ground survey was felt necessary to further evaluate the current scenario of rapidly changing available ICT means and tools. On the contrary, this was not possible due to the temporal and spatial limitation of the report formation. However, scope of further study on the subject would address the issue adequately in order to accommodate the ever growing tendency of modernization and new inventions in ICT field far beyond the imagination.

CHAPTER 2: PREVAILING NATURAL DISASTERS IN BANGLADESH

2.1 Significant Natural Hazard Profile in General

Bangladesh is the fifth most disaster-prone country in the world according to Global Climate Risk Index 2014 (URL 6). The country is highly vulnerable to different types of disaster because of climatic variability, extreme events, high population density, high incidence of poverty and social inequity, poor institutional capacity, inadequate financial resources, and poor infrastructure. These disasters cause immense losses of lives and damage to properties, livelihoods and economic infrastructure. The country faces at least one major disaster a year; it has lost on average 3.02% of its GDP every year during the last decade and holds the highest disaster mortality rate in the world (URL 7). Adverse effects of climate change in Bangladesh could result in losing one-third of its mainland into the Bay of Bengal due to rise in sea level. Moreover, coupled with the problem of rising temperature may reduce crop production significantly in an agri-based country like Bangladesh (Shaw, Mallick and Islam, 2013).

Bangladesh occupies the greater parts of the Bengal Basin, which is one of the largest geosynclinals[4] of the world (URL 8). Bangladesh has truly been emerged from the sea and hundreds of rivers have given the shape of its landscapes as one of the fertile landmasses of the earth. The geographical setting of Bangladesh has made the country vulnerable to a series of geological and hydro-metrological hazards. The major hazards concerned here are the occurrences of floods, cyclones, droughts, tidal surges, tornadoes, earthquakes, river erosion, fire, infrastructure collapse, high arsenic contents of ground water, water logging, water and soil salinity, epidemic and various forms of pollution. These are termed as disasters when they adversely affect the whole environment, including human beings, their shelters and the resources essential for their livelihoods.

[4] Geosyncline is linear trough of subsidence of the Earth's crust within which vast amounts of sediment accumulate. Source: http://global.britannica.com/EBchecked/topic/230387/geosyncline.

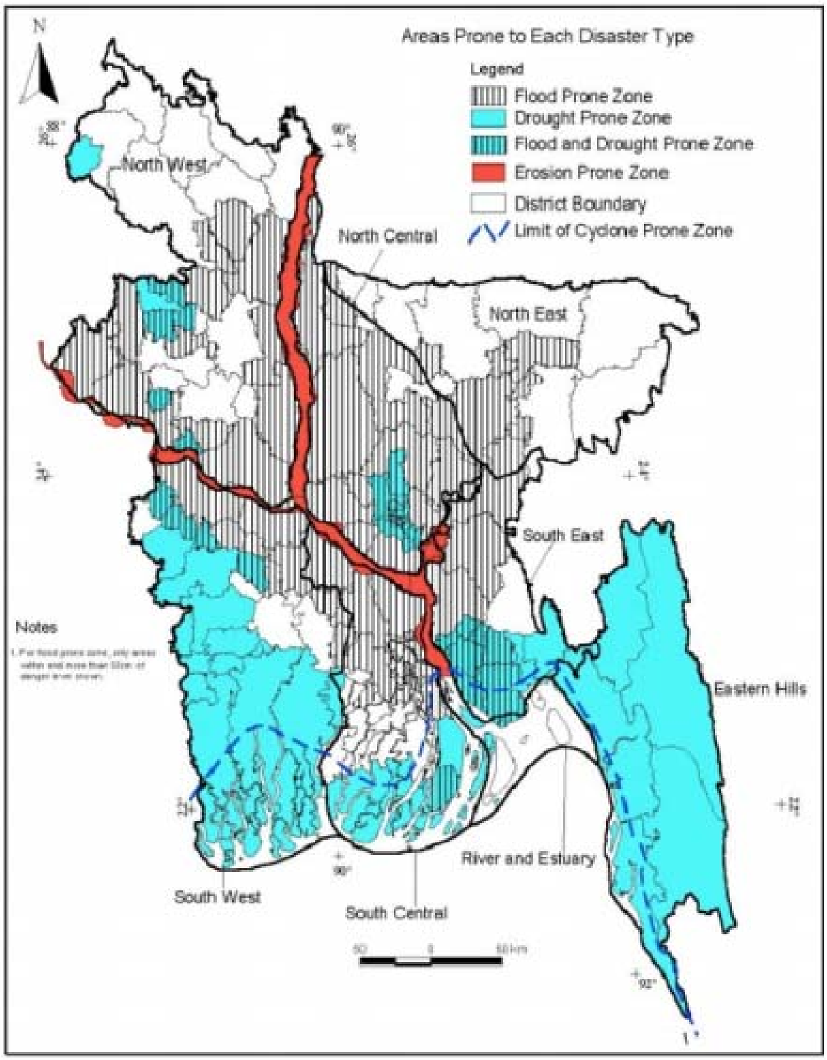

Figure 2.1: Areas Prone to Each Type of Disaster

(Source: http://www.adrc.asia/countryreport/BGD/2013/BGD_CR2013B.pdf)

For the purposes of this dissertation, the term "natural hazards" is taken to include the wide variety of meteorological, hydrological, geological and climate phenomena which can pose a threat to life, property and the environment. The spatial and temporal scales of these hazards vary widely from short-lived, violent, phenomena of limited extent (e.g. tornadoes and severe thunderstorms) through large systems (e.g. tropical and extra-tropical cyclones). These events can affect the whole country with strong winds, heavy flood-producing rains, storm surges, coastal flooding and extreme hot or cold temperatures in the context of local climate for periods of several days. At the larger scale are widespread droughts which may affect huge areas for months to years causing famine and loss of life and loss of animal populations along with increased risk of desertification (O'Neill, 1997).

Meteorological and hydrological forecasting requirements for effective early warnings of these hazards span a very broad continuum. These can range from less than one hour in the case of tornadoes, severe thunderstorms and flash floods through short and medium forecast ranges extending from hours through days for tropical cyclones, heavy rains and high winds. Hence, timely and effective warnings of natural and related hazards coupled with local capability to take avoidance or mitigating actions are fundamental requirements for such kind of DRR. However, natural hazards such as floods, cyclones, tornados, earthquakes and droughts may also cause or exacerbate other disasters. These events include the possible risks of secondary hazards like fire, toxic gas releases, oil spills etc.

The mountains and hills bordering almost three-fourths of the country, along with the funnel shaped Bay of Bengal in the south. Such shape made the country a meeting place of life-giving monsoon rains and made it subjected to catastrophic ravages of natural disasters. The Bay of Bengal is widely known as the breeding place of catastrophic cyclones due to the presence of Inter-Tropical Convergence Zone (ITCZ)[5]. These cyclones turn into disaster and finally find their way towards the coastal belt of Bangladesh which is primarily responsible for colossal damages to life and property almost every year (DDM-MODMR, 2014).

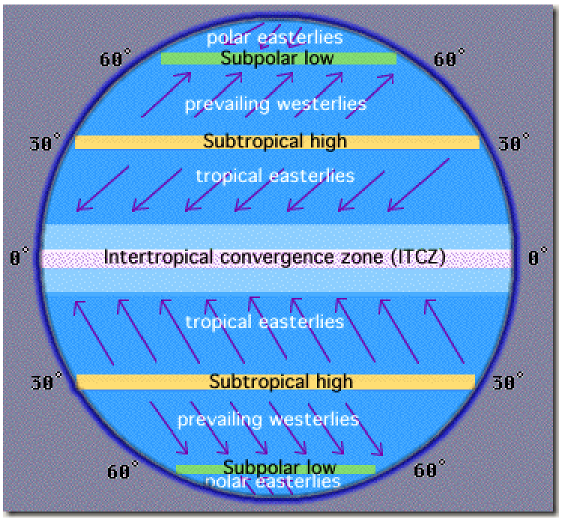

Figure 2.2: Inter-tropical Convergence Zone (ITCZ)

(Source: http://aspirantforum.com/2015/02/02/inter-tropical-convergence-zone)

[5] ITCZ is a belt of converging trade winds and rising air that encircles the Earth near the Equator. Source: http://global.britannica.com/EBchecked/topic/291738

Flood is a recurring phenomenon in the country. Floodplains of the Brahmaputra-Jamuna, the Ganges-Padma and the Meghna river systems are regularly flooded during the monsoon of each year. Although this country with monsoon climate has enough rain, droughts frequently take place especially in the northwest region of the country with a significant impact on agricultural. 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. The higher figure of casualties occurs due to the fact that cyclones are always associated with storm surges. Disastrous erosions are mainly associated with the major river systems of the country and seen along the banks of the Brahmaputra-Jamuna, Ganges-Padma and Meghna River system. Due to riverbank erosion, lands are lost and people are displaced to new places, mostly in urban or peripheral areas (DDM-MODMR, 2014).

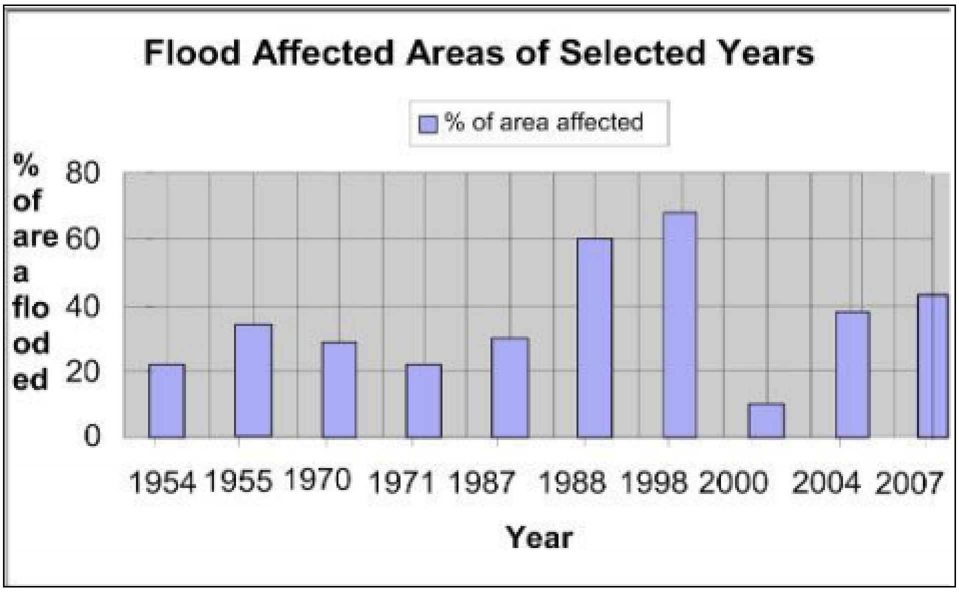

Figure 2.3: Flood Affected Areas (percentage)

(Source: http://www.adrc.asia/countryreport/BGD/2013/BGD_CR2013B.pdf)

2.1.1 Earthquake Risk Scenario

Bangladesh lies in a seismically active zone making the occurrence of major earthquakes a realistic possibility. Geographically Bangladesh is located close to the junction of two subduction zones created by two active tectonic plates: the Indian plate and the Eurasian plate (URL 9). Moreover, the country is surrounded by the Himalayan Arc, the Shillong Plateau and the Dauki fault system in the north, the Burmese Arc in the east and the Naga Disang Haflong thrust zone in the northeast. The capital city is vulnerable to the earthquake as the country is in an active region in terms of vertical and horizontal movement of tremor. The existence of an active fault has been proved in Haluaghat of Mymensingh recently, adding further risk to the vulnerability (Saha, 2010 and Bangladesh Disaster Report 2012).

Bangladesh is one of the most vulnerable countries of the world to earthquake hazard. This is not only due to its geographical location closer to the seismically active Indian-Burmese plate boundaries but also for its poor infrastructure and complex social conditions. In Bangladesh, cities are more vulnerable than the rural area due to population concentration and unplanned growth of the cities. Geographical orientation of Dhaka, Chittagong, Sylhet, Mymensingh, Rangpur, Comilla and north-eastern extended areas are under great threat to earthquake hazard (DDM-MODMR, 2014).

Among the natural disasters which are likely to increase due to rapid unplanned urbanization, earthquake is a serious concern. During the last few years several light to wild tremors have jolted Bangladesh. Whether these jolts are forecasting a major earthquake is becoming a concern to most people as well as the experts. According to statistics of Earthquake Observation Centre of Bangladesh University of Engineering & Technology (BUET), between January 2006 and May 2009, eighty six earthquakes hit Bangladesh which measured at more than four on the richter scale. Experts opine that Dhaka is likely to be affected most if an earthquake hit because of the thick density of population, dilapidated buildings and modern buildings made without following proper guidelines of Bangladesh Building Code (Time-Predictable Fault Modeling, 2009).

Experts suspect that if an earthquake with a 7.0 magnitude occurs in large cities of Bangladesh, there would be a major human tragedy due to the structural failure of many buildings (URL 10). In spite of the increasing urban earthquake risk there are limited comprehensive approach to deal with the risks in Bangladesh in general and Dhaka in particular. Moreover, there are practically few attempts to look into the disaster risk and vulnerability beyond the narrow approaches seeking mere technical input oriented solutions (Sharmin and Saadi, 2013).

Geographically Bangladesh is located close to the boundary of two active plates (URL 11). Bangladesh earthquake zone with its surrounding countries is illustrated in following figure:

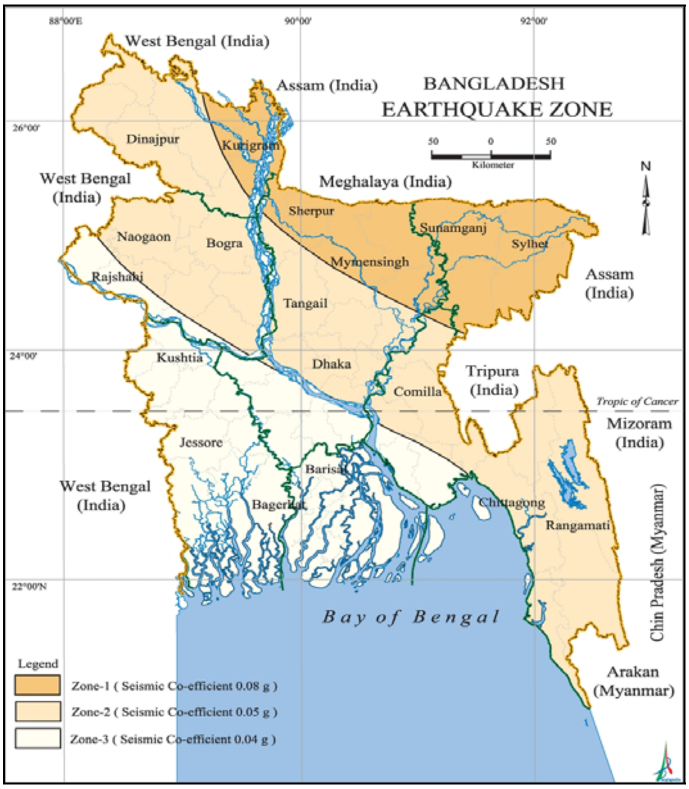

Figure 2.4: Bangladesh Earthquake Zone with its Surrounding Countries

(Source: http://commons.wikimedia.org/wiki/File:Bangladesh_earthquake_zones.jpg)

It is well known that 95% of world's earthquake occurs along the boundary line of tectonic plates. Bangladesh is very close to the boundary of Indian and Eurasian plate (Figure 2.5). Based on the record of the Geological Survey of Bangladesh, the country has experienced at least 465 earthquakes of minor-tomoderate magnitudes between 1971 and 2006. The actual number of earthquakes is considered to be many more than this, because many tremors are not recorded due to a lack of proper seismic equipment in the lone operational observatory. Seismic experts consider recent repeated earthquakes of low to medium magnitude as an early warning for a massive and potentially disastrous earthquake in the near future; as these tremors fail to release the majority of the stress that accumulates within fault ruptures zones. Seismic experts also suspect that if an earthquake with a magnitude 7.0 on the Richter scale occurs in large cities of Bangladesh, there would be a major human tragedy and economic disaster due to the structural failure of many buildings built in these urban centers without the use of proper construction materials coupled with violation of building codes (Saha, 2010).

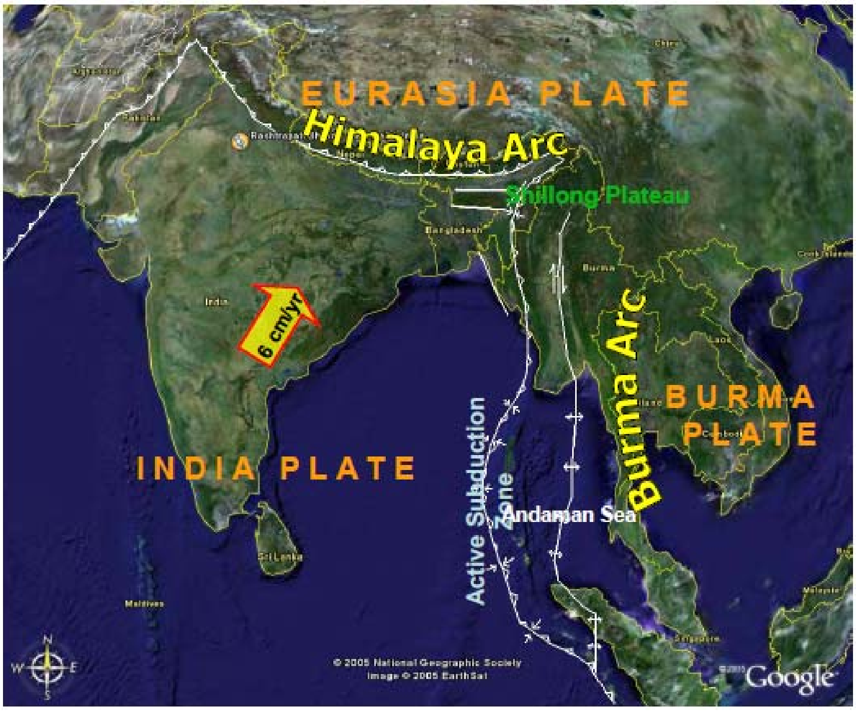

Figure 2.5: Plate Boundary between Indian and Eurasian Plate

(Source: http://www.geolsoc.org.uk/Plate-Tectonics/Chap3-Plate-Margins/Convergent/Continental-Collision)

During the last 300 years, seven major earthquakes (with>7) have affected Bangladesh. Out of the major earthquakes, only two (1885 and 1918) had their epicenters within Bangladesh border. Major earthquakes affecting Bangladesh is enumerated in following table:

Table 2.1: Major Earthquakes Affecting Bangladesh (1548-2009)

Date	Name of Earthquake	Magnitude (Richter)	Epicenter
10 January, 1869	Cachar Earthquake	7.5	India–Myanmar border
14 July, 1885	Bengal Earthquake	7.0	Bangladesh-India border
12 June, 1897	Great Indian Earthquake	8.7	Western part of the Shillong Plateau
8 July, 1918	Srimongal Earthquake	7.6	Bangladesh-Tripura border
9 September 1923	Meghalaya earthquake	7.1	Bangladesh-India border (Meghalaya)
2 July, 1930	Dhubri Earthquake	7.1	Dabigiri, India
6 March, 1933	India Bangladesh earthquake	7.6	India Bangladesh border
15 January, 1934	Bihar-Nepal Earthquake	8.3	Bihar-Nepal border
11 February, 1936	Bihar earthquake	7.5	North Bihar, India
16 August, 1938	Manipur Earthquake	7.2	Manipur, India
15 August, 1950	Assam Earthquake	8.5	Hojai Assam, India
21 March, 1954	Manipur-Myanmar earthquake	7.4	Manipur-Myanmar border
21 November 1997	Bandarban earthquake	7.1	Mizoram-Myanmar border
26 December 2004	Cox's Bazar earthquake	7.0	Bonda Aceh, Indonesia
12 September 2007	Tsunami due earthquake (Cox's Bazar)	8.5	Bengkula, Sumatra
21 September 2009	Bhutan earthquake	6.1	Eastern Bhutan
11 August 2009	Bay of Bengal Earthquake	7.5	Bay of Bengal between north Andaman Island and Myanmar coast

Source: Bangladesh National Plan for Disaster Management 2010-2015

(http://www.dmb.gov.bd/reports/National%20Disaster%20Management%20Plan%20approved%20by%20NDMC.pdf)

Earthquakes are more deadly than any other form of natural hazard. Because of this, scientists have been searching for accurate ways to predict earthquakes to save numerous lives. Statistical analysis is useful method of predicting earthquakes. They provide additional insights to the seismic hazard. Moreover, an earthquake prediction basing on statistical analysis states the probability of occurrence, temporal span, spatial dimension and magnitude range of the earthquake (Roy, 2014).

Bangladesh is seismically very active and earthquake risks are increasingly seen as a major problem. According to Earthquake Disaster Risk Index (EDRI) parameters Dhaka is one of the top twenty high earthquake risk cities in the world (URL 12). During 1918-2007, twelve earthquakes with magnitude M ≥ 7 have affected parts of Bangladesh. Though no major event occurred during the last decades, but seismicity still remains high. The pictorial and tabular behaviors of this entire earthquake are exhibited in following figure (Roy, 2014).

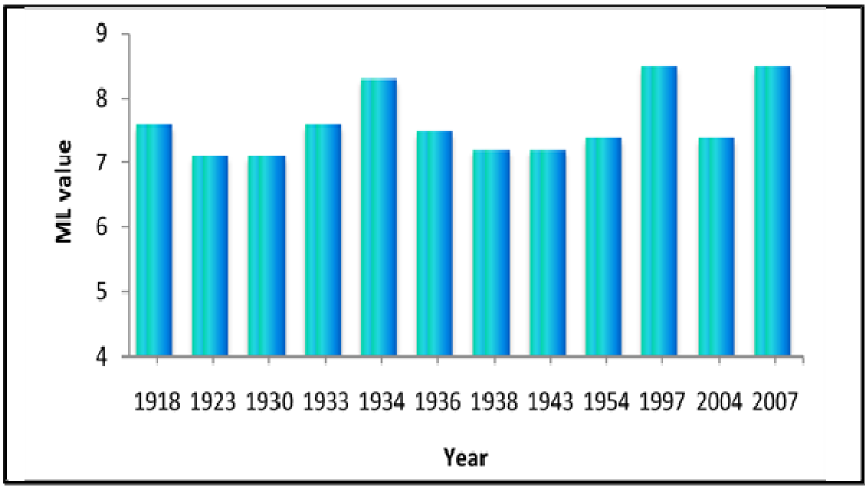

Figure 2.6: Earthquake Magnitude M ≥ 7 in Bangladesh

(Source: http://file.scirp.org/Html/htmlimages%5C6-2740031x%5C58da0008-2060-4de1-a2a1-0a676ee6dd24.png)

If earthquakes in a given region have a recurrent pattern, then a long-term prediction can be made basing on that. There were twenty nine earthquakes (ML 6 and above) strong enough to damage houses during 1918 to 2008. Three of them (ML 8.5 and above) were powerful enough to cause serious devastation. Using statistical analysis of earthquake, the average interval among these twenty nine earthquakes is

3.179 years. If only three severe earthquakes are considered, the average interval is 24.33 years. But by 2007, 10 years had elapsed since the last severe earthquake, the one in 1997. So it is expected to have another earthquake having magnitude equal to 6 or above in Bangladesh is average 2.95 years later than the preceding one. The probability of having another earthquake with magnitude 6 or above in 7 years later with the same magnitude is 92% (Roy, 2014).

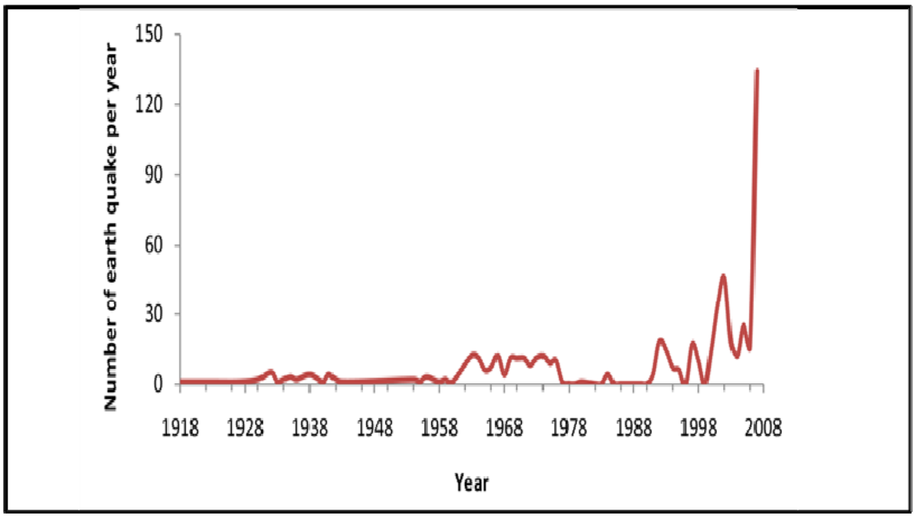

Figure 2.7: Trend in Number of Earthquake Each Year (1918-2008)

(Source: http://file.scirp.org/Html/htmlimages%5C6-2740031x%5C58da0008-2060-4de1-a2a1-0a676ee6dd24.png)

Earthquakes are endogenic in origin and independent of seasonality. The recently measured plate motions at six different sites of Bangladesh including Dhaka clearly demonstrate that Dhaka is moving 30.6 mm/year in the direction northeast. Further, the rate of strain accumulation is relatively high in and around Dhaka city. It may precipitate in an earthquake of magnitude 6.8 in the event of the release of accumulated strain (Bangladesh Disaster Report 2012). BMD has recorded 16 earthquake tremors in 2013 with a magnitude ranging from 3.3 to 5.9 RS in and around Bangladesh border areas. There were two incidents of magnitude higher than 5, but no noticeable damages were observed. The earthquake of January 9, 2013 had a magnitude of 5.9.RS and was felt throughout the country. The epicenter was 495 km away from Dhaka city, located near Bangladesh-Myanmar border area though there were no reports of any casualties or damages (DDM-MODMR, 2014).

2.1.2 Flood Risk Scenario

Bangladesh is one of the most flood prone areas of the world because of its unique geographical setting and physiographic features together with a massive hydraulic system. The ever increasing population, ill-planned infrastructural development and massive flood control interventions in a floodplain environment have resulted in flood disasters becoming larger and more frequent in recent times. Socio-economic impact of floods is profound; the flood prone zones represent areas with the highest incidence of the extreme poor and the number of poor living in high flood risk areas is on the rise. The damage to infrastructure constitutes the major proportion when it comes down to economic damage resulting from floods (Shaw, Mallick and Islam, 2013).

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Bangladesh is one of the biggest deltas of the world with an extensive network of more than 310 rivers. Monsoon rainfall in the upstream catchment of Ganges-Brahmaputra-Meghna basins system (Figure 2.8) and within the country is the major cause of flood in Bangladesh.

Figure 2.8: Ganges-Brahmaputra-Meghna Basins

(Source: http://en.wikipedia.org/wiki/Ganges)

Flood is a normal monsoon phenomenon in this deltaic plains landmass. In the Brahmaputra basin, flood usually begins in the late June, while in the Ganges basin it starts from the second half of July. Rivers in the North and Southeastern Hill basins are characterized by flash flood. The coastal belt of Bangladesh is inundated by regular tidal flood. The livelihood of the people in Bangladesh is well adapted to normal monsoon flood. However, damages and human suffering to flood are common features in many parts of the country. Flood often has disastrous consequences and is the cause of major damage to infrastructure, great loss of property, crops, livestock, poultry etc. Each of the major flood adversely affected food security and poverty situation of the country (DDM-MODMR, 2014).

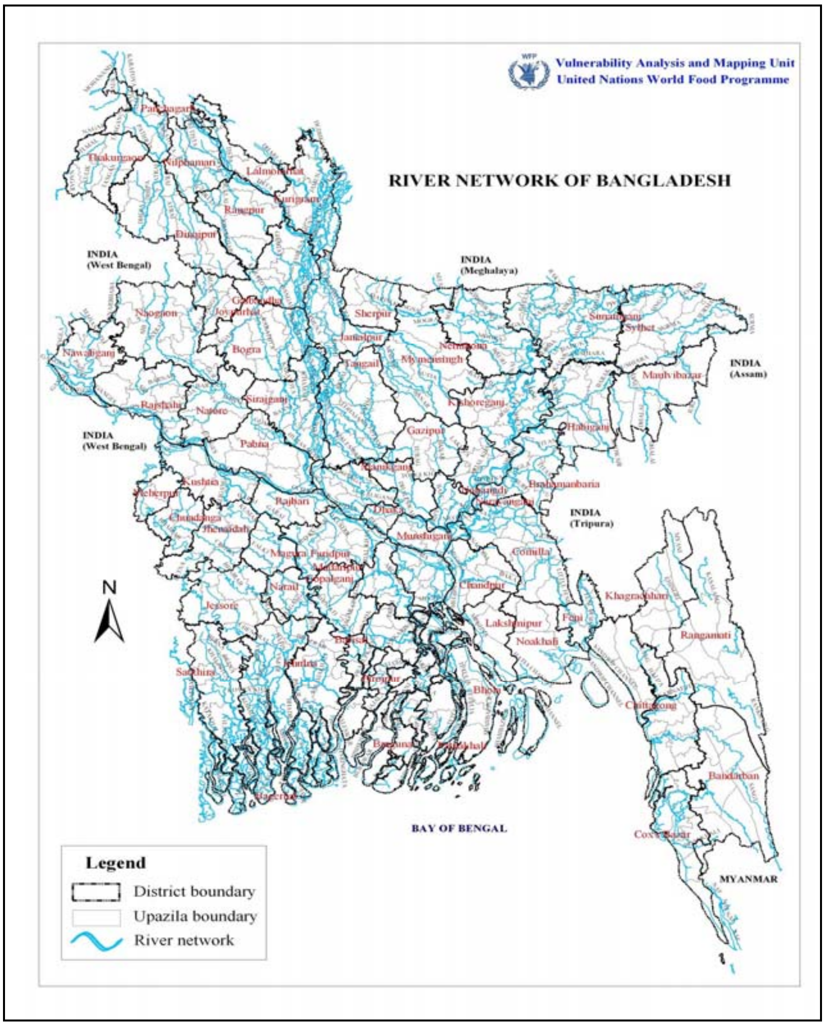


Figure 2.9: Intricate Network of Rivers in Bangladesh

(Source: http://www.foodsecurityatlas.org/bgd/country/availability/agriculturalproduction_files/availability/River-Network50.JPG)

Floods in Bangladesh 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 and 2004 were particularly catastrophic, resulting in large-scale destruction and loss of lives. Approximately 37%, 43%, 52% and 68% of the country is inundated with floods of return periods of 10, 20, 50 and 100 years respectively (Figure 2.10) (NDMP, 2010).

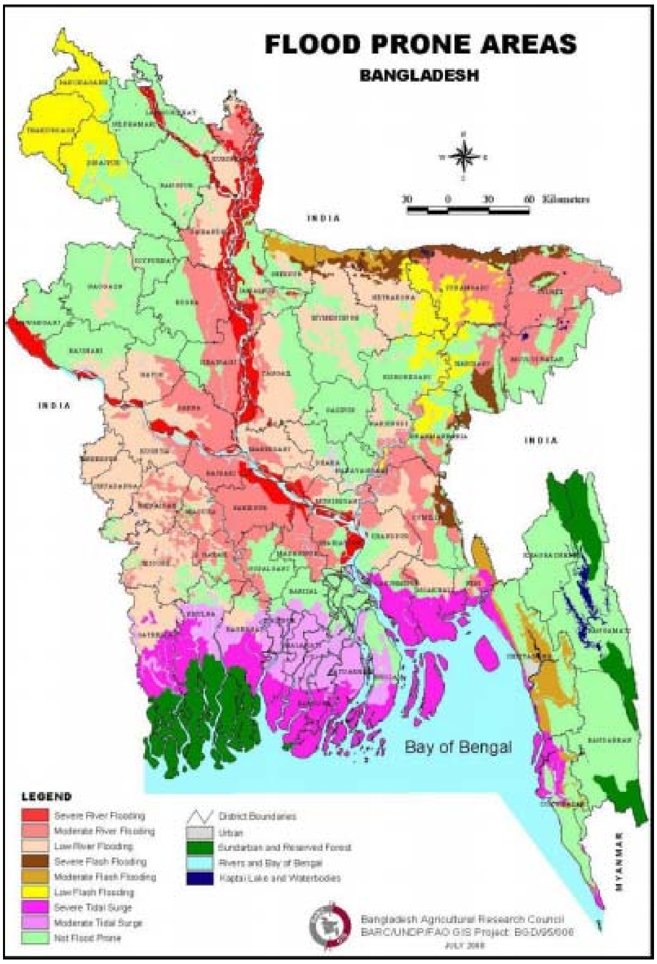


Figure 2.10: Flood Prone Areas in Bangladesh

(Source: http://www.adrc.asia/countryreport/BGD/2013/BGD_CR2013B.pdf)

Five main types of natural floods occur in Bangladesh: river flood; rainfall flood; flash flood; tidal flood; and storm surge flood. Areas prone to different types of floods are shown in Figure 15. In addition, some floods result from human activities.

- **Flash Floods**. Caused by overflowing of hilly rivers in eastern and northern Bangladesh (in April-May and September-November).
- **Rainfall Floods**. Caused by drainage congestion and heavy rains.

- **Tidal Floods**. The areas adjacent to estuaries and tidal rivers in the southwest and south-central parts of the country (where they are not empoldered) experience tidal floods twice a day due to astronomical tide from the Bay of Bengal.

- **Monsoon Floods**. Caused by major rivers usually in the monsoon (during June-September).

- **Coastal Floods**. Caused by storm surges.

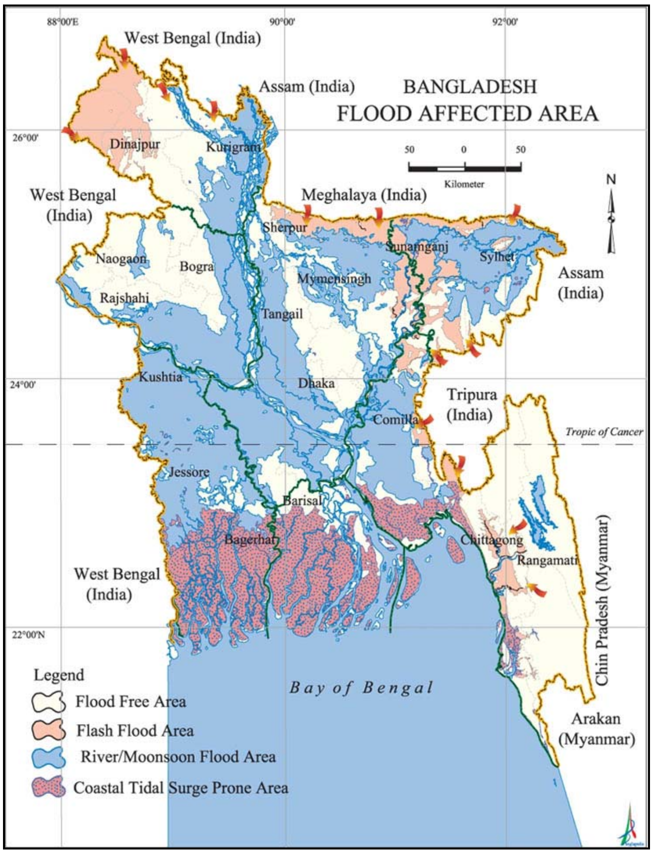


Figure 2.11: Flood Areas by Types of Floods in Bangladesh

(Source: http://www.saarc-sadkn.org/countries/bangladesh/hazard_profile.aspx)

Floods continue to be major hazards in Bangladesh. To mitigate the impacts of floods, the government has been developing and implementing various measures to better equip the country to deal with floods. The Ministry of Water Resources (MoWR) is leading the country on flood mitigation initiatives. Important initiatives include Flood Action Plan, Flood Hydrology Study, Flood Management Model Study, National Water Management Plan, National Water Policy, Flood Early Warning System Study, etc (NDMP, 2010).

➢ *Statistics of Flooding*

Many parts of the Asia during monsoon frequently suffer from severe floods. Some parts of India and Bangladesh experience floods almost every year with considerable damage. The floods of 1954, 1955, 1974, 1987, 1988, 1998, 2004 and 2007 all caused enormous damages to properties and considerable loss of life. The floods of 1987, 1988 1998, 2004 and 2007 flood caused heavy damage. During the monsoon 2013, the flood was not a severe one and stayed for short duration in all the four basins, the Brahmaputra, the Ganges, the Meghna and South Eastern Hill Basin. Percent of total area of Bangladesh affected by the flood are available since 1954 is presented in following Table (FFWC Annual Flood Report, 2013):

Table 2.2: Year-wise Flood Affected Area in Bangladesh

Year	Flood Affected area		Year	Flood affected area		Year	Flood affected area	
	Sq-Km	%		Sq-Km	%		Sq-Km	%
1954	36,800	25	1975	16,600	11	1995	32,000	22
1955	50,500	34	1976	28,300	19	1996	35,800	24
1956	35,400	24	1977	12,500	8	**1998**	**1,00,250**	**68**
1960	28,400	19	1978	10,800	7	1999	32,000	22
1961	28,800	20	1980	33,000	22	2000	35,700	24
1962	37,200	25	1982	3,140	2	2001	4,000	2.8
1963	43,100	29	1983	11,100	7.5	2002	15,000	10
1964	31,000	21	1984	28,200	19	2003	21,500	14
1965	28,400	19	1985	11,400	8	2004	55,000	38
1966	33,400	23	1986	6,600	4	2005	17,850	12
1967	25,700	17	1987	57,300	39	2006	16,175	11
1968	37,200	25	**1988**	**89,970**	**61**	**2007**	**62,300**	**42**
1969	41,400	28	1989	6,100	4	2008	33,655	23
1970	42,400	29	1990	3,500	2.4	2009	28,593	19
1971	36,300	25	1991	28,600	19	2010	26,530	18
1972	20,800	14	1992	2,000	1.4	2011	29,800	20
1973	29,800	20	1993	28,742	20	2012	17,700	12
1974	52.600	36	1994	419	0.2	2013	15,650	10.6

(Source: http://www.ffwc.gov.bd/?Itemid=181)

2.1.3 Cyclone and Storm Surge Risk Scenario

The physiographical features of Bangladesh coast make it susceptible to cyclones and associated surges. According to the Multipurpose Cyclone Shelter Program report, 6.4 % of the country is considered High Risk Area where the surge height may exceed one meter. The country has been devastated by a number of cyclones resulting hundreds of thousands of human deaths. Besides, loss and damage of people's assets and properties have been extensive.

The Bay of Bengal is called a breeding ground for tropical cyclones. Bangladesh is one of the worst victims in terms of fatalities and economic losses for cyclones. The global distributions of cyclones show that only 1% of all cyclones that form every year strike Bangladesh; but unfortunately the fatalities they cause account for 53% of the global total. Records show that 16 out of 35 of the tropical cyclones worldwide that caused deaths of more than five thousand people have occurred in Bangladesh. The funnel shaped coast line and particularly the low topography make the coastal area subject to high surge associated with cyclones (Figure 2.12).

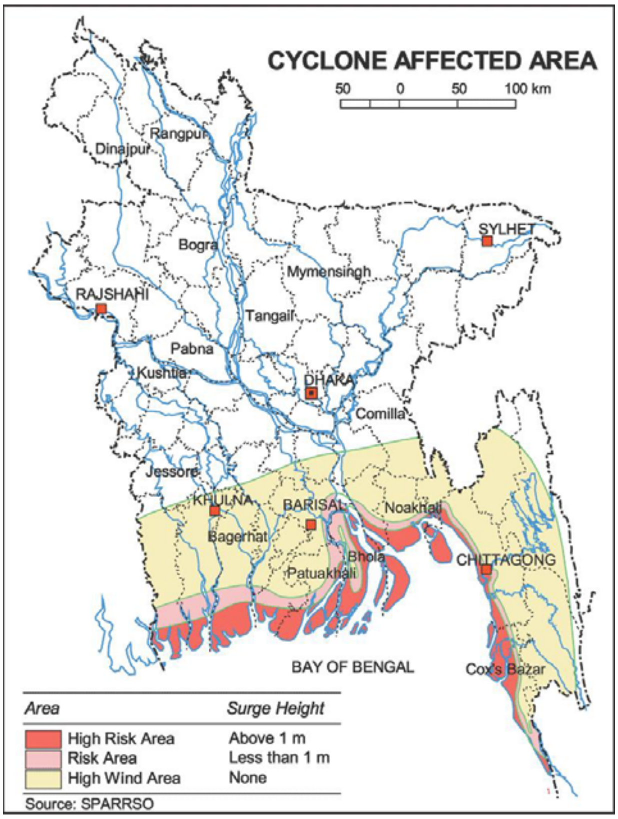


Figure 2.12: Cyclone Affected Areas in Bangladesh

Unique geographic allocation of Bangladesh causes cyclones and tidal surges to be considered the most regular catastrophic phenomena along the coastal regions. These have affected around twenty million poverty- stricken people in fifteen districts and hundreds of offshore islands. Most cyclones are formed in either pre or post-monsoon period. The deadliest cyclone made landfall in Bangladesh was the cyclone of 1970 (November 12, 1970) and took a toll of more than 300,000 lives with property losses of more than a billion US dollar (DMB, 2010).

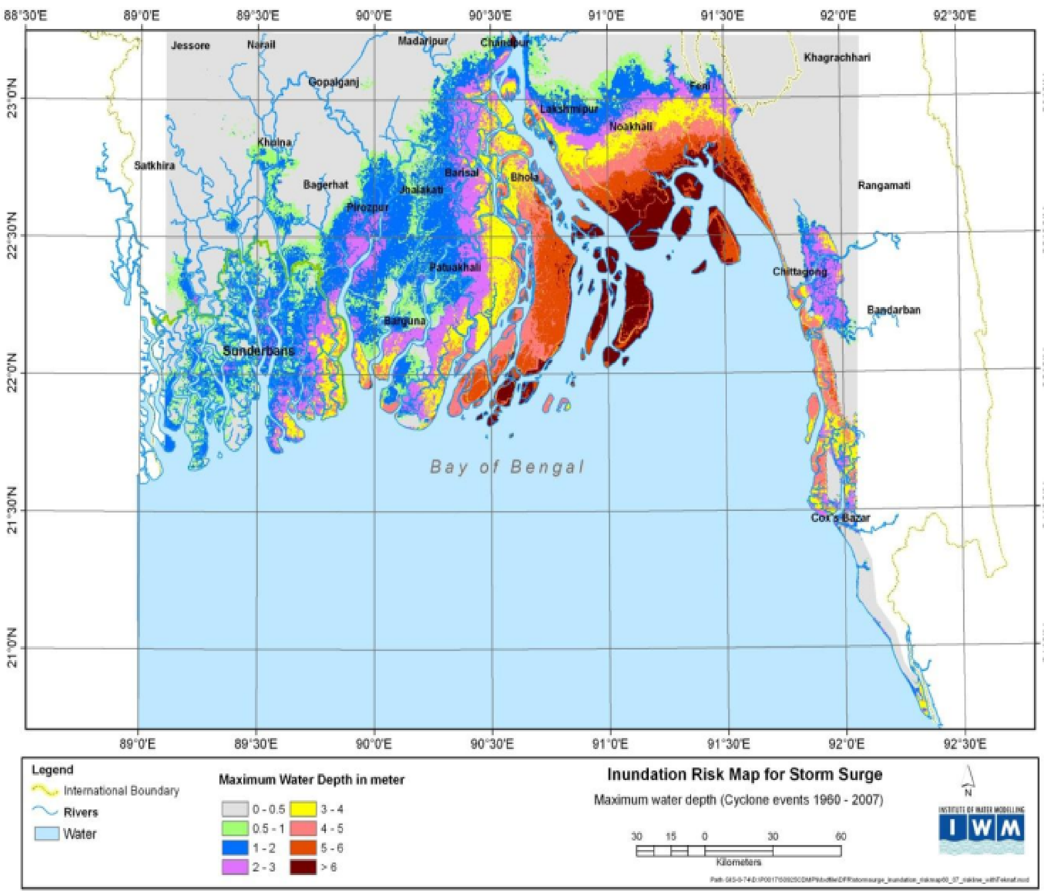


Figure 2.13: Inundation Risk Map for Storm Surge

(Source: http://www.adrc.asia/countryreport/BGD/2013/BGD_CR2013B.pdf)

Within a little over two decades, another catastrophic cyclone on April 29, 1991 claimed lives of about 138,000 people inflicting extensive damage to property worth more than two billion US dollars. Till today, forty five major cyclones have been recorded of which some catastrophic cyclones are of 1965, 1970, 1985, 1991, 1997, 2007, 2009 and 2013. Historic cyclone events are shown in the following table:

Table 2.3: Severe Cyclones Affecting Bangladesh (Since 1960)

Month	Year	Max. Wind Speed (km/h)	Storm Surge Height (metre)	Human Deaths
October	1960	210	4.5-6	5149
May	1961	146	2.5-3	11466
May	1963	203	4-5	11520
May	1965	162	3.5	19279
December	1965	210	4.5-6	-
October	1966	146	4.5-9	850
November	1970	223	6-9	500000
May	1985	154	3-4.5	11069
April	1991	225	6-7.5	138000
May	1994	200	-	170
May	1997	225	2.5-4	126
November	2007	223	3-4	3363
May	2009	92	3+	190
May	2013	88	1.5-2	17

(Source: http://www.adrc.asia/countryreport/BGD/2013/BGD_CR2013B.pdf)

Apart from the human casualties that resulted from cyclone events, the damage to properties, which include physical infrastructure, livelihoods means and various direct tangible/intangible and indirect tangible/intangible items, is substantial. The continuum of loss and damage caused by these disaster events is very difficult to frame; it transcends the spatial and temporal boundaries. The population exposed to the risk of cyclones cannot afford shifting their settlements to a safer location since their livelihood activities are localized. Thus, after every cyclone the people, as if, "rise from the ashes" to get ready to face another.

2.1.4 Tornado Risk Scenario

Though Bangladesh is considered the only other part of the world outside the United States where strong and violent tornadoes are prevalent, little attention has been given to mitigate the risks. Absences of appropriate forecasting and early warning system as well as lack of shelter provision make Bangladesh the country of highest death tolls from Severe Local Convective Storms (SLCS) like tornado and nor-westers. However, 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.

Table 2.4: Devastating Nor-westers and Tornadoes in 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

(Source: http://www.adrc.asia/countryreport/BGD/2013/BGD_CR2013B.pdf)

Wind speeds in nor-westers usually do not exceed 113-130 km/hr, though often their speeds exceed 162 km/hr. When the winds become whirling with funnel shaped clouds having a speed of several hundred kilometers per hour, they are called tornados. Nor-westers bring the much needed pre-monsoon rain. They can also cause huge 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.

2.2 Risk Reduction Approaches in Disaster Management

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, the country has created a simplistic model to guide DRR and emergency response management efforts. The model ensures that the move to a more comprehensive risk reduction culture remains central to all efforts. Mainstreaming risk reduction efforts within government, NGOs and private sector is viewed as being the key to achieving sustainable all hazards risk reduction interventions across the whole country. In Bangladesh mainstreaming is seen in much the same light as poverty reduction in that it is the outcome of many top down and bottom up interventions (MODMR, 2014).

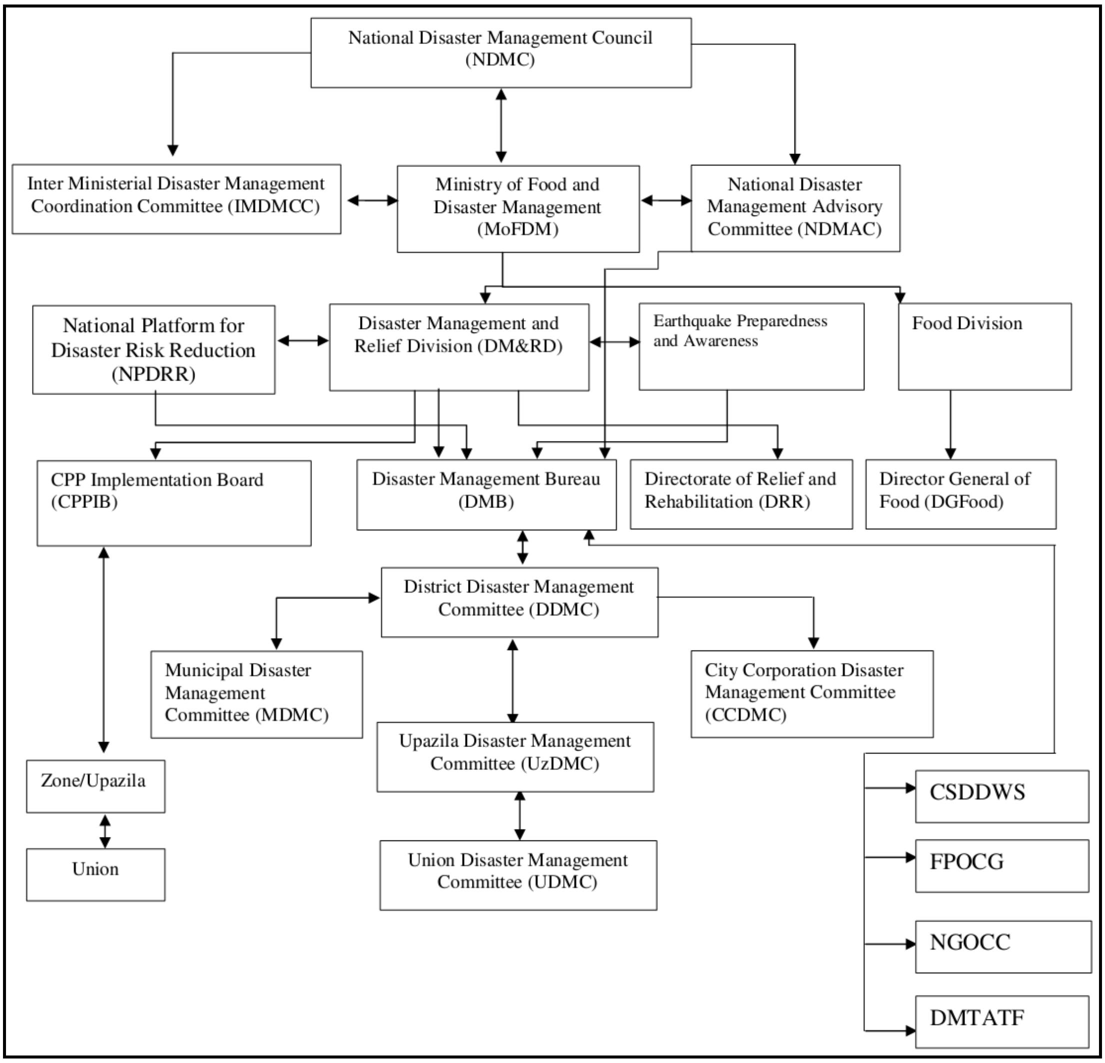
Bangladesh initiated its actions for disaster preparedness immediately after the cyclone of 1991. At present Bangladesh has National Disaster Management Act-2012, National Disaster Management Policy, Standing Order on Disaster and National Plan for Disaster Management 2010–2015 as key documents guiding the disaster management works in Bangladesh. The country also has disaster management mechanism at both national and sub-national levels. The Bangladesh National Plan for Disaster Management is a strategic document to be effective for a certain period of time. This is an umbrella plan that provides the overall guideline for the relevant sectors and the disaster management committees at all levels to prepare and implement their area of roles specific plans for both thematic level and different levels of administrative structure (DMB, 2010).

DRR is development & application of policies and practices that minimizes risks to vulnerabilities and disasters, applies to managing and/or responding to current disaster risks. Since climate system is fundamental for both issues: 75% of all disasters originate from weather-climate extremes. Thus, DRR and adaptation to climate change strategies both are aimed at enhancing sustainability, resilient societies and human security. In this regard DRR options are the front line adaptation. Current risk reduction will lead to reduction of anticipatory risks of climate change in the form of adaptation. The DRR options that best suit the user and accepted by them will eventually emerge as adaptation options. Bangladesh Climate Change Strategy and Action Plan (BCCSAP) 2009 rightly weighted the linkage of the climate change and disaster potentials and appropriately taken disaster management as one of the pillar of strategy which are: Food security, Social protection and health, Comprehensive disaster management, Infrastructure, Research and knowledge management, Mitigation and low carbon development and Capacity building and institutional strengthening (BCCSAP, 2009).

The Disaster Management and Relief Division (DM&RD), MoFDM of the Government of Bangladesh has the responsibility for coordinating national disaster management efforts across all agencies. In January 1997 the Ministry issued the Standing Orders on Disaster (SOD) to guide and monitor disaster management activities in Bangladesh. The SOD has been prepared with the avowed objective of making the concerned persons understand their duties and responsibilities regarding disaster management at all levels, and accomplishing them. 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 (URL 14). The Disaster Management Bureau will render all assistance to them by facilitating the process. To achieve the aims, the concerned authorities have adopted strategies like:

- Bringing a paradigm shift in disaster management from conventional response and relief practice to a more comprehensive risk reduction culture.
- Strengthening the capacity of the Bangladesh disaster management system in improving the response and recovery management at all levels.

Figure 2.14: Disaster Management Institutions in Bangladesh



(Source: http://www.ddm.gov.bd/site/page/735c2560-a926-4676-8fa4-588f39e96db0)

A paradigm shift in disaster management from conventional response and relief practice to a more comprehensive risk reduction culture is slowly taking place. Although a detailed system on Disaster Management has been put in place (by CDMP) with Disaster Management Committees at different levels, they are still not supported with any funds to carry out their responsibility. There is also no broad-based ownership of the plans, resulting in different stakeholders implementing them in many different ways. Numerous promising disaster reduction approaches validated by local organizations and communities is yet to be merged into a common national approach (MODMR, 2014).

A summary of the institutional mechanisms and committees for DRR is given in following table:

Table 2.5: Summary of Institutional Mechanism and Committees for DRR

Level	Summary
National Level Bodies	**National Disaster Management Council (NDMC)** headed by the Prime Minister to formulate and review the disaster management policies and issue directives. **Inter-Ministerial Disaster Management Co-ordination Committee (IMDMCC)** headed by the Minister for Food and Disaster Management to implement disaster management policies and decisions of NDMC/Government. **National Disaster Management Advisory Committee (NDMAC)** headed by an experienced person nominated by the Prime Minister. **Cyclone Preparedness Programme Implementation Board (CPPIB)** headed by the Secretary, MoFDM, to review the preparedness activities at the initial stage of an impending cyclone. **Disaster Management Training and Public Awareness Building Task Force (DMTATF)** headed by the Director General of the Disaster Management Bureau (DMB) to co-ordinate disaster related training and public awareness activities of the government, NGOs and other organisations. **Focal Point Operation Coordination Group of Disaster Management (FPOCG)** headed by the Director General of the DMB to review and co-ordinate the activities of various departments and agencies working on disaster management and also to review the Contingency Plan prepared by relevant departments. **NGO Coordination Committee on Disaster Management (NGOCC)** headed by the Director General of the DMB to review and co-ordinate the activities of NGOs working on disaster management. **Committee for Speedy Dissemination of Disaster Related Warning/Signals (CSDDWS)** headed by the Director General of the DMB to examine, ensure and identify the ways and means for speedy dissemination of warnings and signals to the population at risk.
Sub-National Level Bodies	**District Disaster Management Committee (DDMC)** headed by the Deputy Commissioner (DC) to co-ordinate and review the disaster management activities at the district level. **Upazilla Disaster Management Committee (UZDMC)** headed by the Upazilla Nirbahi Officer (UNO) to co-ordinate and review the disaster management activities at the Upazilla 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 the 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.

(Source: http://www.wri.org/sites/default/files/uploads/wrr_case_study_bangladesh)

While the Government of Bangladesh has made considerable progress in addressing the issue of Disaster Management and DRR, there are still gaps as many of the policies and plans at national and local levels where some have been developed as a part of larger international and regional initiatives such as the SAARC Framework of Action and the Hyogo Framework for Action (HFA), which is still facing the problem of inadequate funding, coordination and effective implementation. Disaster Management Committees at different levels still are not supported with any funds to carry out their responsibility. The regional coordination is still relatively weak although Bangladesh is very much dependent on the DRR and Climate Change policy of the neighboring countries. This refers also to the cross-border flood forecasting system. Existing earthquake building codes are not applied and the preparedness and the operational crisis coping and response capacity of the government regarding earthquakes is still in its initial stages (DMB, 2010).

Institutional donors such as DFID, EU, UNDP showed their commitment to initiatives of the Government of Bangladesh with regard to DRR, e.g. through supporting the CDMP program. In this program UNDP is providing policy advisory services and capacity development to the Government of Bangladesh in risk mitigation and effective humanitarian response. Important stakeholders at a regional level are the United Nations Strategy for Disaster Reduction (UNISDR) and the Asian Disaster Preparedness Centre (ADPC) with offices in Bangkok but also involved in program in Bangladesh. However, existing coordination set-up between government and donors is still largely response and not prevention and preparedness oriented. Harmonization among donors is still not institutionalized; this applies also to regional coordination (World Resources Report Case Study, 2014).

Bangladesh has one of the largest NGO communities in the world. Under the umbrella of their integrated development projects many of them are active in post-disaster response and rehabilitation operation as supplementary to the efforts of the government. Some of them like OXFAM, CARE, Concern and Action Aid as international as well as BRAC, BDPC, CNRS and other as national NGOs, have high focus on pre-disaster awareness and preparedness at household and community level. They have also started to mainstream their programs for DRR and organized themselves in a number of DRR consortia, such as Disaster Forum (initiated by Oxfam), Nirapad (initiated by CARE) and NC4 (200 national and local NGOs under the secretariat of BDPC) (DRR National Coordinating Mechanisms in Bangladesh, 2014).

In general, risks associated with natural hazards can be expected to increase because of the effects of climate change and the fast-growing population and infrastructure, mainly in areas not suitable for living. The frequency and intensity of floods have increased during the last years and in addition, the country faces the risk of losing at least 10% of its land mass within the first half of this century because of rising sea levels. Although floods can be seen as a regular phenomenon in Bangladesh and people have tried to adapt themselves over generations, yet with the fast rate of population growth and rapid urbanization has forced people to live in areas which are very much exposed to flooding. Thus, well-proven coping mechanisms don't work any longer (Shaw, Mallick and Islam, 2013).

Moreover, cyclones and storm surges are a continuous threat for coastal population. The average annual frequency of tropical disturbances in Bay of Bengal ranges between 12 and 13, of which five attain the cyclonic strength. Most of these cyclones strike land on the Bangladesh coast or eastern coast of India. Although they make up only 5% to 6% of global total, they are the deadliest in the world accounting for about 75% of the global losses in terms of lives. According to experts, after almost 80 years without any large earthquake, the probability of a major earthquake occurring soon is high. It is point of concern that this may cause great devastation due to the rapid growth of densely populated urban areas with structures lacking quality as well as earthquake resistant design (URL 15 and 16).

Within this incredibly challenging context, Bangladesh is one of the best examples in the world of real achievements in disaster management, a result of long-term focus on the issue. The country fundamentally transformed its approach, long before the global consensus on the risk reduction agenda was agreed under the Hyogo Framework of Action (HFA) in 2005. Bangladesh has moved from "reactive humanitarian relief" after a disaster to "proactive risk management" before the disaster and an emphasis on the combination of response and an early return to the development trajectory, immediately after a crisis. Innovation is a crucial element of how Bangladesh responds to disasters. Early warnings for cyclones and floods are disseminated through mobile phone alerts from the Disaster Management Information Centre (DMIC). But even with all these efforts, it is very clear that Bangladesh faces a real challenge in managing and reducing risk and in ensuring highest quality preparedness and response after any natural disaster (Shaw, Mallick and Islam, 2013).

CHAPTER 3: ROLE OF ICT IN DISASTER MANAGEMENT PRACTICE

3.1 ICT in Disaster Risk Reduction Approaches

The consequences of natural disasters and the vulnerabilities to which populations are exposed can be mitigated if they are addressed proactively. Though it is not always possible to completely eliminate a risk, experience and practice have demonstrated that the damage caused by any disaster can be minimized largely by careful planning, mitigation and prompt action. In this context, ICT can potentially play a pivotal role in disaster prevention, mitigation and management. ICT encompasses both traditional media (radio, television) as well as new emerging media (cell broadcasting, Internet, satellite radio, etc) all of which can play a major role in minimizing the risks of a potential or impending disaster. Before disasters strike, ICTs are used as a conduit for disseminating information on an impending danger, thereby making it possible to take the necessary precautions to mitigate the impact of these disasters. Hence, it is crucial that there is consistency in the application of ICT for at-risk areas in achieving effective DRR (Wattegama, 2007).

A disaster presents a particular context for ICT use. Data need to be acquired and analysed under severe time pressure. Practically, the data users are frequently without adequate training and working under difficult circumstances. Uncertainty and ambiguity are an inherent part of the environment. A disaster may have discrete origins but its effects propagate and interact in such a way that intensifies the complexity and uncertainties. Thus, the specific communication and information processing requirements will vary with context, type, distance of disaster site, time relative to disaster onset, latency of disaster and available bandwidth (Yap, 2011).

ICT can play a significant role in highlighting risk areas, vulnerabilities and potentially affected populations by producing geographically referenced analysis. The importance of timely disaster warning in mitigating negative impacts can never be under-estimated. Though damage to property cannot be avoided, developed countries have been able to reduce loss of life due to disasters much more effectively than their counterparts in the developing world. A key reason for this is the implementation of effective disaster warning systems and evacuation procedures used by the developed countries contrary to absence of such measures in the developing world (Wattegama, 2007).

In global DRR scenario there is a growing concern for the use of ICT in effective disaster management. Consequently, studies are carried in respect to typical requirements of developing countries for drawing findings on several ICT tools for emergency management (ICT4E). In this regard, a study was carried out in 2007 by the Disaster Resource Network to examine the factors contributing to effective ICT use in DRR. Also in 2007 the US National Research Council's Committee on Using ICT to Enhance Disaster Management identified areas of ICT capabilities necessary for improving ICT use. The EU ICT Strategy for Disaster Mitigation also listed few key elements for enhancement in use of ICT. In 2010, a post-Haiti earthquake meeting of technology and development experts identified opportunities facing ICT use in disaster response (Yap, 2011). Due importance of the new era in digital domain highlighting change in the trend was fully explored in IFRC's World Disasters Report 2013 with a focus on technology and the future of humanitarian action The UN Broadband Commission for Digital Development, a public–private partnership, is currently championing high-speed connectivity and through it, access to a set of transformative technologies (IFRC Annual Report, 2013).

Advancement in ICT in the form of Internet, GIS, Remote Sensing and satellite-based communication links can help a great deal in planning and implementation of DRR measures. These technologies have been playing a major role in designing early warning systems, catalysing the process of preparedness, response and mitigation. ICT tools are also being widely used to build knowledge warehouses using internet and data warehousing techniques. These knowledge warehouses can facilitate planning & policy decisions for preparedness, response, recovery and mitigation at all levels. Similarly, GIS-based systems improve the quality of analysis of hazard vulnerability and capacity assessments, guide development planning and assist planners in the selection of mitigation measures. Communication systems have also become indispensable for providing emergency communication and timely relief and response measures (Yap, 2011).

3.2 ICT in Disaster Risk Mitigation, Prevention and Preparedness Activities

ICT can be used to minimize the impact of disasters in many ways. In disaster mitigation and preparedness process, ICT is widely used to create early warning systems (EWS). A EWS may use more than one ICT tool in parallel and these can be either traditional (radio, television, telephone) or modern (SMS, cell broadcasting, Internet). Media plays an important role in disseminating timely disaster information. EWS, television and radio broadcasting, web portals, long-distance education and telecommunications have a significant role in disaster mitigation. Despite essentiality of ICT in disaster management it should also not be taken as panacea for all ills. ICT, like any other tool, can deliver its best force multiplier effect when other necessary ingredients are in place simultaneously (Munodawafa, 2008).

The emergence of new technology and scientific knowledge provides opportunities to increase the lead times of predictions of natural hazards. It also ensures the availability and accuracy of user-friendly data to help countries and communities especially the most vulnerable. World Meteorological Organization (WMO) coordinates a global network of the national meteorological and hydrological services (NMHSs) of its 191 members with more than fifty thousand weather reports and several thousand charts and digital products, which are disseminated every day through the system (URL 17). The network is comprised of three interlinked operational components:

- **Global Integrated Observing System**: Collects data from 17 satellites, hundreds of ocean buoys, thousands of aircrafts and ships and nearly ten thousand land-based stations.
- **Global Telecommunication System (GTS)**: A dedicated network of surface and satellite-based telecommunication links and centres operated round the clock throughout the year.
- **Global Data Processing and Forecasting System**: A network of nearly 50 global and regional specialized meteorological centres that provides analysis, bulletins and related information.

3.2.1 Early Warning Systems (EWS)

Disaster warning is indeed a system, not a singular technology. It consist the identification, detection and risk assessment of the hazard, the accurate identification of the vulnerability of a population at risk. Finally, the communication of information about the threat to the vulnerable population is essential in sufficient time and clarity so that they can take action to avert negative consequences. This final component underscores the importance of education and creating awareness in the population so that they may respond with the appropriate actions. Effective disaster management relies on thorough integration of emergency plans at all levels of government and non-government involvement. Activities at each level (individual, group, community) affect the other levels (UN-APCICT, 2007).

EWS is used to assist preparedness for the prevention of disasters, thus timing of such warnings is very important. EWS has four separate but interlinked elements as follows (ITU, 2015):

- Risk knowledge.
- Technical monitoring and warning service.
- Dissemination and communication of warnings.
- Response capability and preparedness to act (by authorities and by those at risk).

3.2.2 Timely and Effective Delivery of Early Warnings to the 'Last Mile'

'Last mile' is the term used to express the sentiment that warnings and the means to respond to them often do not reach those who need it the most, which was described by Nonita T. Yap in his study. He also viewed, people who for reasons of age, gender, culture or poverty are not reached by disaster preparedness and thus remain in the weakest link in the communication chain resulting many casualties. People-centred approaches to EWS are predicated on the assumption that people can be capable, resilient and able to protect themselves given accurate, timely, consistent and actionable information from a trusted source. Such approaches require that individuals and communities at risk, particularly those at the 'last mile', understand the threats to their lives and property, share this awareness with others, and are able to take action to avoid or reduce their exposure (Yap, 2011).

3.3 ICT Channels Used for Disaster Risk Reduction

The different digital technologies and their use to reduce disaster risks are briefly highlighted below. This is not meant to be an exhaustive list of ICTs but provide highlights of some key ICTs that have proved indispensable to DRR. Some may be more effective than the rest, depending on the nature of the disaster, the regions affected and socio-economic status of the affected communities.

3.3.1 Terrestrial Radio and Television

Radio and television remain the traditional media used in disaster management, because they are relatively cheap, provide a reliable one-to-many communication medium and most importantly, do not require literacy. Radio in particular is the most accessible medium to the poor, especially women in their homes, or fishermen at sea, workers out in the fields. They can be used to spread a warning quickly to a broad population. The only possible drawback of these two media is that their effectiveness is significantly reduced at night, when they are normally switched off. However, in the poorest communities, even battery-powered radio still remains a luxury (UN-APCICT, 2010).

3.3.2 Mobile Technology

A target set by world leaders at the World Summit on the Information Society (WSIS) (URL 18) that more than half the world's population should have access to ICTs has been reached seven years ahead of schedule (URL 19). Details of post-2015 ICT indicators target list is given at annex A. Mobile technology is probably the most rapidly expanding technology in terms of the speed of expansion and reach to the unconnected. The technology is mostly based on voice and short message service (SMS). But with the rapid growth in mobile phone usage, more sophisticated mobile services are being introduced. The extensive use of mobile phones in some countries has prompted humanitarian organizations to explore their extensive usage for DRR, in particular for early warning (UN-APCICT, 2010).

The number of mobile-cellular subscriptions worldwide is approaching the number of people on earth. Mobile-cellular subscriptions were forecasted to reach almost seven billion by the end of 2014, corresponding to a penetration rate of 96%.

More than half of these connections (3.6 billion subscriptions) to be in the Asia-Pacific region. In developing countries, mobile-cellular penetration to reach 90% by the end of 2014, compared with 121% in developed countries (URL 20).

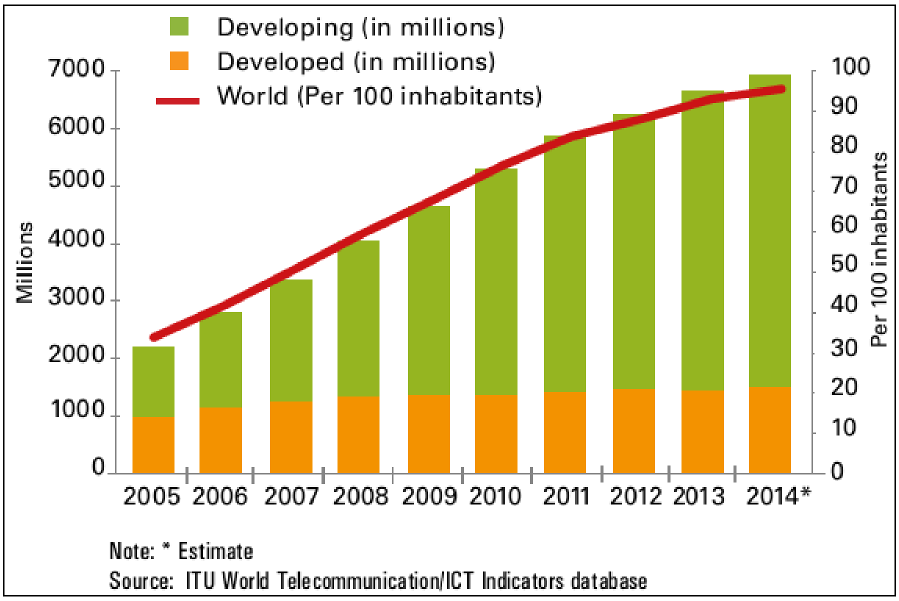


Figure 3.1: Mobile-cellular Subscriptions, Total and Per 100 Inhabitants

(Source: http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFacts2014-e.pdf)

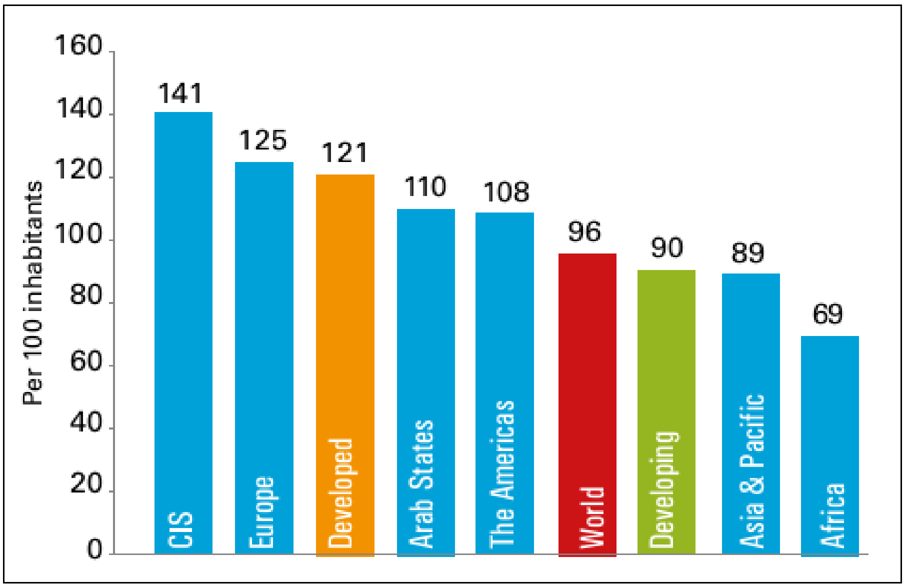


Figure 3.2: Mobile Subscriptions, Total and Per 100 Inhabitants by Region

(Source: http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFacts2014-e.pdf)

The developing countries share continues to increase and by end of 2014, the number of mobile-cellular subscriptions will account for 78% of the world's total (URL 20).

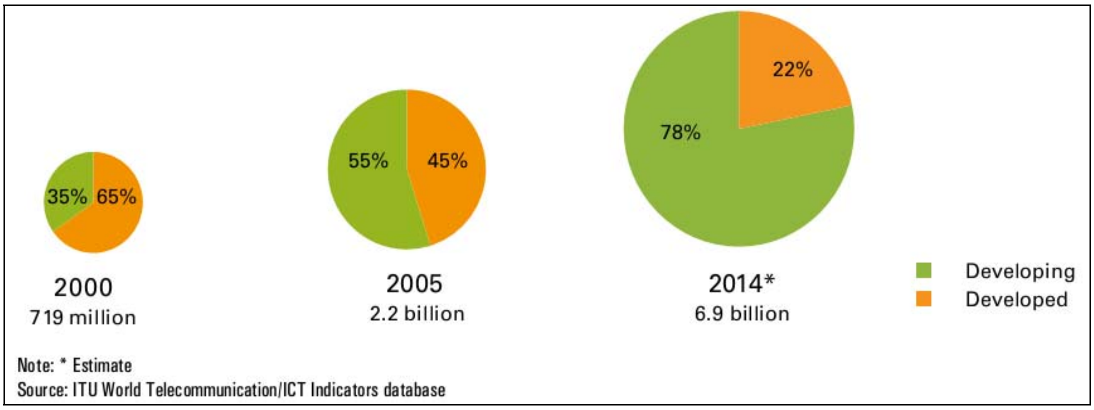


Figure 3.3: Share of Mobile-cellular Subscriptions by Level of Development

- **Cell Broadcasting (CB)**

CB has several advantages over SMS, particularly for early warning. This is being assessed and tested successfully in a number of countries including Bangladesh. While SMS is a one-to-one and one-to-a-few service, CB is a one-to-many geographically focused messaging service (URL 21). Messages can be tailored to multiple phone subscribers located within a given part of its network coverage area at the time the message is broadcast (URL 22).

Figure 3.4: Cell Broadcasting in Disaster Management

(Source: http://www.cellbroadcastforum.org/whatisCB)

3.3.3 Satellite Radio

Satellite radio receives its signal from a communication satellite and therefore has a wider geographical range than terrestrial radio. It is very useful when transmission towers are damaged. Recently in Sri Lanka, a satellite radio, combined with fixed or mobile phones was shown to be the most effective and reliable of five ICT tools in eight combinations tested for transmitting early warning information from government agencies to 32 at-risk villages. However, satellite usage is very costly for both service set up and the purchase of a satellite-enabled radio. Service can also be interrupted by trees, buildings and some weather conditions (Yap, 2011).

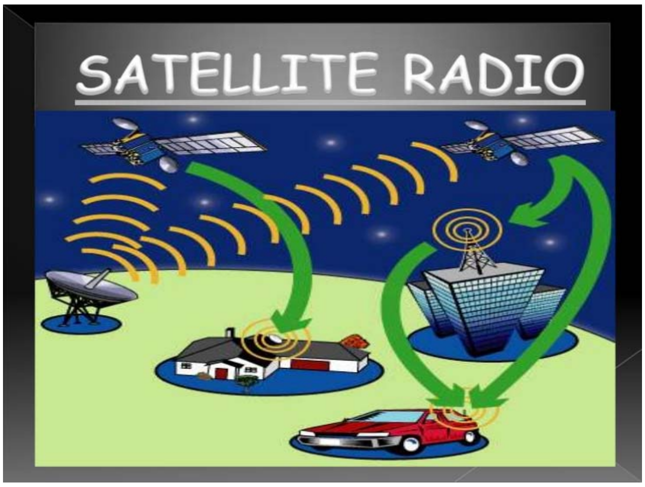


Figure 3.5: Satellite Radio (Source: http://en.wikipedia.org/wiki/Satellite_radio)

3.3.4 Amateur and Community Radio

In times of crisis, amateur and community radio is often used as a means of emergency communication when other conventional means of communication become damaged or destroyed. This is because amateur radio is not as dependent on terrestrial systems that can fail. Amateur radio operators are trained volunteers known worldwide not only for their skills to provide emergency communication facilities but also for their dedication to help save lives. Amateur radio broadcasters are authorized to communicate on high frequency (HF), very high frequency (VHF), ultra high frequency (UHF) or all three bands of the radio spectrum. Details are given at Annex D. However, they require a license from the licensing authority to ensure that only competent operators use their skills (Wattegama, 2007).

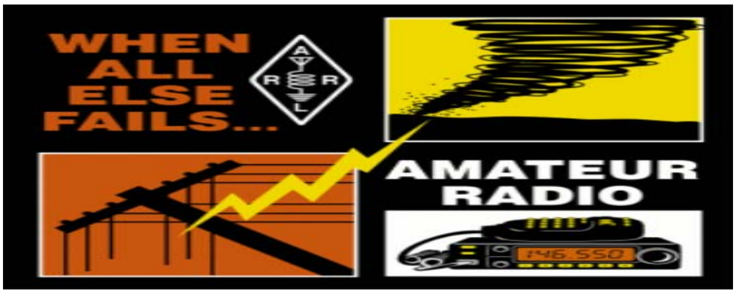


Figure 3.6: Amateur Radio in Disaster Management

(Source*:* en.wikipedia.org/wiki/Community radio)

Recently, amateur radio's role in response after the Sichuan earthquake has been well documented. Within three minutes after the tremors from the Sichuan earthquake was felt in Chengdu, the capital of Sichuan, the first local amateur radio emergency network was set up. Seventeen minutes later, over 200 stations around Chengdu city had checked in to the emergency network. This became the major channel for coordinating local response (UN-APCICT, 2010).

3.3.5 Broadcast Radio

Broadcast radio has been used to disseminate early warning messages, as well as for awareness raising and community education. For example, in Afghanistan, broadcast radio has been used successfully to raise awareness on disaster-related issues through a radio soap opera. New Home New Life (NHNL) has been broadcasted in Dari and Pashto on the BBC World Service since 1994. Evaluation results provided clear evidence that, listeners of NHNL recall the disaster-related messages from the soap opera, and some of them have even taken specific actions to prepare for disasters (UN-APCICT, 2010).

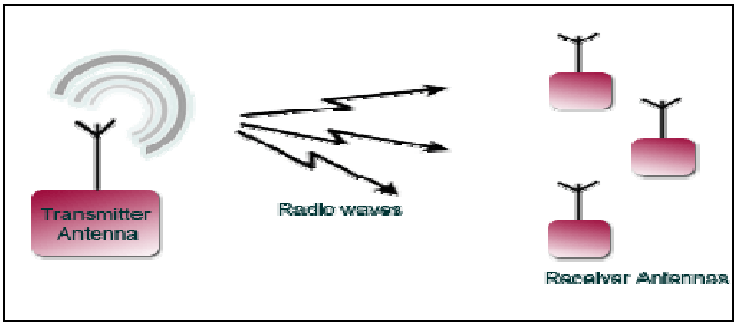


Figure 3.7: Broadcast Radio in Disaster Management

(Source: http://en.wikipedia.org/wiki/Radio_broadcasting)

3.3.6 Internet/Email

Internet use is spreading rapidly in the global context. The role of Internet, email and instant messages can play in disaster warning entirely depends on their penetration within a community and usage by professionals such as first responders, coordinating bodies, etc. Aimed at improving early warning and response, the Global Disaster Alert and Coordination System (GDACS) of OCHA provides near real-time alerts about natural disasters around the world and tools to facilitate response coordination, including media monitoring, map catalogues and the Virtual On-Site Operations Coordination Centre (Virtual OSOCC).

There are also online portals and communities that focus on knowledge sharing for long term recovery, preparedness and mitigation processes. Portals, such as PreventionWeb, ProVention, Consortium and ReliefWeb focus on providing a searchable repository of relevant resources, news and events; and communities, such as the UN Solution Exchange for Disaster Management Community. These emphasizes the building of an online community over time to exchange ideas and experiences and advance the field of disaster management, including the sharing of good practices and lessons learned.

The Internet is acknowledged to be one of the most reliable information infrastructures even under adverse physical conditions, and electronic mail, its most widely used application. The utility of the Internet and email in disaster management is however limited by the low Internet penetration (2 to 5%) in developing countries and the fact that many of those with connection are not regular users. The non-English content of the Internet also remains limited (Yap, 2011).

- **Internet User Statistics**

  By the end 2014, the number of Internet users globally would have reached almost three billion. Two-thirds of the world's Internet users are from the developing world. In developing countries, the number of Internet users would have doubled in five years, from 974 million in 2009 to1.9 billion in 2014. The number of mobile-broadband internet subscriptions reaches 2.3 billion, with 55% of them in developing countries (URL 20). Differences in high-speed access to the internet are given at Annex C.

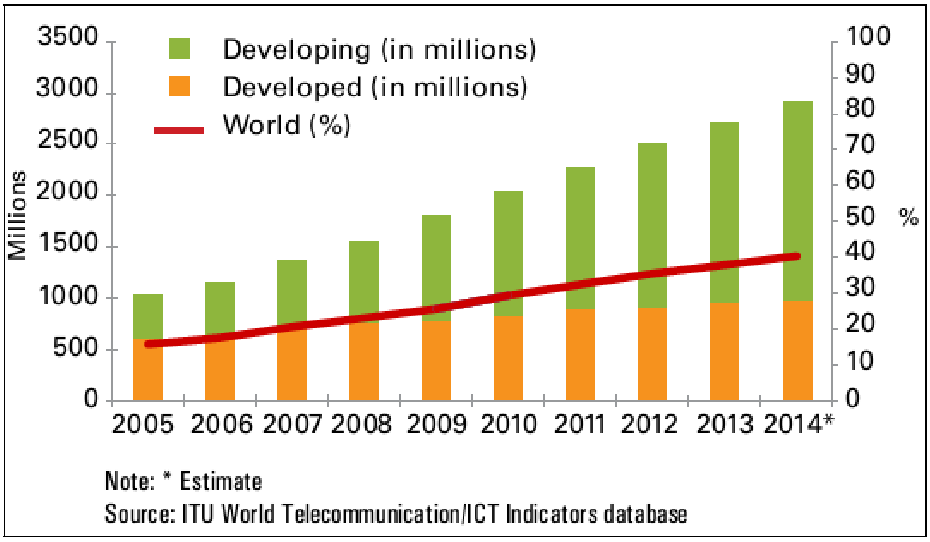


Figure 3.8: Individuals Using the Internet (Total and Percentage)

(http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2014-e.pdf)

Internet User Penetration Rate

It has reached 40% globally, 78% in developed countries and 32% in developing countries. 2014 growth rates in developed countries remain at a relatively low, at 3.3% compared with 8.7% in developing countries. Globally, there are 4 billion people not yet using the Internet and more than 90% of them are from the developing world (URL 20).

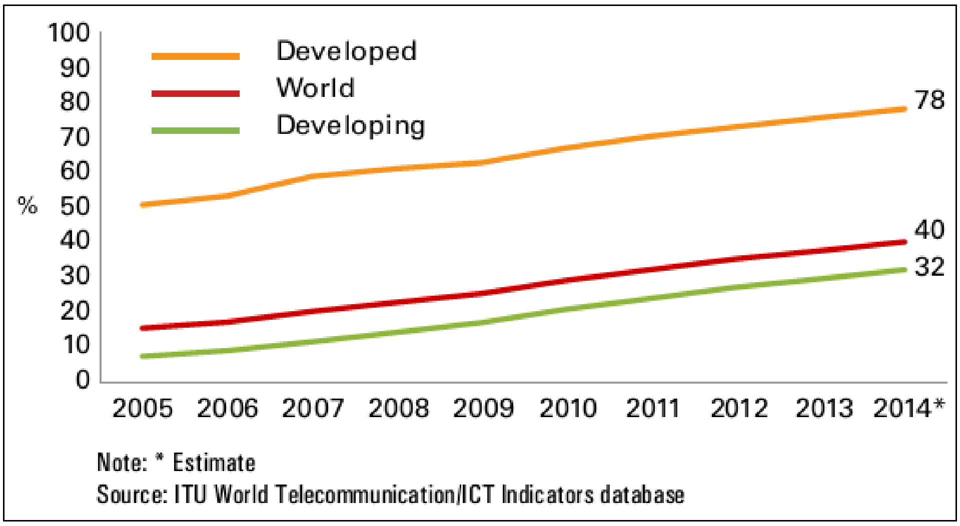


Figure 3.9: Percentage of Individuals Using the Internet

(http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2014-e.pdf)

Households Internet Access Rate

By end 2014, 44% of the world's households would have Internet access at home. Close to one third (31%) of households in developing countries will be connected to the Internet, compared with 78% in developed countries (URL 20).

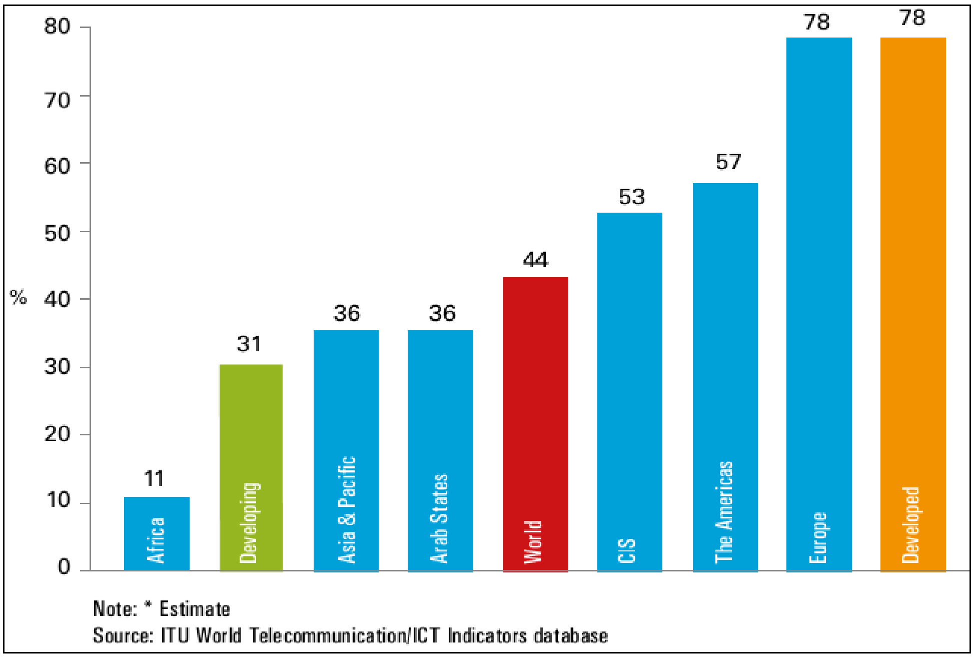


Figure 3.10: Percentage of Households with Internet Access by Region

(http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2014-e.pdf)

Social Medias

Internet social networks, such as Twitter, Google Plus, YouTube and Facebook, represent a newly emergent channel of communications which gained great social prominence over a relatively short span of time. The vast audiences that can be reached by them represent a valuable opportunity to promote the goals of DRR. A study conducted on Social Media and Emergency Management offers potential DRR applications as follows (Williams and Phillips, 2014):

- Meeting and managing citizen expectations.
- Increasing situational awareness.
- Crowdsourcing and leveraging citizens as force multipliers.

3.3.7 Space-based Technology

Space-based technologies are increasingly being recognized as essential in improving performance during all phases of the DRR cycle, particularly for remote sensing, mapping and communication. The United Nations Institute for Training and Research (UNITAR) offers countries access to satellite data through the UNITAR Operational Satellite Applications Program. According to UNITAR, "UNOSAT is a technology-intensive program delivering imagery analysis and satellite solutions to relief and development organizations within and outside the UN system to help make a difference in critical areas such as humanitarian relief, human security, strategic territorial and development planning. UNOSAT develops applied research solutions keeping in sight the needs of the beneficiaries at the end of the process."

- **Remote Sensing**

Remote sensing refers to the process of recording information from sensors mounted either on satellites or aircrafts. Earth observation satellites, for example, can be used to view the same area over long periods of time and thus, make it possible to monitor environmental change, human impact and natural processes. This helps scientists and planners create models to simulate trends observed, and offer projection for the future.

Operational Satellite Applications Program (UNOSAT) of the UNITAR that supports the humanitarian community (UN and non-UN) with maps and analyses derived from satellite imagery acquired commercially or via the International Charter on Space and Major Disasters. In 2003, UNOSAT created a humanitarian rapid mapping service to help coordinate response and relief efforts (UN-APCICT, 2010).

- **Geographic Information Systems (GIS)**

GIS is a vital application for transforming images generated through remote sensing to an information system that can be used to produce interactive maps, conduct spatial analyses, present results in a variety of ways and manage the data. GIS is essentially the merging of cartography and database technology.

For mitigation, GIS can be used to identify high risk areas and prioritize them for mitigation activities. For preparedness, GIS can be used to identify evacuation routes, shelters outside the hazard zone, and resources available (people, equipment, supplies) in the area and its vicinity that can be mobilized in the event of a disaster (UN-APCICT, 2010).

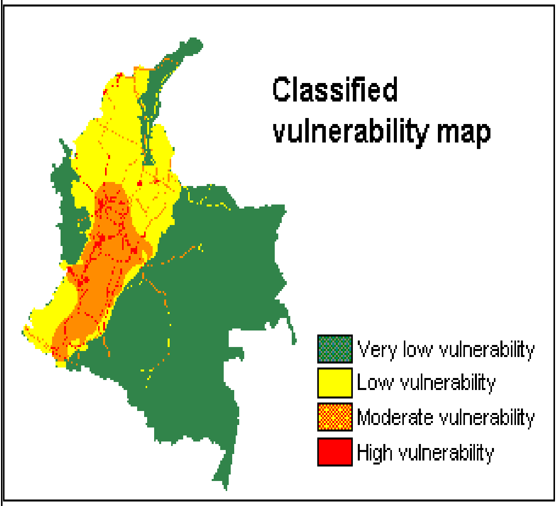
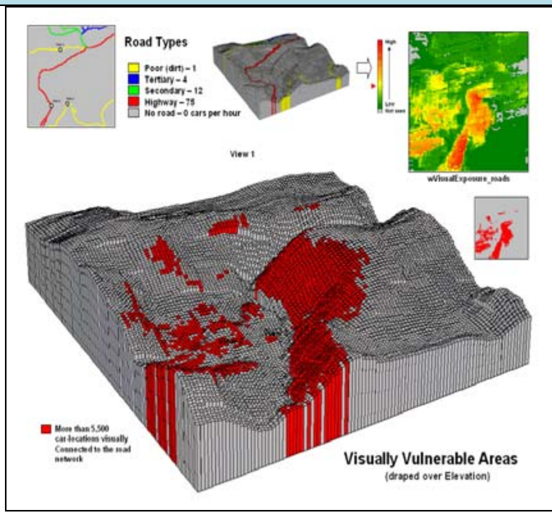
Vulnerability Map without RS/GIS Components	**Vulnerability Map with RS/GIS Components**
	
Static Information. Mostly analogue and non-interactive	Dynamic Information (with cause and effect relationship). Real Perspective visualization

Figure 3.11: Difference of Ordinary (2D) Map and Map with GIS Input

(Source: UNOSAT retrieved from http://www.unitar.org/unosat)

- **Satellite Communications**

Many emergency communication systems use satellite phones either as back up or a means for two-way communication during disasters as these technologies will remain functional when terrestrial networks fail (URL 23). High-speed internet access can be switched to satellites in the event of a disaster. Satellite communications have also been used to reach the remote communities where terrestrial or wireless networks are not available and not considered commercially and technologically viable to set up. Combining remote sensing satellites with communication satellites can be useful in ensuring that data generated by satellites reach disaster managers and planners. Being able to integrate satellite data with other geo-spatial datasets and ICTs is also equally important (ITU, 2015).

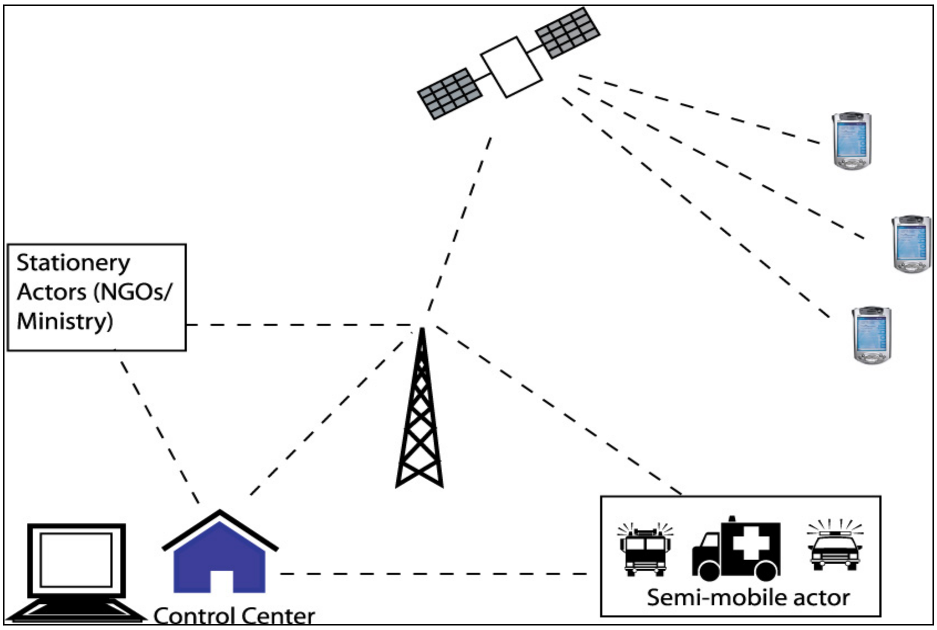


Figure 3.12: Satellite Communication in Disaster Management

(Source: http://www.un-spider.org/book/5101/4c-challenge-communication-coordination-cooperation-capacity-development)

On-line Searchable Remote Sensing Disaster Database

Remote Sensing Disaster Database (SFCG) contains sources of satellite-based remote sensing data helpful in times of natural disasters. The database was constructed in response to a request from International Telecommunications Union (URL 25). The database provides information on instruments, mission, frequency of operation, data product, product usage and also data latency on remote sensing missions and instruments that can support disaster management and relief support efforts (URL 26).

Global Positioning System (GPS)

GPS has played a vital role in relief efforts for global disasters such as the tsunami that struck in the Indian Ocean region in 2004, Hurricanes Katrina and Rita that wreaked havoc in the Gulf of Mexico in 2005, and the Pakistan-India earthquake in 2005. Search and rescue teams used GPS, geographic information system (GIS), and remote sensing technology to create maps of the disaster areas for rescue and aid operations, as well as to assess damage (URL27).

3.3.8 Comparative Picture of ICT Applications in DRR

ICT Application	Advantages	Disadvantages
Cell Broadcasting	- Not affected by traffic load. - Will not add to congestion. - Messages can be differentiated by cells or sets of cells. - Greater authenticity of message.	- Must be literate. - Phone must be switched on. - Phone must be set to receive cell broadcasting.
GIS and Remote Sensing	- Continuous monitoring. - Spatial presentation of data. - Facilitates cooperative effort.	- Require high bandwidth. - Require high-speed networks. - Costly hardware and software - Require skilled professionals. - Difficulty capturing qualitative data.
Internet/Email	- Interactive. - Multiple sources can be checked for accuracy of information.	- Low penetration rate. - Must be literate. - Internet content in local languages may be limited.
Mobile Phone [Text SMS]	- High penetration rate. - Portable. - Relatively low cost.	- Must be literate. - No indication that message is generated by a legitimate authority. - Subject to congestion and thereby delay.
Radio	- One-to-many broadcasting. - Does not require user to be literate. - Portable.	- Less effective at night.
Satellite Communications	- Independent of terrestrial communication network that can be damaged by natural hazards.	- High cost of systems hardware and bandwidth utilization. - Unlikely to work indoors.
Telephone	- Does not require user to be literate.	- Inadequate penetration rates. - Congestion of phone lines during emergencies. - Disasters can damage infrastructure.
Television	- One-to-many broadcasting. - Does not require user to be literate.	- Less effective at night.

(Source: http://www.unapcict.org/ecohub/resources/
Disaster%20Management%20Role%20of%20ICTs.pdf)

3.4 ICT in Disaster Response Mechanism

The most difficult period of a disaster is immediate aftermath. This period calls for prompt action within an exceptionally short period of time. In the aftermath of any disaster, a significant number of individuals will be injured and/or displaced. Many of them may still be living with the trauma they have encountered, including loss of loved ones. For affected communities it is to communicate with the front-line responders, look for family and friends, and increasingly also connect with diaspora communities. The biggest communication surge is said to be in the first 12 hours after the onset with the intensity of demand declining somewhat but remaining high for up to three days. Even in a developed country like Japan- the 11 March 2011 earthquake and tsunami caused 1.2 million fixed telephone lines and 15,000 mobile base stations unusable and 80% of these breakdowns in both cases were caused by widespread and prolonged power outages (ITU, 2015). The available information tools were very much affected by the damage caused by the tsunami as shown in following figure:

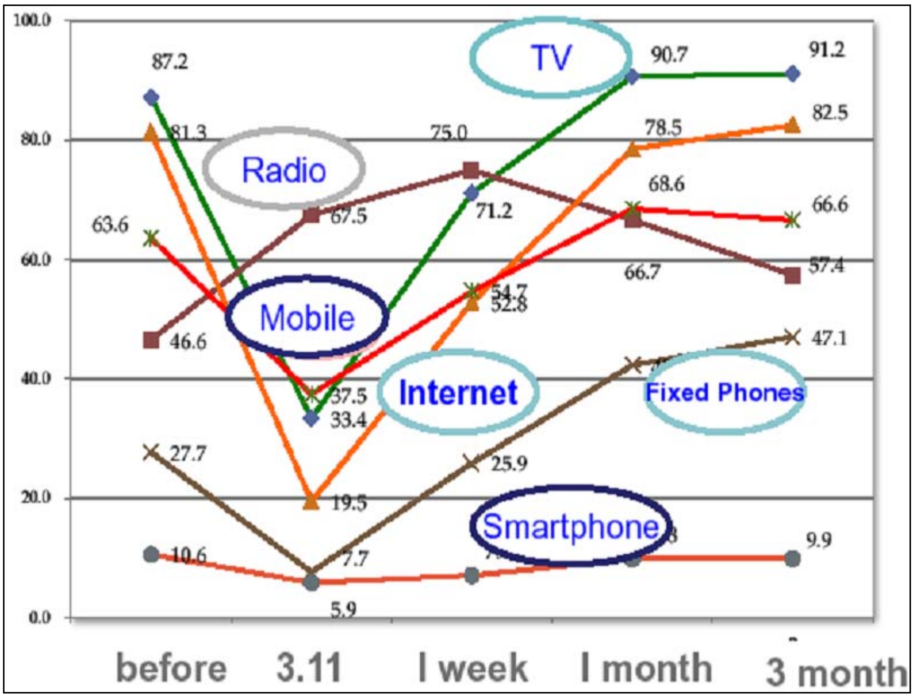


Figure 3.13: Available ICT Tools in Japan Earthquake Disaster

(Source: http://www.itu.int/en/ITU-T/focusgroups/drnrr/Documents/Technical_report-2013-06.pdf)

However, frequently large parts of the telecommunications infrastructure are destroyed or incapacitated for several days if not weeks; those that survive suffer overload. The complex interdependencies of technology systems and ICT networks make them vulnerable to failure from ignorance, human malice and technical malfunction. It also means the failure of one system can lead to failure of another (URL 28).

Communication and coordination under such uncertain conditions has benefited from technological development and the creativity of committed ICT professionals. For effective response, emergency response planning before disaster strikes is absolutely critical. As part of this emergency planning process, many countries have established Emergency Operation Centres (EOCs) (URL 29).

3.4.1 Providing Emergency Communication Means

When a disaster strikes, there are a handful of organizations that are ready to provide assistance. In providing emergency communication ITU for instance, deploys mobile satellite terminals and various other communications equipment to help restore vital communication links for the coordination of relief operations. This is part of the ITU Framework for Cooperation in Emergencies that has benefited from the contribution of funds and equipment from its partners - FedEx, ICO Global Communications, Inmarsat, Iridium, TerreStar Global, Thuraya and Vizada (UN-APCICT, 2010).

Telecoms Sans Frontiers (TSF) that is involved in the provision of communications to UN agencies and humanitarian organizations to coordinate emergency relief, and in providing those affected by the disaster a free phone call. Recently, TSF has also been working with various countries in strengthening their capacities to respond to disasters through training and by expanding the ICT infrastructure. Most data needed in a disaster are geospatial. The first questions typically asked are related to the location of the disaster event. In this context, there are a number of information systems and communication solutions for response and recovery being developed and continually improved upon. Examples of systems developed in Asia include DUMBO, OpenCARE and Sahana (UN-APCICT, 2010).

WFP has partnered with Vodafone Foundation and United Nations Foundation to set up an ICT Humanitarian Emergency Platform to increase the efficiency and coordination of emergency communication by optimizing and standardizing ICT solutions in emergencies, organizing training programmes on the use of ICTs in disaster preparedness and response to expand the pool of trained ICT experts, (URL 29) establishing a network of stand-by partners ready for deployment, and enabling immediate dispatch of ICT emergency responders (WFP, 2015).

3.4.2 Use of Internet in the Aftermath of Disaster

On 17 August 1999, a major earthquake caught people off guard in Izmit, Turkey, resulting in 15,000 deaths. During the Izmit earthquake, telecommunications infrastructure was so extensively damaged that it was impossible to access emergency services. The use of public phones was almost impossible, while mobile phone networks were operating with reduced bandwidth. In addition, many of the microwave repeaters mounted on apartment buildings had been damaged during the quake. In this situation, Internet was the only possible medium that could connect the affected areas to the outside world. Several Internet applications were used in the post-disaster response, mainly in two key areas: coordination of aid disbursement and finding information about missing people (UN-APCICT, 2007).

Due to system disruption, donors often found them acting as the distributors of aid as well, thus, the internet proved a valuable resource. The importance of information security and privacy can never be underestimated in ICT-based humanitarian systems. In these cases, data privacy is not just a matter of encryption; it can also be a matter of life and death. More recently, with the growing popularity of Web 2.0 tools, they have been used as a mechanism for the coordination of response and recovery initiatives. Hundreds of blogs emerged in the first few days following the 2004 Indian Ocean Tsunami. These were used for providing instantaneous situation reports, information sharing, locating missing persons and fund raising. (UN-APCICT, 2007) (URL 30).

3.4.3 Tracing Missing Persons

After a disaster onset, there are often a large number of individuals missing. It is common to find families scattered and children separated from their parents. Outside relatives and friends, especially those living overseas, naturally want to know the latest information about the condition of their loved ones. The psychological strain on children can be severe and it is essential that they be reunited with their families as soon as possible.

Sahana, free and open source software (FOSS)-based system developed by Lanka Software Foundation after the 2004 Indian Ocean Tsunami, is a suite of web-based applications that provides solutions to such problems arising in a post-disaster situation. Sahana is a popular web-based disaster management application for tracking missing people and coordinating relief and recovery efforts of different agencies, including the matching of pledges of aid to requests from the field and the management of camps. Sahana is a FOSS application, which means all users can use, copy, distribute and modify the software without having to seek permission for a license (UN-APCICT, 2010).

3.5 ICT in Disaster Recovery Enhancement

Disaster reconstruction has to start as soon as the initial disaster clean-up has taken place. This is a very complex endeavour, requiring a huge array of skill sets and a thorough knowledge of an ever-increasing variety of techniques and equipment. A range of software tools are being used for these purposes. Thus, while the role of ICT in the long-term disaster recovery process is not as apparent as it is in disaster warning, there is no doubt that ICT is being used widely to expedite these activities (URL 31).

Even in a developed country like Japan- due to the 11 March 2011 earthquake and tsunami; although the telecommunications infrastructure was severely impacted the damages affected fewer households than the damages to other utilities such as power and water supply and the recovery time was shorter than for these services (Table 3.1). Thus, it is important that the telecommunications infrastructure is more resilient than other utility infrastructures as ICT is used both to support these other services and is critical in the overall recovery process (ITU, 2015).

Social Infrastructure	Damage (# of Houses)	Recovery (days)
Power Grid	8.5 Millions	99
City Gas	2.0 Millions	54
Water Supply	2.3 Millions	Not completed by the end of July, 2011
Telecommunication	1.0 Millions	56

Table 3.1: Recovery Time - Damaged Infrastructure in Japan Earthquake-Tsunami

(Source: http://www.bousai.go.jp/jishin/chubou/higashinihon/8/4.pdf)

3.5.1 Specific Disaster Management Software

Different types of software tools are being used to gather, store and analyse data related to disasters, not only in post-disaster conditions, but also as a long-term measure to mitigate the risk of the disasters. One such approach is known as DesInventar. It is a methodical way to gather and store information about characteristics and effects of different types of disasters, particularly the ones not visible from global or national scales. This allows for the observation and analysis of accumulated data regarding these 'invisible' disasters at a global or national scale (URL 32)

The DesInventar system can also be used to simulate disasters and study their impact. For example, it is possible to trigger an earthquake in the virtual environment and analyse its impact on a geographical area ranging from a municipality to a group of countries. The system forecasts information on the possible loss of human lives, impact on the economy and damage to infrastructure, etc. DesInventar is also a tool that facilitates the analysis of disaster-related information for applications in planning, risk mitigation and disaster recovery purposes. It can be used not just by government agencies, but by NGOs as well in their DRR effort. Apart from the specific software applications, there are many international and regional organizations that use ICT effectively in the disaster management process (Wattegama, 2007).

3.5.2 Disaster Information Networks

A disaster is an event that has terrible consequences. Today, disasters appear all over the media and they fascinate many people. In the past, disasters were a major source for myths and legends. Unlike accidents, disasters have resulted in new kind of thinking on ways to implement to avoid or to mitigate the effects of natural disasters. New principles of precaution and prevention are created all the time, affecting also legal constraints (URL 31).

Presently, number of Disaster Information Networks is working in the Global, Regional and National context. Global Disaster Information Network (GDIN), International Disaster Information Network (IDIN), Wide area Disaster information Network (WDN), ReliefWeb, Caribbean Disaster Information Network (CARDIN), ASEAN Disaster Information network (ADINet) are few of them (URL 32).

3.5.3 GIS Application in Disaster Recovery

In addition to its usage during the prevention, mitigation, preparedness and response phases of disaster management, GIS can also play a role in disaster recovery, in both the immediate and long-term phases.

- **Immediate Aftermath**

In the aftermath of any disaster, it is essential to restore vital services and systems. This may include providing temporary food, water and shelter to those who have lost homes in the disaster. Medical services are needed for those who are injured. GIS can play several roles in this process. It can identify the damage and begin to establish priorities for action. GIS can also ensure uniformity in the distribution of supplies (medicine, food, water, clothing, etc.) to emergency distribution centres. They can be assigned in proper amounts based on the extent and type of damage in each area (Wattegama, 2007).

Earth observation satellites could also be used in emergency situations where on-the-ground resources are often not available. Satellites can provide data rapidly when there are earthquakes, landslides, floods and other natural disasters that often prevent assessment by ground or aerial services. They also provide accurate global coverage and operability no matter what the weather or conditions are on the ground. They can also be used for a large number of activities during their lifetime (Yap, 2011).

Long Term Application

Long-term recovery is to restore all services to normal or better than they were prior to the disaster. It involves replacement of homes, water systems, streets, hospitals, bridges, schools, etc. and returning life to normal. This can take several years. GIS tools can be used to track the progress of these activities. It is also possible to prioritize restoration investments with the help of GIS. A GIS can ease the burden of accounting for recovery activities (Wattegama, 2007).

For example, December 26, 2004, ushered in the largest natural disaster in recent history. A magnitude 9.1 earthquake and resulting tsunami brought incredible devastation to many countries in Southeast Asia. Apart from providing informative topographic maps to coordinate relief efforts, GIS was extensively used in specific sectors during the initial response to the disaster including the following (ESRI, 2014):

- **Health**. GIS was to create an accurate picture of the damage and prioritize need. Activities were coordinated thus field hospitals and mobile health clinics were set up in the places they were needed.
- **Mobile Resource Planning.** GIS was used to plan movement of trucks and prioritize shipments.
- **Infrastructure.** GIS was used to identify risk areas and develop management plans to deal with infrastructure related issues.
- **Housing.** GIS was seen as a crucial tool to assist coordination among the various agencies to focus their resources on coordinating activities including spatial planning, village mapping, community planning, engineering design, and house building. Recovery programs were focused on rebuilding houses and infrastructure and restoring livelihoods.
- **Education.** GIS was used to discover where best to build, or not build, new schools based on population analysis and proximity to health facilities.

3.6 Comparison of Different ICT Tools in DRR Effort

Each specific technology has its strengths but also its limitations. These are summarised in following Table:

Channel	Advantages	Disadvantages
Radio and Television	Most accessible to low income households One-to-many Portable	Takes time to get the warnings Limited use at night
Community Radio	Excellent for rural poor and remote communities One-to-many Portable	Not widespread Obtaining a license can take time in some countries
Telephone (fixed)	Quick delivery	One-to-one Requires expensive infrastructure Vulnerable to congestion and delay
Telephone (mobile)	Relatively low cost Increasingly high penetration in rural areas	One-to-one Vulnerable to congestion and delay
SMS	Available on most mobile phones One-to-many Quick delivery	Vulnerable to congestion and delay Does not reach non-registered numbers Literacy required
Cell Broadcasting	One-to-many Not affected by nor adding to traffic Message can be differentiated by cells or sets of cells Geo-scalable Geo-specific targets Greater authenticity	Phone must be switched on and set to receive message Does not reach non-users Requires literacy No standardisation across networks to date
Internet/email	Fast and interactive Multiple sources can be checked for authenticity	Limited penetration in developing countries Limited local language content Subject to overload
GIS	Integrates spatial with social, economic and cultural data One-to-many Visual display of patterns	Require high bandwidth and high speed networks Utility depends on data Costly hardware and software Requires expertise – interpretation, integration
Satellite-based Systems	Large geographic range One-to-many Independent of terrestrial infrastructure Two-way, one-to-many communication Provides broadband connectivity Rapid deployment Reaches 'last mile'	Expensive, requires technical specialists Requires line of sight Data less accurate than ground-based systems (expanse over detail) Delays in propagation depending on satellite orbit
Web 2.0 Tools	Many-to-many and hence resilient Self-organising, self-managed	Requires Internet connectivity No security, open to false information Heterogeneity of wireless standards complicates inter-operability

Table 3.2: Comparison of ICT Tools (Source: http://www.niccd.org)

CHAPTER 4: PRESENT STATE OF ICT AND ITS LIMITATIONS IN BANGLADESH

4.1 State of ICT and its Trends for DRR

Disaster management in Bangladesh has gone through a process of significant reforms. ICT has played a fundamental role to bring this paradigm shift in disaster management from conventional response and relief practice to a more comprehensive risk reduction culture (Azad, Bahauddin, Khalid and Himel, 2013). In this context the Comprehensive Disaster Management Program (CDMP) is a multi-donor framework to assist the Government of Bangladesh in the achievement of the disaster management related Vision, Mission and Objectives. CDMP is a very high profile multi-hazard, multi-sector and multi-stakeholders program supported mainly by the UNDP, the UK Government's Department for International Development (DFID) and the European Union, with the Secretary of Ministry of Disaster Management and Relief (MoDMR) as the National Program Director. CDMP is a whole-of-country strategy. Communities within high risk areas are the immediate beneficiaries of program interventions (UNAPCICT, 2010).

For many decades, ICT services are delivered through fixed lines, which are reliable, and easier to be expanded for broadband subscription, but they are expensive to install and time consuming to deploy and maintain. Fixed lines have been mainly diffused in major cities and highly populated areas; therefore, ICT is extraneous for people who live in rural areas because the cost of installation has been high and geographical obstacles, such as the rivers and mountainous terrain, prevent the installation and maintenance of cables (Saito, 2009).

The advent of wireless technology gives alternative means of ICT access to people who live in isolated and disaster prone areas. Wireless technology covers a quite wide range of areas without the use of physical cables, and it is relatively easy to install the wireless equipment. The trend of wireless technology seems to be helping the expansion of access in rural and isolated areas in Bangladesh for effective DRR (Saito, 2009).

4.1.1 ICT Policy and Govt. Vision Regarding Disaster Management

The 2009 ICT Policy is structured as a hierarchical pyramid with a single vision, 10 broad objectives, 56 strategic themes and 306 action items implementable in the short term (18 months or less), medium term (5 years or less) and long term (10 years or less). The objectives set under the policy related to environment and disaster management are: enhancing creation and adoption of environment-friendly green technologies; ensuring safe disposal of toxic wastes; minimizing disaster response times; and enabling effective climate change management programs through the use of ICTs (ICT Policy, 2009).

In strategic theme 9.3 of ICT Policy 2009, it stated that protect citizens from natural disasters through ICT based disaster warning & management technologies:

- Utilize remote sensing technologies for disaster management and mitigation.
- Promote SMS based disaster warning systems targeted to the population likely to be affected.
- Web-based environmental clearance certification system.
- Promote efficient relief management and post-disaster activities monitoring.
- Utilize GIS based systems to monitor flood & cyclone shelters (including equitable distribution in vulnerable areas).
- Utilize GIS based systems to ensure equitable distribution of relief goods with special focus on the hard to reach areas.

4.1.2 ICT Initiative in Disaster Management

In the context of disaster management Government of Bangladesh is taking the advantage of ICT through the following issues:

- Interactive Voice Response (IVR) through mobile phone for early warning.
- Short Message Services (SMS) through mobile phone for early warning and preparedness.

- Cell Broadcasting Services (CBS) through mobile phone for early warning and preparedness.
- Web based on line damage and need assessment after any disaster.
- Development of hazard and risk map through satellite and GIS.
- Micro zonation map of the country.
- Cyclone and flood shelter on line data base.
- Volunteers on line data base.

4.1.3 Disaster Information Management System in Bangladesh

The responsibility for managing disasters in Bangladesh is entrusted with the Department of Disaster Management (DDM), a government agency, under the Ministry of Disaster Management and Relief. With the advent of ICT, there has been increased demand of ICT based disaster management system at the national, regional and local platforms. National level forecasting for cyclones and floods are managed by the Bangladesh Meteorological Department and Bangladesh Water Development Board (BWDB) (Azad, Bahauddin, Khalid and Himel, 2013).

- **National Disaster Management Information Centre (DMIC)**

The establishment of DMIC through CDMP program is linked with all actors and sectors from the national level down to the community level. The goal of DMIC is to put in place a more effective and better coordinated information management system, aimed to improve coordination among agencies at all levels with access to appropriate, timely and accurate information before, during and after emergency situations (UNAPCICT, 2010).

DMIC has built the internal capacity to produce and issue daily situation reports, which are composites of damage, loss and response data received through its communication networks from several sources. DMIC technical staff uses image analysis and GIS tools to develop these reports. They combine GIS functionality with web applications that automate production and provide users with online GIS tools to manipulate data (UNAPCICT, 2010).

The DMIC generates time-sensitive information items such as early warnings, situation reports and other real-time data, and presents them in information products delivered through communication channels that cause the least delay, and are consistent with the capacity of users to receive and comprehend them.

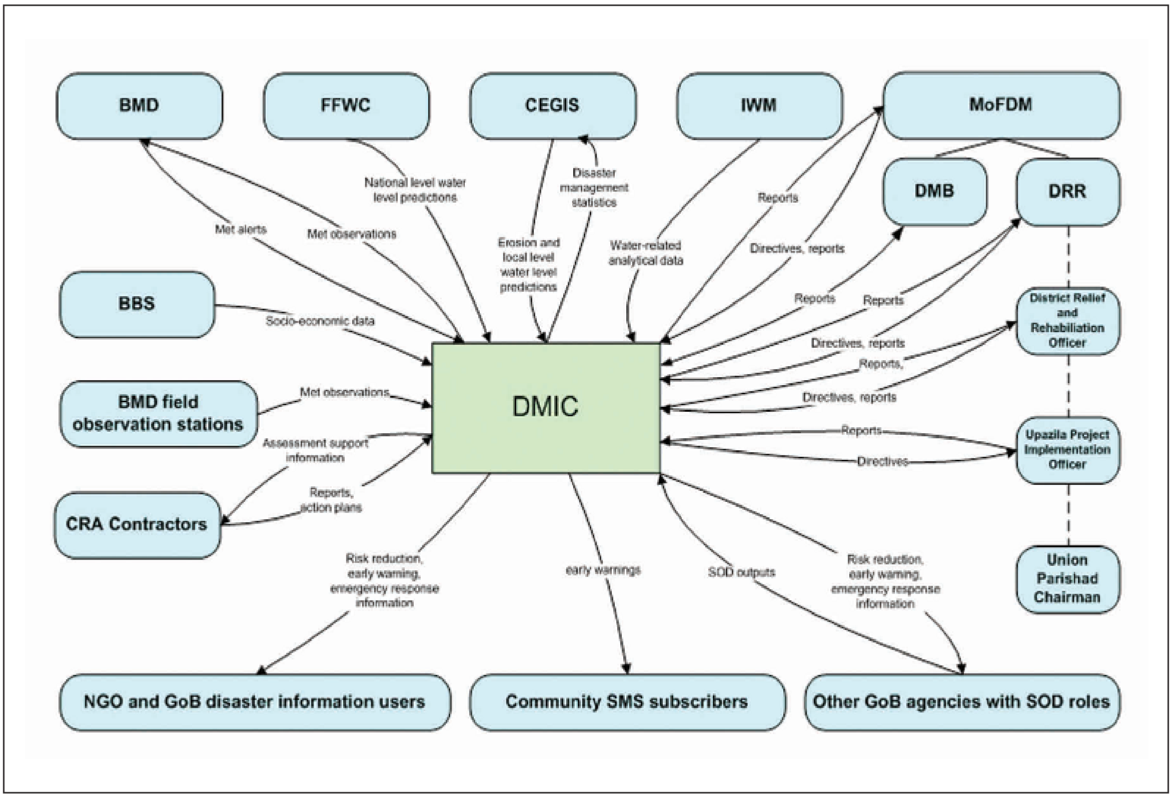


Figure 4.1: DMIC Operation (Source: UNAPCICT, 2010)

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 (URL 33).

Bangladesh Meteorological Department (BMD)

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. 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.

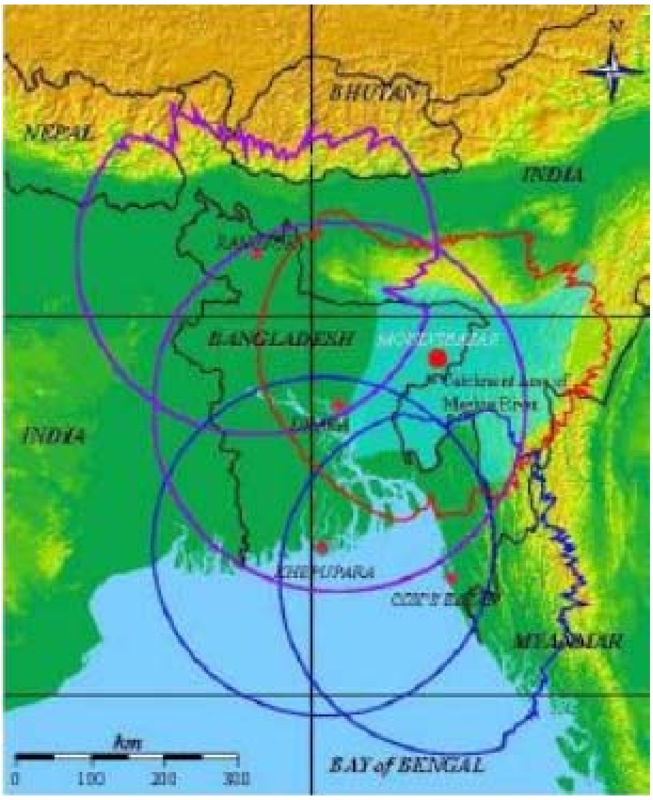


Figure 4.2: Radar Network of BMD

(Source: http://www.unosd.org/content/documents/1069EWS%20Dilder%20Ahmed%20revised.pdf)

BMD contributes to flood forecasting and warnings by preparing short, medium and long term weather forecasts, heavy rainfall warnings and special weather bulletins with storm surge information. BMD is affiliated to the World Meteorological Organization (WMO) since 1972 (URL 34).

Flood Forecasting Warning Centre (FFWC)

Flood Forecasting & Warning Services (FFWS) in Bangladesh is the mandate & responsibility of FFWC of Bangladesh Water Development Board (BWDB) under Ministry of Water Resources. The FFWC was established in 1972 and is fully operative in the flood season, during April-October, as directed by the SOD of the Government of Bangladesh (URL 35).

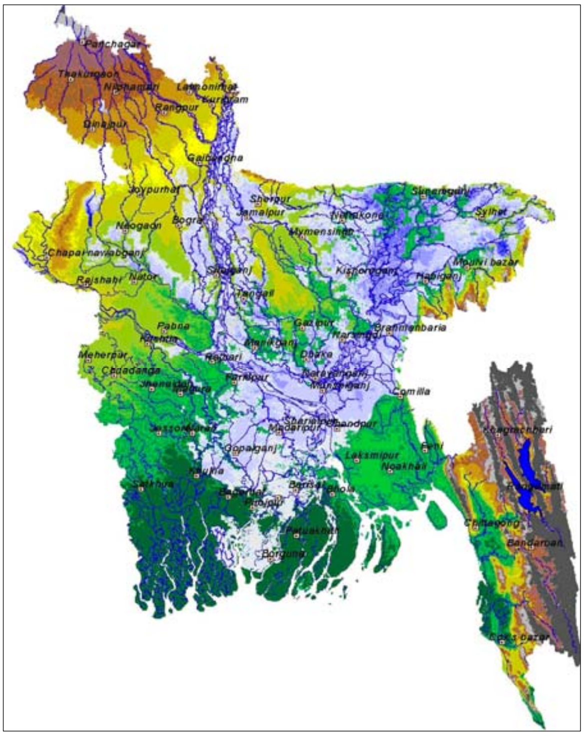
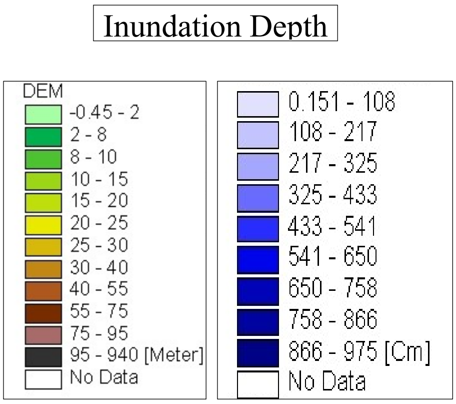


Figure 4.3: Sample Flood Map (FFWC)

Generated using Water Level on Digital Elevation Model (DEM)

(Not precise, but indicating coarse level flood extent)

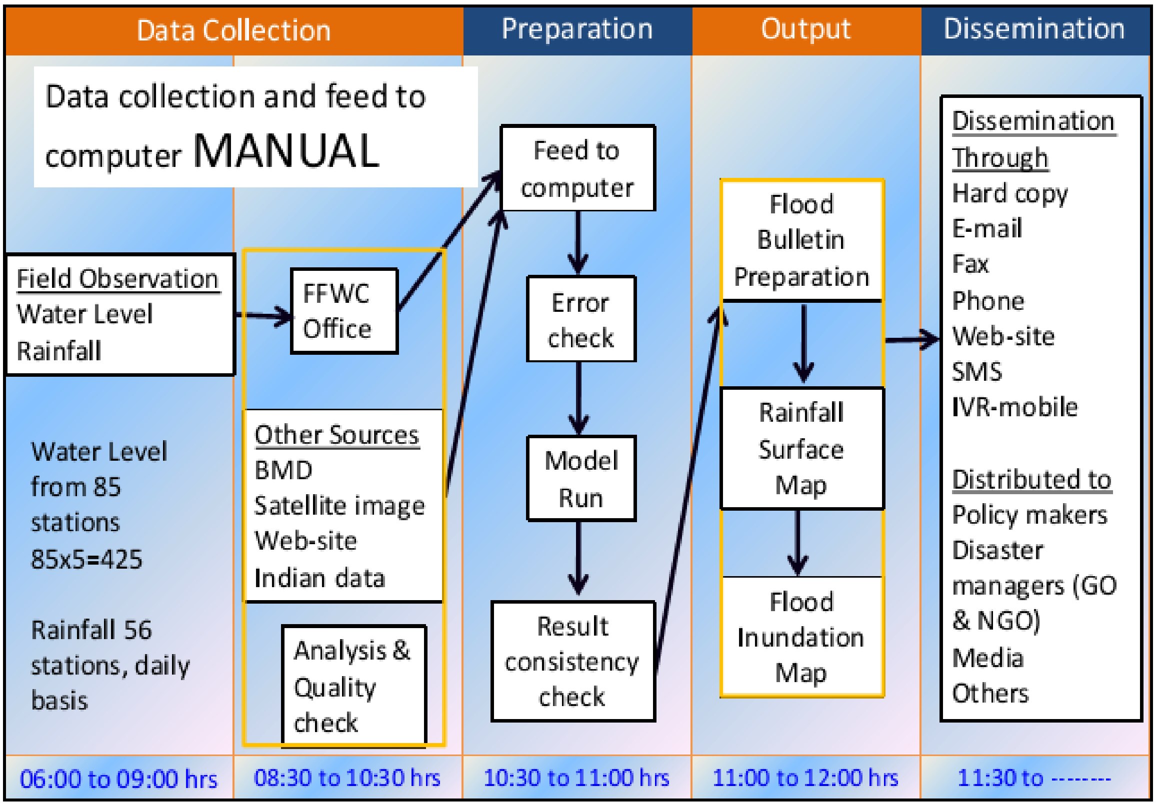


(Source: FFWC at http://www.ffwc.gov.bd)

The objectives of FFWS are to enable and persuade people, community and organizations to be prepared for the flood and take action for safety and reduce damage. Its goal is to alert the 'combat' agencies to enhance preparedness & motivate communities to undertake protective measures. The basis of flood forecasting is rainfall and water level data which are used to interpret the present flood situation and generate flood forecasts. The flood monitoring and forecasting depend on:

- Hydro-meteorological monitoring system of BWDB covering Bangladesh.
- Additional rainfall and water levels data of upper catchment from India.
- Additional meteorological data from BMD and ECMWF.
- Satellite and radar images.

Figure 4.4: Flood Forecasting & Warning Activities



(Source: FFWC at http://www.ffwc.gov.bd)

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 modeling, 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) (URL 36).

Currently, CEGIS is in the process of development/acquiring technology for a regional basin flood forecast modeling for use in Bangladesh. CEGIS has also 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 easily understandable mobile SMS. This created an important opportunity for low-cost, reliable, and deeply penetrating dissemination of flood forecasts for vulnerable communities (Islam, 2013).

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 (Islam, 2013).

- **Institute for Water Modeling (IWM)**

IWM is an institute of learning and research in the fields of water modeling, 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 and issuing medium (ten days) flood predictions based on climate forecasts produced by the CFAB project (URL 37).

4.1.4 Early Warning Dissemination Mechanisms

Traditionally, early warning information originates in central institutions, propagates by fax to district and upazila offices, and continues down the administrative hierarchy in hand- and voice-carried bulletins to the community. This traversal erodes prediction lead time, often entirely, and a single broken link starves all of the nodes below it so that some communities may not receive the message at all. Mass media, especially state-operated media, broadcast early warnings directly to communities throughout the country, but necessarily due to time constraints they aggregate the information to the extent that it is no longer as localized as it began or should usefully be.

The national DMIC is fully operational on a 24/7 basis and is playing the role of a catalyst in early warning dissemination from the national level down to the upazila level. DMIC uses a range of ICTs to disseminate information. DMIC is currently equipped with high-end servers, SMS/Fax gateway, a GIS unit and redundant data connectivity. In the last few years, mobile penetration in Bangladesh has escalated rapidly, and mobile technology is increasingly being used as a tool for early warning dissemination. However, the institutional mechanism and responsible generating organization for EWS in Bangladesh is as follows (Ahmed, 2014):

Figure 4.5: Early Warning Institutional Mechanism

Hazard Types	Mandated Warning Agencies
Cyclone	BMD
Storm Surge, Tsunami	BMD
Nor'wester, Tornado, Hailstorm	BMD
River Flood, Flash Flood	FFWC (BWDB); BMD, SPARRSO
Erosion	BWDB
Drought, Heatwave	BMD, DAE, BWDB
Cold wave, Fog	BMD
Earthquake, Landslide	BMD
Waterborne Hazards	ICDDRB, DOE

PMO, NDRCG/C	Decision Making
NDRCC, DDM /DMIC/DMIN,	Transmission
Fire Services, AFD, Coastguard, CPP, the Media, Telecoms Provides (IVR, SMS)	Dissemination
CPP Volunteers, Urban Volunteers, BETAR< BTV, Media	Last Mile

(Source:
http://www.lcgbangladesh.org/DERweb/minutes/2013/cdmp%20DER+EWS.pdf)

Process of Issuing Warnings

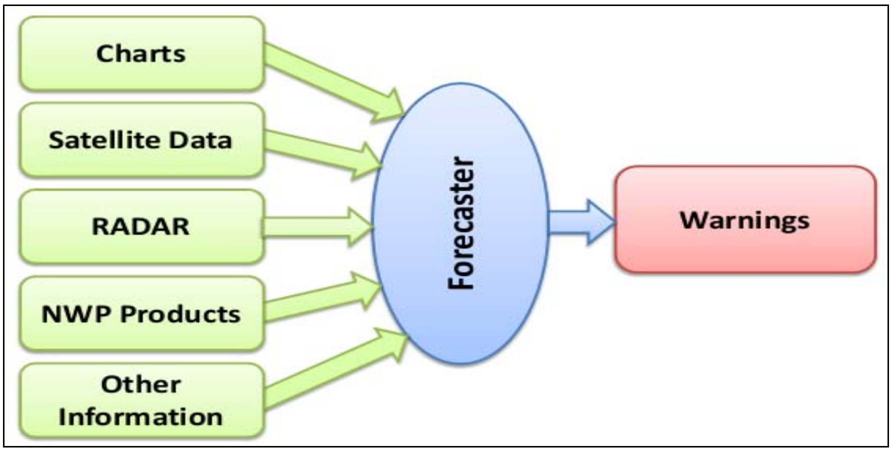


Figure 4.6: Process of Issuing Warnings (Source: CDMP, 2014)

Analysing Processes/Tools by BMD

Diagnostic Charts:

- Surface Synoptic Chart- every 3 hours or more frequent.
- Upper air pilot chart- every 6 hours.
- Upper air constant pressure chart- every 12 hours.
- Pressure change chart- every 3 hours and more frequent.

Model Products:

- Global Forecasting System (GFS) Model analysis from NOAA.
- Limited Area Model (LAM) Products.
- NWP output from different centres.
- Track product by running STP & STEEPER Models of BMD.
- WRF Model, NHM Model.
- Empirical and Numerical /Dynamical Storm Surge Models (IIT-D Model).
- MRI (JMA) Storm Surge and Wave Model.

Warning Configuration Mechanism

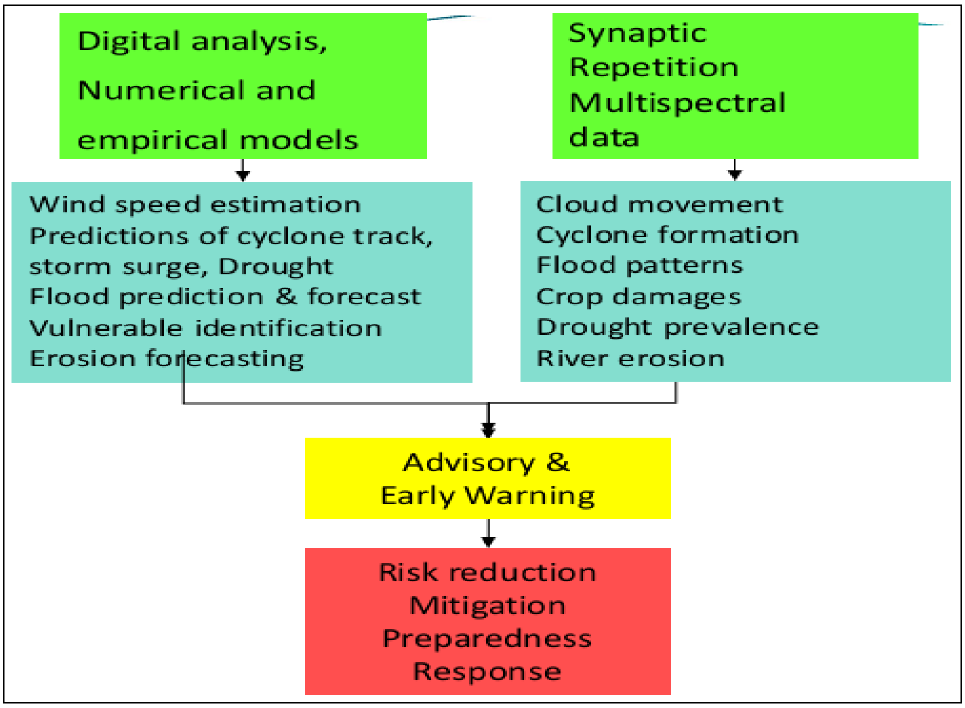


Figure 4.7: Warning Configuration Mechanism

(http://www.lcgbangladesh.org/DERweb/minutes/2013/cdmp%20DER+EWS.pdf)

Use of ICT in EWS to Reach Last Mile at Community Level

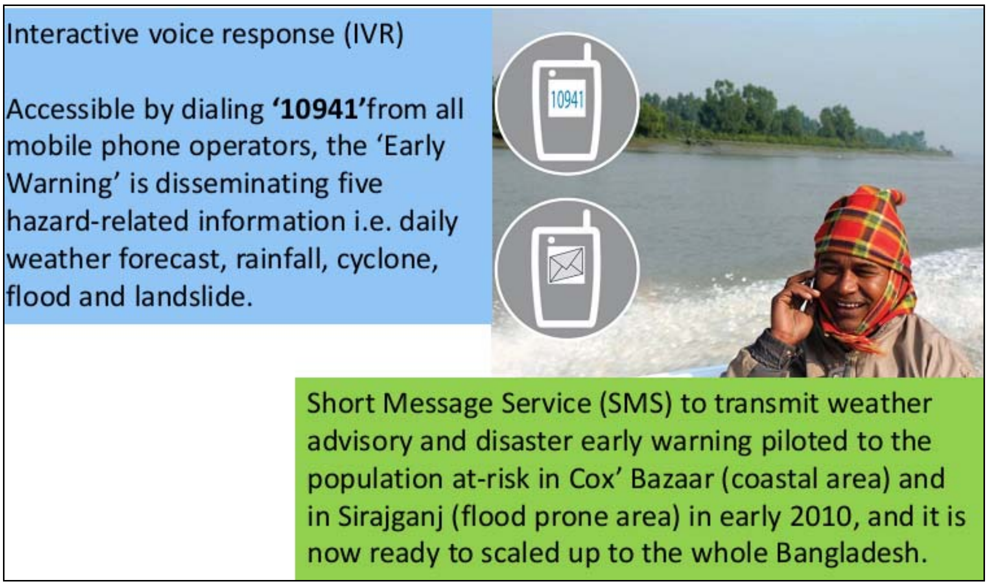


Figure 4.8: ICT in EWS to Reach Last Mile at Community Level

(http://www.lcgbangladesh.org/DERweb/minutes/2013/cdmp%20DER+EWS.pdf)

4.2 Availability of ICT Tools and Usage Pattern

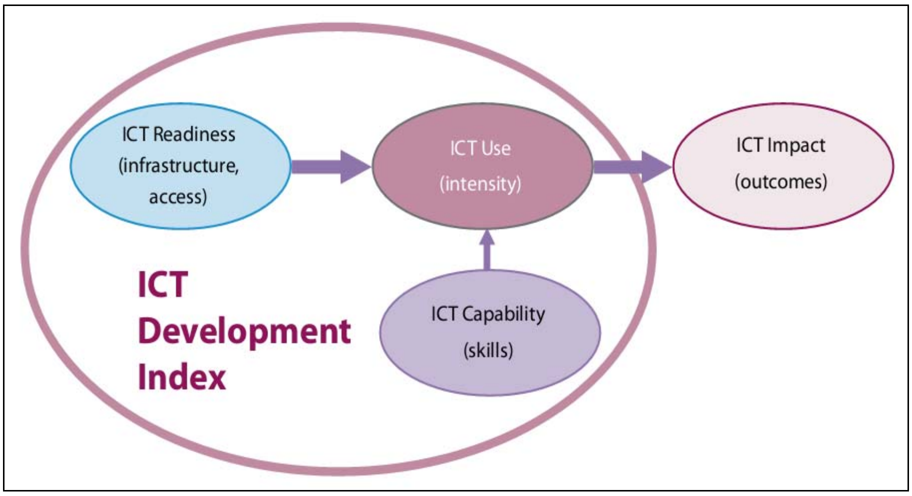
The use of ICTs is conceived as an "enabling" factor for facilitating and streamlining institutional processes toward improving public service delivery to the excluded. In short, this process is coined as ICT for development (ICT4D) where ICT is perceived to have the potential to boost economic, social and political development, contributing toward the progress of humankind as a whole. ICTs can expand the capacity of the poor by empowering them to enjoy their right to freedom of expression in the decision-making process, alongside ensuring their participation in the opportunities brought about by economic growth. Bangladesh government has put in place a number of laws, policies and strategies to put in action the Digital Bangladesh vision. The ICT Policy 2009, ICT Act 2009 and the Right to Information (RTI) Act 2009 have laid the foundations for identifying the Digital Bangladesh priorities for the government (IGS 2010). In 2010, the government approved the Digital Bangladesh Strategy and the amended Telecommunication Act 2010 (BBS, 2013).

4.2.1 ICT Indicators of Bangladesh

- **ICT Development Index (IDI) of ITU**

  IDI is a composite index combining 11 indicators into one benchmark measure that serves to monitor and compare developments in ICT across countries. The IDI was developed by ITU in 2008 and first presented in the 2009 edition of Measuring the Information Society. Details of weights used for indicators and sub-indices included in the IDI is given at Annex B. IDI was established in response to ITU Member States' request to develop an ICT index and publish it regularly (ITU, 2013).

Figure 4.9: Three Stages in the Evolution Towards IDI



(Source: https://www.itu.int/en/ITU/Statistics/Documents/publications/mis)

World Economic Forum's (WEF) Networked Readiness Index (NRI)

NRI measures the propensity for countries to exploit the opportunities offered by ICTs. The NRI assesses the impact of ICT on the competitiveness of nations. The Index is a composite of three components: the environment for ICT offered by a given country or community (market, political and regulatory, infrastructure environment), the readiness of the community's key stakeholders (individuals, businesses, and governments) to use ICT, and finally the usage of ICT amongst these stakeholders (BBS, 2013).

Table 4.1: Rankings in the Networked Readiness Index (NRI)

Countries	NRI		Sub-indices					
			Environment		Readiness		Usage	
	2012	*2011*	*2012*	*2011*	*2012*	*2011*	*2012*	*2011*
Top 3								
Sweden	1	1	3	1	3	3	1	3
Singapore	2	2	1	4	8	1	5	4
Finland	3	3	2	3	2	2	4	6
Asia								
Bangladesh	113	115	123	115	103	104	108	122
Cambodia	108	111	89	109	106	111	111	110
China	51	36	64	57	66	16	51	36
India	69	48	78	58	64	33	78	67
Malaysia	29	28	23	36	55	10	29	25
Nepal	128	131	125	134	111	118	135	133
Pakistan	102	88	112	96	97	60	107	96

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(http://203.112.218.66/WebTestApplication/userfile/Image/Other%20Reports/ICT4D)

IDI Values Compared with the Global and Regional Country Averages

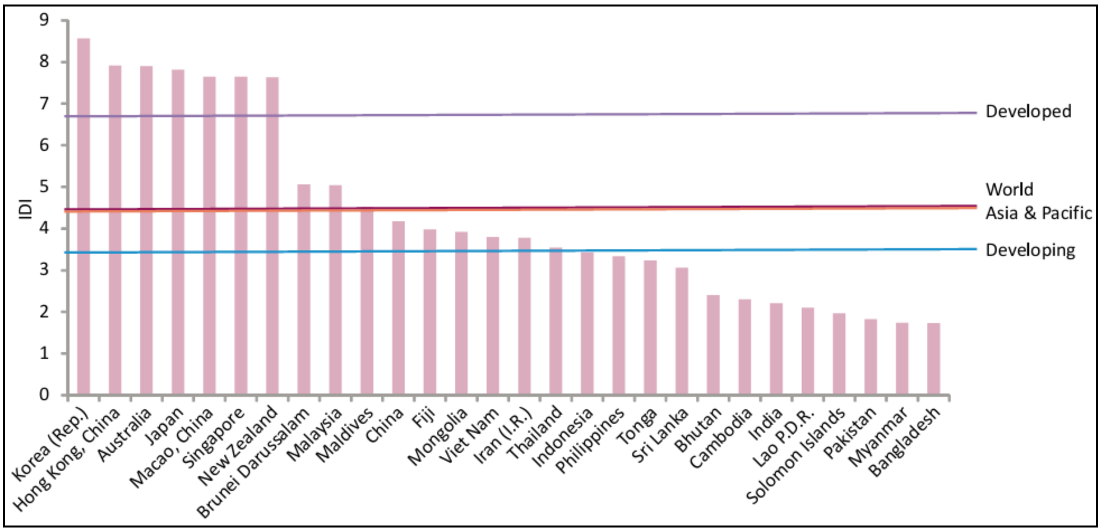


Figure 4.10: IDI Values Compared with the Global, Regional, Developing and Developed Country Averages (Source: ITU, 2013)

IDI Standing of Bangladesh in Asia Pacific Region and Global Scenario

Table 4.2: IDI Standing of Bangladesh in Asia and the Pacific

Economy	Regional rank 2012	Global rank 2012	IDI 2012	Global rank 2011	IDI 2011	Global rank change 2011-2012
Korea (Rep.)	1	1	8.57	1	8.51	0
Hong Kong, China	2	10	7.92	10	7.66	0
Australia	3	11	7.90	15	7.54	4
Japan	4	12	7.82	8	7.77	-4
Macao, China	5	14	7.65	13	7.57	-1
Singapore	6	15	7.65	14	7.55	-1
New Zealand	7	16	7.64	18	7.31	2
Brunei Darussalam	8	58	5.06	56	4.93	-2
Malaysia	9	59	5.04	57	4.81	-2
Maldives	10	73	4.53	71	4.31	-2
China	11	78	4.18	79	3.86	1
Fiji	12	82	3.99	81	3.79	-1
Mongolia	13	85	3.92	90	3.59	5
Viet Nam	14	88	3.80	86	3.65	-2
Iran (I.R.)	15	90	3.79	88	3.61	-2
Thailand	16	95	3.54	94	3.42	-1
Indonesia	17	97	3.43	97	3.14	0
Philippines	18	98	3.34	98	3.14	0
Tonga	19	101	3.23	101	3.09	0
Sri Lanka	20	107	3.06	107	2.92	0
Bhutan	21	118	2.40	117	2.19	-1
Cambodia	22	120	2.30	121	2.05	1
India	23	121	2.21	120	2.13	-1
Lao P.D.R.	24	123	2.10	122	1.99	-1
Solomon Islands	25	125	1.97	124	1.91	-1
Pakistan	26	129	1.83	128	1.78	-1
Myanmar	27	134	1.74	132	1.70	-2
Bangladesh	28	135	1.73	139	1.62	4

(Source: https://www.itu.int/en/ITU-D/Statistics/Documents/publications/mis2013/MIS2013_without_Annex_4.pdf)

UN e-Government Survey

One of the most comprehensive indicators evaluating the impact of ICT on the political economy arrangements is the UN's E-Government Survey. The latest report, titled, E-Government for the People, introduced significant changes to the survey instrument in the round, focusing more on how governments are using ICTs to deliver public services and expanding opportunities for citizens to participate in decision-making process. The e-Government Development Index (EGDI) measures e-government development of countries relative to one another within a given year. The EGDI consists of three components: online service, technological infrastructure and human capital (BBS, 2013).

Table 4.3: Ranking of Bangladesh in EGDI

Countries	E-government development index			Sub-indices								
				Online service index			Technological Infrastructure			Human Capital Index		
	2012	*2010*	*2005**	*2012*	*2010*	*2005**	*2012*	*2010*	*2005**	*2012*	*2010*	*2005**
Top 3												
Republic of Korea	1	1	5	1	1	4	7	13	10	6	7	23
Netherlands	2	5	12	5	12	20	8	2	9	10	9	15
UK	3	4	4	4	4	3	10	4	14	34	32	6
Asia												
Afghanistan	184	168	168	148	106	124	168	163	189	184	179	174
Bangladesh	150	134	162	88	60	158	164	161	179	173	167	159
Bhutan	152	152	130	110	114	72	139	139	153	170	164	156
Cambodia	155	140	128	161	135	110	154	166	173	144	135	138
China	78	72	57	62	55	42	87	89	77	106	98	99
India	125	119	87	58	55	38	145	147	141	158	147	150
Malaysia	40	32	43	20	16	40	57	52	42	109	96	93
Maldives	95	92	77	120	127	82	74	60	102	84	90	55
Myanmar	160	141	129	181	154	139	190	190	182	127	127	124
Nepal	164	153	126	141	125	69	167	171	172	163	152	153
Pakistan	156	146	136	106	100	65	135	131	146	175	168	171
Philippines	88	78	41	71	49	19	110	118	97	67	78	59
Sri Lanka	115	111	94	101	97	80	116	120	134	120	107	103
Thailand	92	76	46	67	67	26	103	94	76	104	66	78
Vietnam	83	90	105	95	79	115	69	79	120	116	114	100
Bottom 5												
Sierra Leone	186	177	167	170	189	152	177	179	178	183	169	174
Haiti	187	169	n/a	185	181	181	160	135	155	181	161	157
Niger	188	183	174	160	172	189	180	184	170	189	183	181
Chad	189	182	169	182	181	186	181	177	187	186	180	170
Somalia	190	184	n/a	167	n/a	190	189	183	168	190	n/a	190

(Source: http://203.112.218.66/WebTestApplication/userfile/Image/Other%20Reports/ICT4D)

4.2.2 ICT Profile of Bangladesh

Preceding data and statistics reveals that there is heterogeneity in ICT indicators and they have limitations with regards to their design and conception. It also portrays a pessimistic outlook for the countries in Asia at a time when it is being argued by global economists that the economic centre of gravity is shifting to this region. In 2012, Bangladesh ranked low at 150th in the EGDI; however, the country was identified in the category of countries with populations larger than 100 million that have made a special effort to improve ICT service delivery to large swathes of their populations. Bangladesh was positioned alongside the US, China, India, Brazil, Japan and other giant economies. The low overall ranking is also not a reflection of the Bangladesh's performance in the online service index (BBS, 2013).

Household Income and Expenditure Survey 2010" conducted by BBS, sought information on the use of ICT (use of computer, email, internet, telephone, mobile phone etc.) at the household and individual levels.

Table 4.4: Percentage of Households Having ICT Facilities

Type of facilities	National		Rural		Urban	
Year	**2010**	**2005**	**2010**	**2005**	**2010**	**2005**
Telephone	2.07	2.87	0.70	0.33	5.79	10.36
Mobile Phone	63.74	11.29	56.77	6.05	82.74	26.73
Computer	3.01	1.36	0.97	0.17	8.58	4.88
email	1.39	0.20	0.39	-	4.10	0.81

(Source: BBS, Household Income and Expenditure Survey 2005 &2010)

The table shows increasing tendency of use of computer facilities in Bangladesh especially in rural areas. The most notable information from the survey is that though mobile phone has been introduced in the country in early nineties, there has been substantial growth of mobile phone use. The use of Internet has considerably increased both in urban and rural areas as focus by the recent survey. Understandably, the use of the ICT facilities is much higher in urban areas compared to rural areas. There has been rapid growth of use of Mobile phones between 2005 and 2010. While only 11.29% of households used mobile phones in 2005, more than 63% of households were found to use them in 2010 (BBS, 2011).

4.2.3 Mobile Technology

Bangladesh is currently using third generation (3G) of mobile telecommunications technology. 3G is based on a set of standards used for mobile devices and mobile telecommunications use services and networks that comply with the International Mobile Telecommunications-2000 (IMT-2000) specifications by the ITU. This application denotes wireless voice telephony, mobile Internet access, fixed wireless Internet access, video calls and mobile TV. Presently there are six mobile operators having their cellular communication network in the country (URL 39).

The Mobile Phone subscribers at the end of February 2015 are shown below:

Table 4.5: Mobile Phone Subscribers in Bangladesh (February-2015)

OPERATOR	SUBSCRIBER (IN MILLIONS)
Grameen Phone Ltd. (GP)	51.599
Banglalink Digital Communications Limited	31.515
Robi Axiata Limited (Robi)	26.414
Airtel Bangladesh Limited (Airtel)	7.944
Pacific Bangladesh Telecom Limited (Citycell)	1.263
Teletalk Bangladesh Ltd. (Teletalk)	3.922
Total	**122.657**

(Source: http://www.btrc.gov.bd/content/mobile-phone-subscribers-bangladesh-february-2015)

Bangladesh climbed four places to 135th in the IDI 2012, with the access sub-index showing the highest increases. In particular, mobile-cellular telephone penetration rose from 56 per cent in 2011 to 64 per cent in 2012. Bangladesh has a highly competitive mobile market, with six mobile-cellular operators. Fierce competition led to the lowering of mobile-cellular prices and a concomitant rise in subscription numbers. The ICT Price Basket shows that Bangladesh has relatively affordable mobile-cellular prices and prices have dropped consistently over the past years. Operators in Bangladesh are competing for a large group of low-income customers and were thus obliged to reduce access costs. This includes the introduction of prepaid offers, per-second billing and the reduction of handset prices (ITU, 2013).

Mobile broadband internet services are available as per following figure:

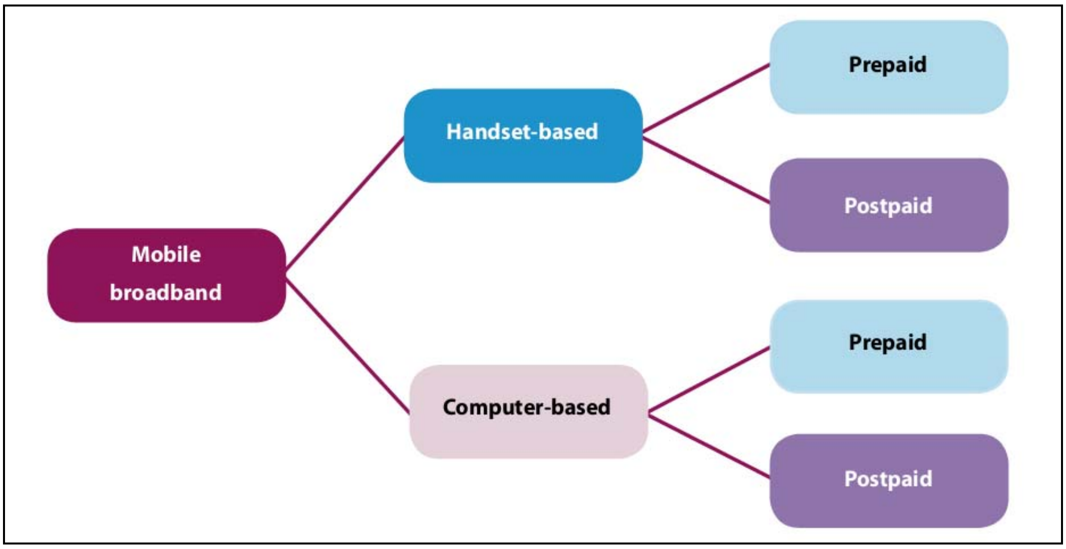


Figure 4.11: Mobile-broadband Services by Type of End-user Device and Plan

4.2.4 Radio and Television

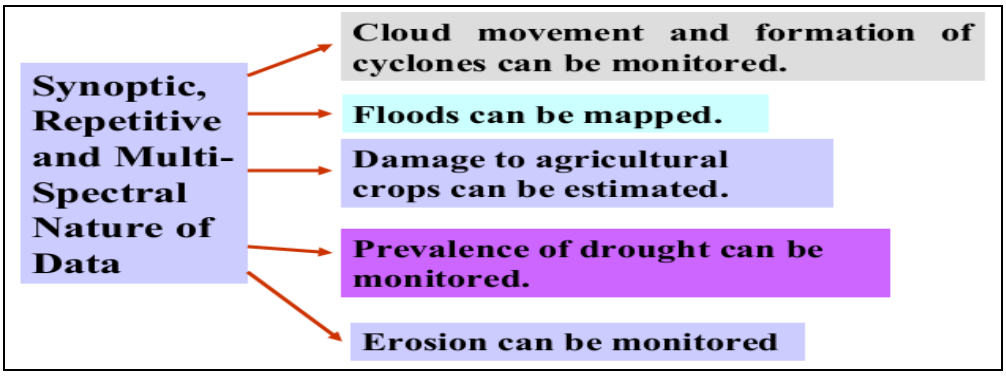
Bangladesh Television is a state-owned television channel which telecasts news and multidimensional programs aiming at presenting information, promoting values, ethics & culture and motivating people towards democracy and development activities. BTV has a satellite channel which covers Russia to the north, Australia to the south, Japan to the east and Cyprus to the west. It has two stations in Dhaka and Chittagong and fourteen sub-stations across the country. BTV's terrestrial transmission covers 95% geographical area of Bangladesh. Furthermore, there are 41 private satellite based channels are also viewing their programs and contributing a lot in DRR effort of the country (URL 41).

National Radio Service (Bangladesh Betar) is a public service broadcaster which has been broadcasting 220 hours 25 minutes program daily from its 11 regional stations, 5 units (Farm broadcasting , Commercial service, External service and Population service) using 27 transmitters. It also broadcasts its program from six FM transmitters. Furthermore, there are 14 privately owned radio stations and 13 online radio stations operating in the country (URL 42).

The Bangladesh NGOs Network for Radio and Communication (BNNRC), in special consultative status with the United Nations Economic and Social Council, considers community radio a special area for intervention. BNNRC has been promoting advocacy to the government in relation to community radio with other organizations since its emergence in 2000. As a result, the Ministry of Information of the People's Republic of Bangladesh announced the Community Radio Installation, Broadcast and Operation Policy 2008. Under this policy, the Ministry of Information approved 16 community radio stations for the first time in Bangladeshi history. To ensure the free flow of information to the people, the government enacted the Right to Information Act 2009. Community radio stations are a strong step in empowering rural people. Initially, the government approved 16 community groups (URL 42).

4.2.5 Space-based Technology (GIS and Remote Sensing)

Since late 1960s, remote sensing is being used for monitoring cyclones in the country. NOAA-AVHRR data are being used to monitor formation, intensity and movement of the cyclones in the Bay of Bengal. The accompanying storm surges are also predicted. Based on these information an EWS has been established in the country. This system effectively reduces the damage lives and properties. The flood damages were estimated and statistics on upazila-wise flood affected areas were derived by SPARSO. They monitored and mapped the devastating flood of 1988, 1987, 1998 and 2004 using NOAA and RADARSAT data. The Government of Bangladesh used this statistics for the post flood management and rehabilitation in the country. Data used from Remote Sensing in Early Warning and Disaster Management is as follows (Howlader, 2013):



4.2.6 Satellite Communications

Bangladesh has planned to launch a Communication & Broadcasting Satellite with the vision to open new dimension of possibility in the telecommunication sector of Bangladesh by launching its first ever satellite. The priority satellite applications are Direct to Home (DTH), VSAT, Network Restoration, Disaster Preparedness and relief etc. The Primary Service Area (PSA) would be Bangladesh and neighboring countries and the Secondary Service Area (SSA) would be South East Asia, Europe, and East Africa depending on orbital slot (BTRC, 2015).

- **Baseline Characteristics of the Country's First Satellite**

The preparatory project has made significant progress since its inception in the area of feasibility study, frequency coordination for achieving an orbital slot, arranging source of fund, RF survey for finalizing two locations for satellite ground stations and preparation of Development Project Proposal (DPP) for the next project named "Bangabandhu Satellite Launching Project". The system concept of the proposed satellite comprises with satellite payload requirements, orbital slot/frequencies, coverage area(s), ground segment, user terminal design characteristics, satellite operations and environmental factors. There will be two ground stations for satellite operation and control, one as the primary site and other as the backup site (BTRC, 2015).

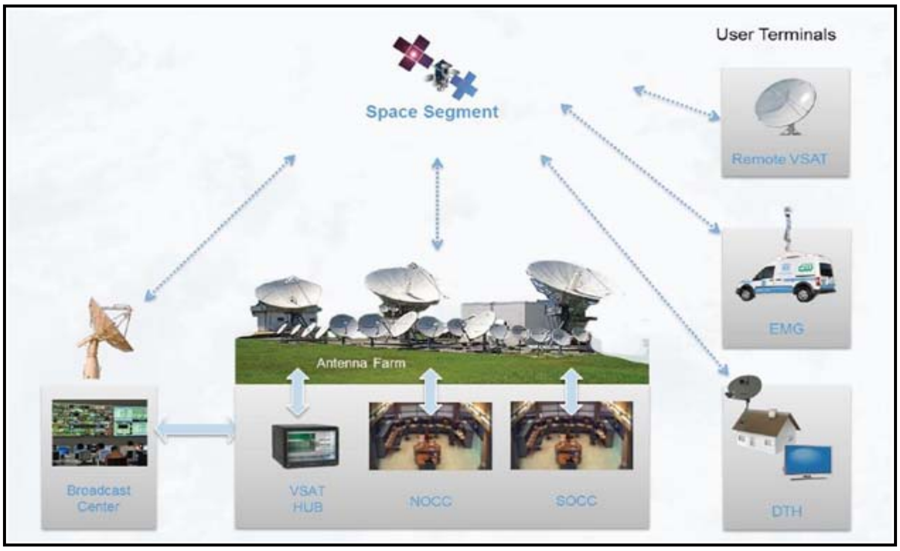


Figure 4.12: Satellite System Concept of Bangladesh
(Source: http://www.btrc.gov.bd/satellite-project)

4.2.7 State of Internet

The total number of Internet Subscribers has reached 43.419 million at the end of February, 2015**.** The mentioned figure represents the number of Active subscribers only. A subscriber/ connection using the internet during the last Ninety (90) days are considered to be an Active subscriber (BTRC, 2015). The Internet subscribers are shown below:

Table 4.6: Internet Subscribers in Bangladesh (February-2015)

SERVICES	SUBSCRIBER (IN MILLIONS)
Mobile Internet	41.959
WiMAX	0.215
ISP + PSTN	1.245
Total	**43.419**

(Source: http://www.btrc.gov.bd/content/internet-subscribers-bangladesh-february-2015)

Significant progress has been made with regard to international Internet bandwidth in Bangladesh. In 2012, Telecommunications Regulatory Commission (BTRC) issued six licenses for the operation of an international terrestrial cable (ITC). Until then, the country's only connection to the world wide web was the SEA-ME-WE4 submarine cable, controlled by the government-owned BTCL. The newly established terrestrial link via India has nearly doubled international Internet bandwidth per Internet user, from 1500 Mbit/s to almost 3000 Mbit/s by end 2012, as well as enhancing the reliability of Bangladesh's international connectivity. While the advances made in the access sub-index are very encouraging, little progress has been made in the use sub-index. Both fixed (wired)-broadband and wireless-broadband penetration remain below 0.5 per cent. The proportion of individuals using the Internet went up by 26 per cent, to 6 per cent in 2012 (ITU, 2013).

4.3 Major Drawbacks of ICT in Disaster Scenario

Telecommunication coverage in Bangladesh is quite satisfactory and national organ BTCL has also very good communication infrastructure, but as of now, they cannot readily be used effectively for disaster management purposes. The underlying factor is the lack of system integration, which is an essential requirement for developing a robust emergency telecommunication system. Furthermore, some of the essential services for an emergency telecommunication system are not also having same protocol to be used as enhanced ICT tool for effective DRR.

4.3.1 Limitations in Emergency Telecommunication Services

Although a good telecommunication infrastructure is in place in Bangladesh, there is yet no comprehensive well-defined system in the country to designate the institutions and their responsibilities for emergency communication in a post-disaster situation. There is a disaster management plan embodied in the Standing Orders on Disasters, but the aspect on emergency telecommunication is not clearly defined. For private telecommunication operators, there is also a disaster contingency plan, but this has not yet been institutionalized. Among government agencies, only the Cyclone Preparedness Programme (CPP) and the Police have dedicated communication facilities for emergency purposes. Existing VHF radios for disseminating cyclone warnings to the community level by CPP has been so far very effective due to its good maintenance and training of radio operators. CPP is jointly managed by the Government of Bangladesh and Bangladesh Red Crescent Society. CPP has an extensive HF and VHF radio network in the coastal areas of Bangladesh that is linked to its headquarters in Dhaka (UNAPCICT, 2010).

4.3.2 Physical Damage of Communication Infrastructure

In the immediate aftermath of disasters, existing emergency telecommunication services might be adversely affected due to physical damage of such infrastructures. For example, in 2004, flood water entered the cable ducts, affecting the communication cables in many districts. Almost 108 km of optical fibre cable link between Dhaka and Chittagong was damaged. Similarly, associated strong wind from cyclones usually disrupts telecommunication links. In the April 1991 cyclone, national and international telecommunication networks were interrupted due to the collapse of a vital microwave tower at the port city of Chittagong and Bangladesh was cut off from the rest of the world for several days. Similar situations cannot be ruled out in case of an earthquake event in Bangladesh (UNAPCICT, 2010).

4.3.3 Power Failure Causing Non-functionality of ICT Tools

The loss of the power supply is one of the main factors preventing the use of ICT equipment and causing the interruption of services during a disaster. The cause may be severed power lines, damaged or destroyed generators, insufficient fuel for emergency generators or lack of spare batteries. It is clear that locating equipment where it is least exposed to risk can reduce infrastructure damage. A steady power supply and power generation equipment should be located at a place where it is least exposed to potential damage from a disaster. Disasters related to water, including flooding and tsunami, may cause significant damage to power supply systems. The equipment should be installed at a higher location on land or in a building where the risk of flooding is reduced. The use of multiple electrical distribution routes is recommended and aerial facilities should be avoided (ITU, 2015).

During disaster events, one of the most common problems for the telecommunication operators (both public and private) and ICT tools user is power failure, which hampers the delivery of services and disruption of communication. Most mobile phone operators have limited power back-ups (6-10 hours), especially in remote areas. Though some of the mobile phone operators have generators but experience shows that supplying fuel at the time of disaster and moreover to remote areas is logistically difficult. Thus an autonomous power supply is critical and there should be sufficient fuel for back-up generators as power outages can be lengthy. Equipment should be installed in buildings in higher locations where the risk of flooding is reduced and basements should be avoided as sites for equipment and reserve generators (UNAPCICT, 2010).

4.3.4 Communication Difficulty Due to Oversubscription

Heavily damaged or destroyed communication networks due to disaster will lead to a complete communication blackout in the affected areas. Even if part of the existing communication system is operational, they may quickly become oversubscribed by increasing traffic volume at the time of the disaster, making communication difficult. Generally, government agencies work independently in an emergency situation, depending on the type of disaster they need to deal with. Most of the agencies' services are restricted to disseminating early warnings. For post-disaster operations, lack of an independent, dedicated and robust communication line for ensuring uninterrupted communication among the operation centres, rescue and relief units as well as all the line agencies make the situation more difficult. Thus, for effective disaster management, an integrated system is indispensable, both in terms of communication channels as well as involving diverse groups of stakeholders (UNAPCICT, 2010).

The network generally reaches its limit only when an extensive number of media and VIP visitors arrive in the area, significantly raising the traffic volume. Relatively quick and numerous deployment of mobile GSM infrastructure may solve that problem "just in time". Lack of coordination among the agencies again causes the delayed operation of such events. Therefore, with the availability of a well-organized interagency radio communication network can solve such problem in an efficient manner (ITU, 2015).

4.3.5 ICT Capacity Deficits

Meteorological data, forecasts and analyses are often inaccessible or incomprehensible to those who need the information most because of lack of the necessary skills to interpret, process and integrate the data. ICT skills development has been the goal of ICT for development projects which have proliferated in the last 15 years. Relatively few are deemed successful or sustainable. Many reasons are cited for the failure but lack of local capacities, such as skills, is a repeating element.

Such capacities can often be quite basic. For example, it is interesting to note that most of the ICT documents reviewed for this dissertation focus on cost as the major issue and market-friendly policy instruments as the solution to the digital divide. On the contrary hardly there is any mention of illiteracy as a significant barrier to access, and basic education as a necessary policy response to this barrier. Yet the digital divide affecting ICT usage in disaster management is partly a literacy divide (Yap, 2011).

CHAPTER 5: POTENTIAL OF ICT IN RISK REDUCTION

5.1 Latest ICT Applications for Enhanced DRR

ICT plays a critical role in environmental monitoring to predict and detect natural disasters and provide warnings of their occurrence and also in the aftermath of a disaster by ensuring the timely flow of information needed by citizens, government agencies and those aid organizations involved in rescue and recovery operations and providing medical assistance to the injured. The value of ICT for helping people in need is recognized in the constitution of the ITU. It is an objective of the ITU "to provide concentrated and special assistance to developing countries and countries in special need, and to assist ITU Member States in responding to climate change and integrating ICTs in disaster management." In addition, the plenipotentiary conference of the ITU in Guadalajara, 2010, agreed Resolution 136 on "The use of ICT for monitoring and management in emergency and disaster situations for early warning, prevention, mitigation and relief" (ITU, 2015). In this regard ITU has a Framework for Cooperation in Emergencies (IFCE) for the provision of ICT equipment in a timely manner wherever a disaster occurs. This is a multi-stakeholder framework as shown in following Figure (URL 43):

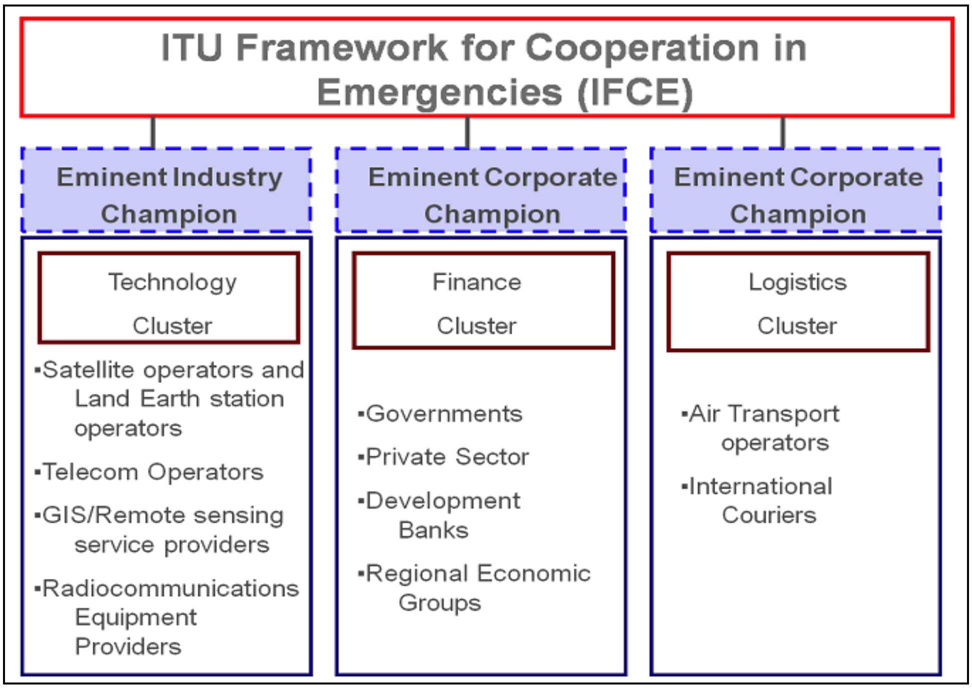


Figure 5.1: Stakeholders in the IFCE (ITU, 2015)

Until now, radio and TV broadcasting, amateur radio and fixed phones have mainly been used for DRR. Recently, mobile communication and digital signage[6] have also been developed and are widely used throughout the world. These new ICT tools should be recognized as new terminals and communication channels for delivering urgent information in a timely way to a huge number of people. They also have great potential for providing area-specific or user-specific information, which is really needed by the people affected by natural disaster. Providing interactive channels is another of their features that provides assistance during times of disaster. New types of early warning and disaster relief systems with mobile terminals and digital signage are also having immense potential in DRR (ITU, 2015).

ICT network resiliency and recovery against disasters can be tackled with multiple approaches. The primary approach is to strengthen networks in operation as much as possible and minimize potential damages. This approach includes redundancy, backups, and switch-over of the system or part of it. Another approach is to prepare transportable replacements that can stand-in for the operational networks.

When a disaster occurs and part of the network is destroyed, these prepared resources will be deployed immediately into the damaged area. The new units will replicate the role of the lost network facilities as a substitute. This approach should work well when a severe disaster occurs and network facilities, protected by the primary approach, are destroyed or rendered impossible to fix quickly. These two approaches complement with each other (URL 44).

5.1.1 Movable and Deployable ICT Resource Unit (MDRU)

The movable and deployable ICT resource unit (MDRU) is a collection of ICT resources that are packaged as an identifiable physical unit, movable by any of multiple transportation means, and workable as a stand-in for damaged network facilities and so reproduce their functionalities as a substitute. The MDRU also brings extra ICT resources to meet extensive communication demands at the disaster area. Packed into a container or box, an MDRU accommodates equipment for

[6] A system that sends information, advertising and other messages to electronic devices (e.g., displays, speakers) in accordance with the time of day and the location of the display, or the actions of audience.

reproducing ICT services such as switches/routers, wired/wireless transmitters/receivers, servers, storage devices, power distribution unit, and air conditioners.

Figure 5.2: Transporting an MDRU to a Remote Disaster Site (ITU, 2015)

The movable and deployable ICT resource unit (MDRU) is expected to bring two benefits:

- Quick recovery of the capabilities lost to realize the communications demanded for disaster relief activities in the area.
- Quick deployment of extra ICT resources will increase network capacity locally and thus minimize the impact of the extensive in communication demand that is usually carried by facilities outside the devastated area.

This traffic spike can cause wide area failures of the network. As a consequence, movable-and-instantaneously-deployable ICT resources will enhance network resiliency and recovery.

Figure 5.3 Components Inside MDRU & Vehicle Equipped with MDRU (ITU, 2015)

5.1.2 Timely and Effective Delivery of Early Warning

Until now, TV and radio broadcasting systems have been used to provide the general public with early warnings. A dedicated radio communication system is also used by local governments. Recently, a system for sending an early warning to an individual mobile terminal has been in development and some mobile network operators (MNO) have already provided it (URL 44 & 45).

- **Warning System with Mobile Terminals**

In case of disaster, mobile networks may be heavily congested by individual voice calls. If the mobile system distributes notifications through mobile broadcast technology, which is independent from or less affected by voice calls, the warning notification can reach multiple mobile terminals simultaneously within the areas affected by such disasters as earthquakes. The recipients of the notification will be made aware of the potential disaster and can prepare for it. The mobile terminal is the key receiver of early warnings because people always carry it with them and its penetration ratio is higher than that of traditional fixed telephones. Even when mobile traffic is severely congested, the warning notification must reach multiple mobile terminals simultaneously within the areas affected by the disaster. If the early warning is delivered through a broadcasting channel that is different from the individual communication channel, it reaches multiple terminals without interference from other voice and e-mail traffic. Following figure shows an example of tsunami mobile warning system used in Japan (URL 46):

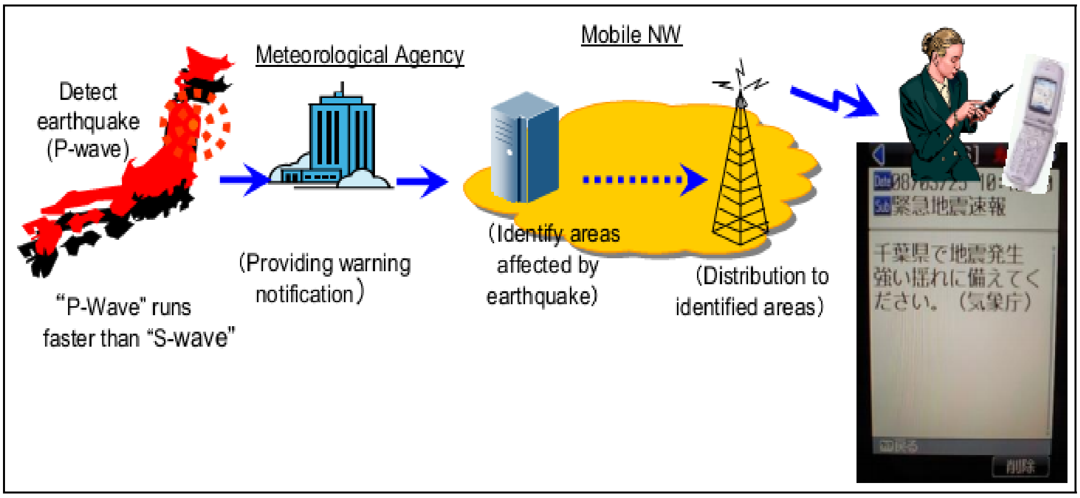


Figure 5.4: Tsunami Mobile Early Warning System in Japan

(Source: http://www.itu.int/en/ITU-D)

The 3GPP early warning system is called the Public Warning System (PWS) and is categorized into three subsystems; Earthquake Tsunami Warning System (ETWS), Commercial Mobile Alert System (CMAS) and European Public Warning System (EU-ALERT). As of 2013, ETWS has been implemented and operates throughout Japan, CMAS has been used on a trial basis in the USA, and EU-Alert has been used in the Netherlands. At present, these systems are actually operated separately in each region or country.

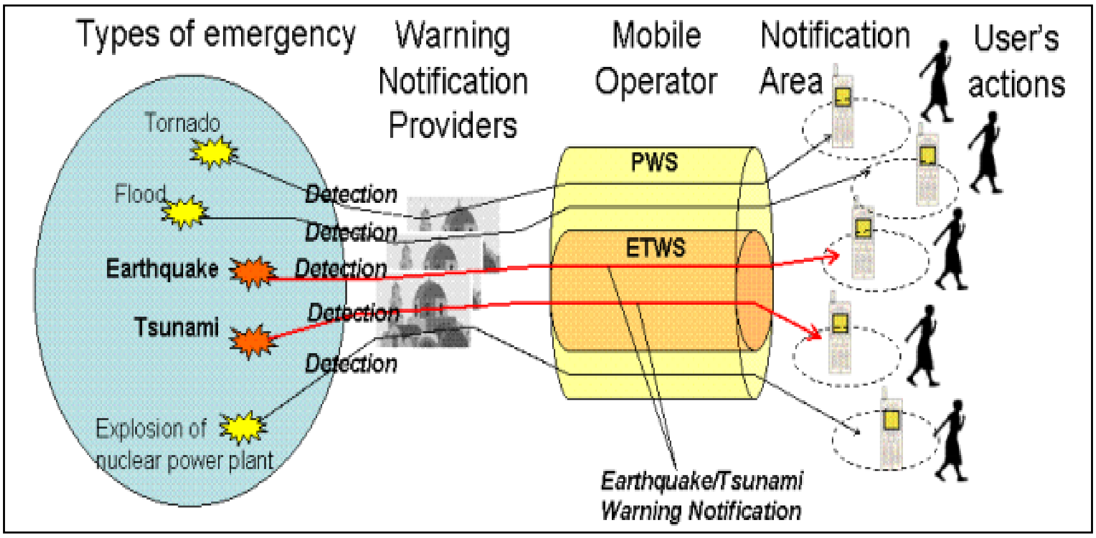


Figure 5.5: ICT Enabled Disaster Warning System (Source: ITU, 2015)

- **Warning System with Digital Signage**

Digital signage (DS) is a kind of information delivery display that shows TV programmes, local news, local public information, advertising and other messages. The display is normally installed in public and semi-public areas, including railway stations, retail outlets, hotels, restaurants, and corporate buildings. When warning information is received from prediction agencies, the warning system can deliver early notification to the DS installed in local public and semi-public areas (URL 46).

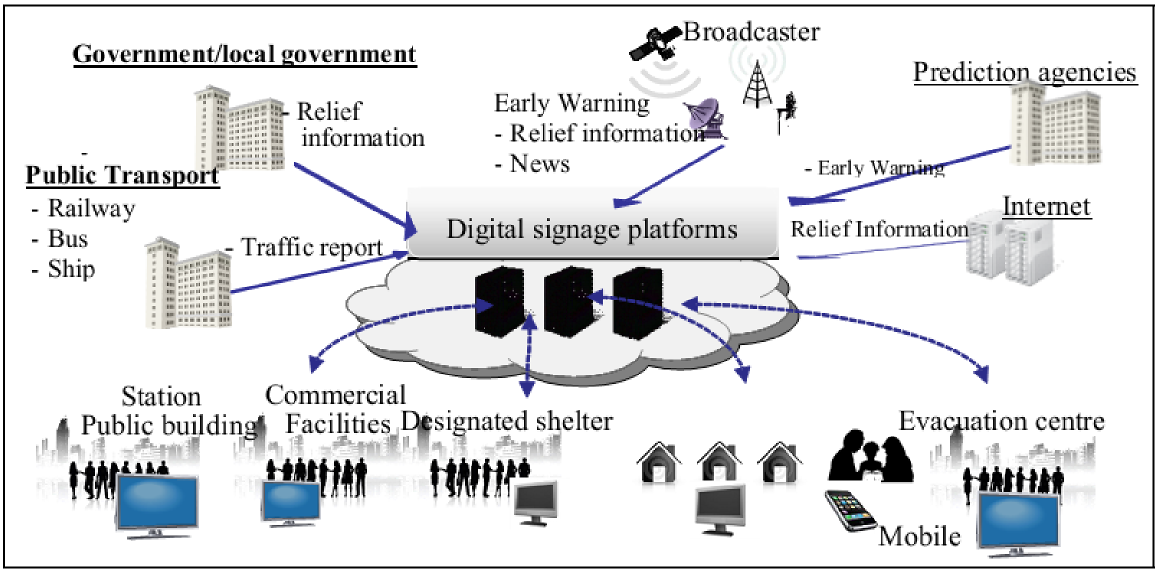


Figure 5.6: Digital Signage System for Disaster Relief and Early Warning (ITU)

5.1.3 Alternative Communication Modes for Voice Call Congestion

Voice call congestion is a well-known problem in the event of certain types of disasters (e.g. earthquakes) and it remains difficult to manage using the public telephone network with both fixed and mobile terminals. Experience shows that, in several cases, operators have regulated voice calls to avoid switching system failure resulting from a sudden increase in the number of voice calls. Internet Protocol (IP) based technologies are capable of mitigating the congestion or providing other communication means (e.g. IP telephony, voice-based messaging, text messaging, e-mail, SNS etc) (URL 47).

5.1.4 Enhanced Disaster Response System

The use of mobile terminals for notifying relief information is currently under development and several mobile operators have already provided some services. It is observed that most people (including victims) keep their mobile phones with them when escaping from danger and the mobile phone penetration ratio is greater than that of fixed telephones. When it comes to networks and systems, disaster relief systems must operate even when voice traffic is severely congested. In contrast to the traditional voice traffic over a circuit switched network and according to several past experiences, IP packet traffic may not be heavily congested even after a disaster. Therefore, an IP-based mobile system can be effective. Disaster relief notification is important and should be effective in relation to rescue, evacuation, safety confirmation and life sustainability. In this context following are few important and emerging tools with immense potential in DRR:

- **Disaster Message Board System**

  After a disaster, people generally want to talk over the telephone network to find out about the condition of their family, relatives and friends. However, they may fail to make contact due to severe voice traffic congestion. IP packet traffic is less congested than voice traffic. So, with an IP messaged-based mobile service, victims can easily inform their friends and family members of their safety or the damage situation. A user, i.e., a victim, places his or her text message on the message board of the system and the messages are delivered to their friends and family members (ITU, 2015).

- **Disaster Voice Delivery System**

  Some people prefer live voice-based communication when confirming the condition of their family, relatives and friends. Voice-based calls are easy for the elderly to make. Traditional circuit switched networks may suffer from congestion, whereas IP packet networks are not generally heavily congested even after a disaster. If part of a victim's voice call is packetized and sent as a notification message, it can be efficiently transmitted to their friends and family members through IP networks. This kind of packetized voice service allows friends and family members to confirm the safety and the damage situation of victims. A user, i.e., a victim, uploads his or her voice message to the server of the system and the message is delivered to friends and family members (ITU, 2015).

- **Disaster Relief Guidance System**

  During and after a disaster, victims may need to go to hospitals and temporary evacuation shelters whose locations they do not know. After a disaster is over, usual public transportation service may have stopped operating. As a result, people might have to travel on foot along long and unfamiliar routes, some of which may be impassable due to the disaster. In such cases, the victim first identifies his or her terminal location (by GPS) and selects the target location (e.g. shelter, hospital or home). Then, the terminal can provide a graphical representation of the route to the location (ITU, 2015).

The key element of the service is the map, which consists of a base map and relief locations such as evacuation shelters and hospitals. The maps are stored in the terminal in advance, because the mobile terminal may not be able to access the map servers within a network due to network outage and heavy traffic congestion. The service must operate even when there are no radio signals from mobile base stations. The map is regularly updated under normal conditions and it must also be capable of being easily and quickly updated after a disaster. Maps are stored in both a central server and local servers because the connection to the central server may be shut down after disasters (ITU, 2015).

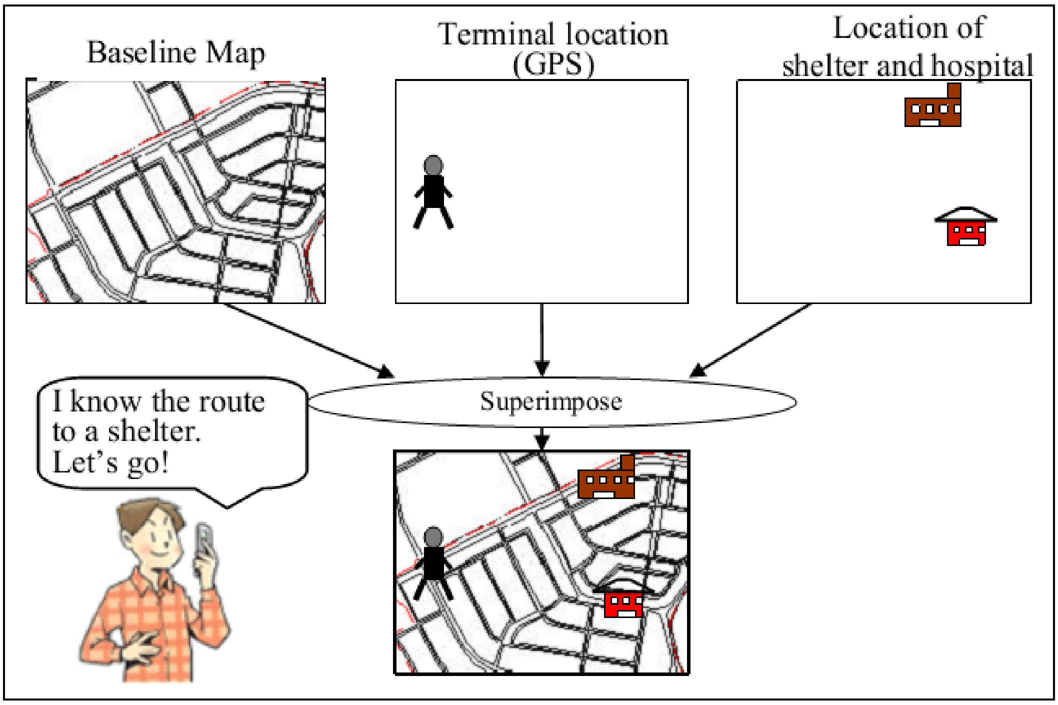


Figure 5.7: Guidance Service for Disaster Response (Source: ITU, 2015)

5.1.5 Effective Preparedness

ICT provide crucial services and systems for emergency and disaster situations as well as daily life. ICT systems against disasters have two aspects, namely service/application and infrastructure. Experience revealed that loss of power and insufficient fuel for back-up generators is a major factor in putting telecommunications equipment out of service. Thus, disaster relief systems (DR) and network resilience and recovery (NRR) along with electric power supply restoration issues are essential for effective preparedness in DRR (ITU, 2015).

- **Integrated View of Promising DR&NRR Technologies**

ICT systems are important in relation to disaster preparedness. To maintain and/or increase opportunities for communication even during disasters, terminals may be enhanced by further access technologies in order to utilize systems on different networks (e.g. fixed access networks, public Wi-Fi, Intelligent Transport Systems (ITS) and satellite networks). The networks will also be enhanced by providing several unconventional communication paths and combining currently independent networks and their capabilities (which are owned and/or operated by different organizations with different policies) in an integrated manner (ITU, 2015).

The integrated view of promising DR and NRR technologies describes the overall structure of networks that support disaster relief services and systems. The networks are divided into three categories:

- Core Networks.
- Access Networks.
- Users.

They are also categorized into two types; owned or not owned by service providers. Making the most of these different options, communication paths in an emergency situation can be secured in a more robust way.

- **Components of Integrated View**

The following items are promising technologies that can be employed in a disaster with regard to both one level and different levels:

- Local Wireless Mesh Network System.
- Delay Tolerant Networking (DTN).
- Mobile terminals with DTN functionalities.
- Nomad Stations with DTN functionalities.
- Resilient network architecture based on Movable and Deployable Resource Unit (MDRU).
- Portable Emergency Communication System (PECS).
- Recovery of optical fibre links in remote areas.
- Satellite Communication Network.
- Low-power VSAT technology.
- Bandwidth Optimisation Control Technology.
- VSAT Recovery.

5.1.6 Creating a Common Operational Picture

Voice communication is typically viewed as the immediate need prior to and after the onset of a disaster. Geospatial data are equally critical for assessing damage, planning relief operations and coordinating relief activities. The different agencies involved are likely to operate different sets of technical equipment with different data units and standards. Coordination will thus require the extraction, processing and integration of information from multiple sources to create a common operational picture, the lack of which is considered a major barrier to intra-and inter-agency coordination (URL 48) (Yap, 2011).

ITU with support from FedEx, IGO global communication, Inmarsat, Iridium, TerraStar Global, Thuraya and Vizada, deploys mobile satellite terminals and other equipment to help establish communication links for coordinating relief operations. The European Commission/Joint Research Centre's Global Disaster Alert and Coordination System (GDACS) sends alerts in real time and provides tools, updatable reports, maps, online discussion forum to help coordinate response (Yap, 2011) (URL 49)..

The International Charter on Space and Major Disasters (ICSMD), established in 1999, provides a unified system of space data acquisition and delivery to disaster-affected communities when so requested by member agencies. It delivers high quality satellite imagery to front-line responders generally within 24 hours. Non-profit ICT-expert organisations are likewise active in providing access to satellite data to low-income countries in disaster response. TSF (Telecom Sans Frontiers) deploys its teams and telecom equipment from one of three regional bases. These reach disaster sites within 48 hours and provide communication to emergency personnel facilitating coordination of response efforts (Yap, 2011).

5.1.7 Establishing Transparency and Accountability

A major disaster generally triggers an outpouring of technical and financial assistance from ordinary citizens around the world, usually channelled through donors and NGOs. The potential for waste, misappropriation and misuse of these resources is high. Lack of transparency and accountability can lead to irreversible loss of goodwill and generosity. Donors and the intended beneficiaries need to know what has been delivered where, to whom and when. Such a task is beyond the capacity of a single organisation. Self-organising, self-managed social networking ICT tools with free and open source platforms have proven powerful in meeting this need (URL 50).

One of such ICT tools is Web 2.0 tools which enable information sharing, collaboration and creation of user-generated content, in areas with broadband Internet connection. People serving as ‘sensors’, crowdsourcing information from mobile phone, email, RSS feeds, the web, and feeding it to decision-makers, add immense value to search and rescue operations and impose transparency in aid allocation and delivery. The ICT tools described here can support the task of providing an overall operational picture but they can also help establish transparency and accountability for resource allocation decisions. However safeguards are required against misinformation and caution must be exercised on unlimited sharing of information (Yap, 2011).

CHAPTER 6: MEANS TO INTEGRATE ICT TOOLS FOR RISK REDUCTION

6.1 Emerging Trends for Integrating ICT Tools

Although the evidence base is relatively limited, it is already clear that ICTs will be increasingly used in natural disaster management in a developing country like Bangladesh. In this context, technical and organisational trends emerging from the development of new wireless technologies; from convergence of telecommunications, advanced computing and multi-media; from ICT-friendly policy revisions; and from lessons learned on previous disaster management initiatives is eminent. In a country like Bangladesh some of these issues like greater standardisation and interoperability, more data availability at lower costs and better inter-agency collaboration need further attention to reap the maximum benefit and enormous potential of ICT tools in effective DRR.

6.1.1 Standardisation of Different System and Technologies

Several global initiatives are targeting this problem. GEOSS promotes the use of common technical standards so that geospatial data from thousands of different instruments can be combined to form a coherent dataset. The International Charter on Space and Major Disasters (ICSMD), UNOSAT and EPIC have similar goals. The Common Alert Protocol standardises early warning messages from different sensors and feeds them to different alerting technologies. This reduces inconsistencies and cost (URL 51).

6.1.2 Interoperability of ICT Devices and Networks

There are strong market interests pushing for technological interoperability of ICT devices and networks. "There can be no mass market without seamless interoperability." The use of free and open source software and open standards for data storage, communication and discovery is the favoured approach in effective DRR for natural disasters. Among public safety agencies this is reflected in the move towards partly or completely infrastructure-less ICT solutions such as those based on Tetra (Terrestrial Trunked Radio) standards and mobile adhoc network (MANET) communication platforms based on software defined radio (SDR) (URL 52).

6.1.3 Increase in Data Availability for ICT Expansion

The use of wireless mesh networks may also become more affordable. In February 2010, ITU signed an agreement with Singapore based Smart-Bridges Solutions to provide WiMAX and WiFi systems to strengthen ITU's on-the-ground disaster response capabilities. The equipment is sent to disaster sites to provide fast wireless phone and Internet connectivity when terrestrial networks are destroyed. Furthermore, recently unmanned aerial vehicles (UAVs) or 'drones' are being adapted to monitor disaster impacts. UAV images are cheaper to produce and have higher resolution than satellite images because UAVs are not affected by cloud cover since they fly at low altitudes. Although still relatively costly, the decreasing size and increasing use of UAVs through partnership arrangements between donors/NGOs and research institutions are expected to reduce cost (URL 53).

6.1.4 Intra and Inter-Agency Coordination

Weak intra-and inter-agency coordination in disaster response is a significant problem. Greater technological interoperability has not necessarily brought about the organisational behaviour change required to achieve full interoperability. The problem is widely recognised as one of trust. Most of those responding to a disaster will not likely have met face to face before but will nevertheless need to collaborate during and after the disaster, often in a complex, chaotic or completely unplanned environment. Some experts view ICTs as critical in facilitating collaboration among hastily formed networks in disaster context. Thus, trust and efficient knowledge sharing can be achieved with collaborative technologies and appropriate social processes (URL 54).

6.1.5 Global and Strategic Alliances

The ratification of the Tampere Convention in 2005 has helped expedite the deployment, cross border movement, installation and operation of ICT and telecommunication services during disasters. Regional actions have also played their part. For instance, in the Asia Pacific there are initiatives aimed at establishing regional and sub-regional standby communications systems for disaster management purposes as well as arrangements for sharing information. These are enabling access at much reduced cost to countries with fewer resources and weaker infrastructure.

There are also numerous partnership arrangements potential among government, industry and NGOs seeking to address the standardisation, interoperability, data availability, and cost issues related to the use of ICTs in DRR (Yap, 2011).

6.2 Ways Forward

In Bangladesh large-scale natural disasters, regardless of the specific physical event involved, often result in similar scenarios: critical infrastructures destroyed or disabled for several days or weeks, and an influx of different organisations offering assistance. Generally more pronounced in Bangladesh, these scenarios pose tremendous challenges in communication, coordination and accountability, which have important consequences for the effectiveness of DRR. They warrant strategic policy and programme responses.

6.2.1 Ensuring Continuity in Challenged Environments

- Regulations should provide for priority access to communications for disaster responders, and priority repair of communication services to ensure continuity of ICT-enabled services and products.
- If the ICT infrastructure is in private hands, such provisions should be included in licensing and concession contracts.
- Hardened data centres for archiving digital data and running of essential government services should be established. This is admittedly costly but has high development returns.

6.2.2 Mainstreaming Wireless Technology

- A forward looking strategy would 'mainstream' wireless technologies more systematically, expediting the use of cheaper, energy-smart wireless network in early warning systems, and the deployment of inexpensive ICT solutions when infrastructure is compromised.
- Disaster conditions frequently demand extraordinary use of communication tools. ICT systems should be developed not with proprietary solutions but with diverse standard components and operational interfaces that accommodate interoperation.

- While procuring ICT equipment, systems based user friendly easy to maintain and familiar applications should be preferred over those requiring specialised training. Responding to disasters involves solving problems under high stress conditions. Skills used infrequently are often forgotten in such situations. Routine use builds confidence.

6.2.3 Enhancing Inter-agency Coordination and Cooperation

- One of the acknowledged barriers to interoperability is non-technological fragmented planning and poor coordination. Expert opinion in reviews of responses to several major disasters in the last fifteen years share one conclusion, that the quality of the response depended not on response planning or on new equipment, but on the quality of the network that came together to provide response. Furthermore, the existence of a well-established national disaster response plan will definitely appear to make a difference

- Forming an executive committee on site, representing the different organisations, might be a non-threatening way to initiate coordination. Protocols for sharing information, equipment and resources and decision making would have to be agreed upon at the outset. The experience in the 2001 Gujarat earthquake suggests that having ICT experts in the response teams hugely facilitates the coordination process. Tools for labelling and filtering need to be developed so members can avoid being paralysed by information glut, and only access information relevant to their needs.

6.2.4 Maintaining Efficient Accountability

- Whether large or small, disaster response in Bangladesh often relies on external financing and assistance. ICTs have become very effective tools in raising funds for disaster assistance, but such financial assistance will only be continuously provided if donors agencies, governments, individuals are convinced that assistance was widely used. Therefore the use of ICTs to create accountability of disaster response agencies should be more widely adopted.

6.2.5 Integration of Different Technologies in Single Platform

- Almost all of the most valuable ICT applications are those involving integration of technologies. Sometimes, in EWS these run in parallel. But often they run in combination within the same system, integrating the Internet and mobile phones, combining satellites and GIS, and so on (URL 55).

- There is a strong requirement for integrating disaster and development ICT uses into a single system in order to get a multiplier effect and maximizing its potential. For example, generic weather information systems; generic 'human sensor' reporting systems, generic mapping systems etc. Not only these are more efficient but also help to embed DRR systems into the routine functioning of communities.

6.2.6 Preparation of Accessible ICT Enabled Database on DRR

- The role of accessible ICT database in DRR arena is tremendous. The best use of human knowledge to guarantee security and safety of community including persons with disabilities requires significant change of knowledge sharing process of the society.

- Archives on disasters including documentary videos and news programs need to be accessible for community who must learn from previous tragedies as well as good practices.

- In addition, development of accessible and easy to understand scientific knowledge base on DRR will play key role to share solutions to break down the barriers that prevent community to evacuate in time.

- Accessible ICT will create a community which is well prepared for disasters by mobilizing human capacity through sharing of appropriate DRR knowledge on the cloud as well as at telecenters, community radio stations and small mobile libraries in laptops or mobile phones. Thus this will contribute in economic aspects of the sustainable development of the accessible global DRR knowledge base.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

ICT tools show great potential for DRR in the areas of communication, coordination, visualization, and risk analysis, early warning and enhanced response. Many tools, such as Google Maps and Twitter are available for free and do not require ICT specialists to support them. Web resources like EOC is available and has the ability to automate dispatching processes in hazard response situations. ICT tools are also available to be used to predict and model flooding impacts before and during storm situations. Together, these ICT tools provide new capabilities that have never before available to agencies involved in DRR. In day-to-day, non-disaster situations, these tools can be used in planning and developing risk reduction strategies. When a hazard strikes, they can help to manage the wave of information that arrives at a disaster management office in immediate, post-impact instances, which is identified as the most critical time for effective ICT performance (ESCAP, 2009).

The "Digital Divide" is defined as the gap between those with regular, effective access and ability to use digital technologies and those without. Indeed, as impressive as the number may seem in global context, 6.8 billion mobile phone subscriptions and more than 2 billion mobile broadband internet subscriptions (ITU, 2013); but ground reality is more often than not one of information poverty, limited mobile phone coverage and little or no access to internet for both humanitarians and communities at risk. There is no doubt that the prevalence of mobile phones is rapidly growing, but the numbers include inactive connections and multiple connections per user, so that the real number of mobile users worldwide was estimated at 3.2 billion in 2012 or less than half the 6.8 billion mobile subscriptions (IFRC WDR, 2013).

In the same note, digital divide also exists in Bangladesh between urban and rural population. Still a distinct gap exists between the urban and rural population in terms of ICT usage also in rich and poor in the community. Since rich people can have access to up-to-date ICT facilities, digital divide always exists between rich and poor. Poor people hardly can afford high cost of modern ICT equipment. While Bangladesh has made significant inroads to poverty alleviation, the overall incidence of poverty remains still high with considerable population below the poverty level. It is imperative for Bangladesh to take effective steps to bridge the digital divide and ensure ICT facilities at the grass route level of the community. Recently as government pledged to convert Bangladesh into 'Digital Bangladesh' by 2021 which is the golden jubilee year of the independence of Bangladesh, several initiatives have been taken to overcome the digital divide and to produce future qualified generations (URL 56 & 57).

Based on the current status of the digital divide, latest and emerging technologies, and ICT for DRR initiatives in Bangladesh this dissertation concludes that the country still face some difficulties in terms of implementation of ICT initiatives, introducing ICT access and assessing the ICT access need of community with special reference to natural disaster management.

Access to and use of ICT by vulnerable populations with special needs, such as people with disabilities and illiterate populations need to be carefully catered. The important impact that ICT can have for such populations in improving their livelihood in the face of natural disaster has been well documented. To be effective, however, it is important that people with little or no formal education can easily use the interface and navigate the content provided.

While proposing ICT implementation, geographical features of Bangladesh may be one of the most important factors. From coastal regions to mountainous terrains, jungles and vast flat lands, the country is blessed with vast geographic diversity and natural endowment. These varied geographic conditions have placed hindrances to achieve social and economic development, and created income gaps and the digital divide between people living in urban and remote areas. Moreover, recent developments in wireless and mobile technologies have opened up new possibilities of allowing the un-connected and under-serviced community to access ICT at a faster rate with lower costs than with the traditional methods.

Furthermore, the latest satellite technology promises to connect any place around the world. Therefore, selecting and combining technologies is the key solution to expand and sustain the last mile connectivity. From the end users' perspective, raising public awareness and creating demand are important factors to determine the sustainability of ICT initiatives.

7.2 Recommendations

This dissertation recommends for holistic and comprehensive ICT implementation approaches in adopting appropriate technologies and maximizing the benefits of existing infrastructure and initiatives as well as raising public awareness regarding use of ICT tools for effective DRR. In this regard, following considerations are recommended from this study:

- Effort for reducing the digital divide between urban and rural areas need to be given high priority in the context of DRR where the urban/rural dimension of the digital divide is more pronounced in poorer communities. Moreover, it is essential to continue monitoring the urban/rural character of the digital divide in order to gradually close it.

- Intermediate ICT services may be useful in Bangladesh in areas where illiteracy is prevalent. This can take different forms, such as community access centres that are operated by a facilitator or mobile help services for people with low literacy.

- In order to share experiences, challenges and good practices in common among developing countries in the context of ICT for enhancing DRR, regional cooperation should be further encouraged or strengthened.

- Since development agencies have recognized the importance of ICT in economic and social development and striving for the effectiveness of ICT in accelerating DRR, the provisioning of ICT services need to be built into development strategies with fullest effort.

- It is essential to identify what is urgently needed by end users and which mode of access will be suitable for the people to fill the last mile gap along with the technological considerations. Cost effective and socio-economically beneficial ICT applications contribute to reduce the social divide and improve quality of life through enhanced access to DRR, sustainable development and other benefits of ICT. Therefore, providing access to information and ICT services should remain a high priority in Bangladesh in the context of effective DRR for the community.

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ANNEX A: LIST OF WSIS ICT TARGETS AND THEIR INDICATORS BEYOND 2015

Target 1: Connect villages and establish community access points.

Target 2: Connect all secondary schools and primary schools with ICTs.

Target 3: Connect all scientific and research centres with ICTs.

Target 4: Connect all public libraries, archives, museums, cultural centres and post offices.

Target 5: Connect all health centres and hospitals with ICTs.

Target 6: Connect all local and central government departments and establish websites and e-mail addresses for them.

Target 7: Adapt all primary and secondary school curricula to meet the challenges of the information society, taking into account national circumstances.

Target 8: Ensure that the entire world population has access to television and radio services.

Target 9: Encourage the development of content and putin place technical conditions in order to facilitate the presence and use of all world languages on the Internet.

Target 10: Ensure that more than half the world's inhabitants have personal use of ICT.

(Source: https://www.itu.int/wsis/basic/about.html)

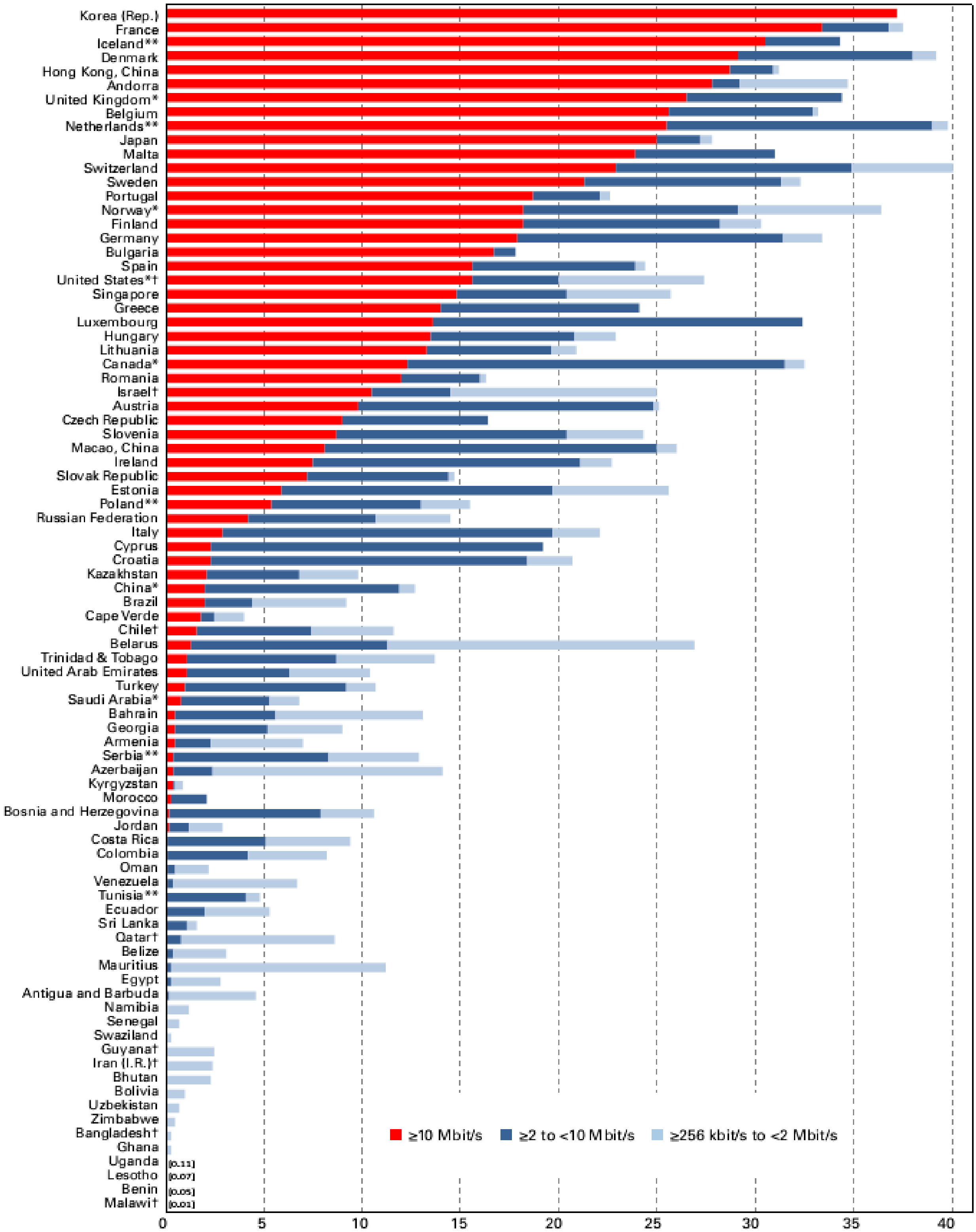
ANNEX B: WEIGHTS USED FOR INDICATORS AND SUB-INDICES INCLUDED IN THE IDI

	Weights (Indicators)	Weights (Sub-indices)
ICT access		
Fixed-telephone subscriptions per 100 inhabitants	0.20	0.40
Mobile-cellular telephone subscriptions per 100 inhabitants	0.20	
International Internet bandwidth per Internet user	0.20	
Percentage of households with a computer	0.20	
Percentage of households with Internet access	0.20	
ICT use		
Percentage of individuals using the Internet	0.33	0.40
Fixed (wired)-broadband Internet subscriptions per 100 inhabitants	0.33	
Wireless-broadband subscriptions per 100 inhabitants	0.33	
ICT skills		
Adult literacy rate	0.33	0.20
Secondary gross enrolment ratio	0.33	
Tertiary gross enrolment ratio	0.33	

(Source: ITU, 2015)

ANNEX C: DIFFERENCES IN HIGH-SPEED ACCESS TO THE INTERNET

Fixed-Broadband Subscriptions per 100 Inhabitants, By Speed, Early 2013



Source: ITU World Telecommunication/ICT Indicators Database, 2014

ANNEX D: THE INTERNATIONAL AMATEUR RADIO UNION (IARU)

1. The International Amateur Radio Union consisting of over 160 national amateur radio societies represents the interests of the global amateur radio community of more than 2 million licensed radio “hams”. The IARU is a member and participates in the work of the ITU-R and ITU-D. In particular, the IARU is active in discussions of emergency communications and disaster planning and response in the ITU-D.

2. The “Amateur Service” is defined in article 25 of the Radio Regulations of ITU that states:

- “Amateur stations may be used for transmitting international communications on behalf of third parties only in case of emergencies or disaster relief. An administration may determine the applicability of this provision to amateur stations under its jurisdiction.”

- “Administrations are encouraged to take the necessary steps to allow amateur stations to prepare for and meet communication needs in support of disaster relief.”

3. The constitution of the IARU promotes the use of amateur radio “as a means of providing relief in the event of natural disasters” and provides information on emergency communications. Amateur radio is a valuable asset during an emergency as the global, regional, national and local links for voice and data communication are independent of vulnerable infrastructure and immune to overload. Radio hams are also very skilled and many have undertaken special training in emergency communications.

4. Amateur radio operators have provided valuable communication channels from areas affected by a disaster to the outside world, for example, for remote locations affected by the 2004 Indian Ocean tsunami, Hurricane Katrina, the Sichuan earthquake in 2008 and, as it was seen, in the earthquakes in Turkey. The Amateur Service is integrated into the emergency preparedness systems in a number of countries such as the USA, Germany, Finland, Indonesia and Cuba.

(Source: ITU, 2015; Technical Report on Telecommunications & Disaster Mitigation)