ROLE OF ICT IN EMERGENCY NATURAL DISASTER MANAGEMENT & EARLY WARNING SYSTEMS OF BANGLADESH

(A study to understand the depth of ICT incorporation in disaster management systems in Bangladesh)

BY

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This Report is Presented in Partial Fulfilment of the Requirements for the Degree of Master of Science in Management Information Systems (MIS)

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APPROVAL

This thesis titled "Role of ICT in Emergency Natural Disaster Management & Early Warning System of Bangladesh", submitted by "U King Swe" to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of Master of Science (MS) in Management Information Systems (MIS) and approved as to its style and contents. The presentation has been held on 04 February 2023.

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I hereby declare that, this thesis has been done by myself under the supervision of **Dr. Sheak Rashed Haider Noori, Professor and Associate Head of Department of CSE** Daffodil International University. I also declare that neither this thesis nor any part of this thesis has been submitted elsewhere for the award of any degree or diploma.

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ABSTRACT

Natural disaster is a seasonal norm in Bangladesh. An abundance of rivers and other geological factors have paved the way for a series of natural calamities including flash floods, floods, cyclones, earthquakes, soil erosion, and other such calamities. These disasters wreak havoc affecting the lives of many. Public, as well as many private resources, are engulfed by these natural disasters. As a developing nation, it is very important to ensure continuous progress in terms of the socioeconomic conditions of the country. However, natural disasters are a great hindrance to this. The Government of Bangladesh (GoB) has been working to tackle this issue with disaster preparedness and management procedures available. GoB is working closely with the concerned international institutes to figure out procedures and methods suitable for the country in battling against such issues. The role of ICT is overwhelming in ensuring appropriate measures are taken in disaster management and preparedness. The impact of ICT has been recognized all over the world and it has proved to provide greater efficiency, speed, and effectiveness in minimizing the damage caused by natural disasters. In Bangladesh, the use of ICT has been prevalent since the inception of this country. Policy changes as well as recent improvements have eased the integration of ICT services for disaster management issues.

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CHAPTER 1

Introduction

1.1 Motivation:

Bangladesh and its people have been victims of natural disasters if the history of this place exists. The intricate web of rivers has made this land fertile enough to grow anything. However, the fertility of the land has been counterbalanced by the abundant floods flushing down the riverbanks on a seasonal basis. The issues have been amplified recently with the initiation of climate change. In terms of the climate change effects, the nation ranks as the first and most vulnerable [1]. Additionally, in recent years, the incidence of natural disasters has been rising steadily. Compared to 50 years ago, these natural disasters occur more than three times as frequently [2] [3]. Low to middle-income countries are at the most risk due to the lack of proper infrastructure in managing disasters.

The effect of natural disasters is more harmful when it comes to developing nations. Over the period of 2008- 2018, Asia was hit the most. Economic losses surmounted to over $49 billion, with Africa coming in second at $30 billion [4]. The trend of such large-scale economic losses as well as the frequency of natural disasters occurring does not seem to rest for a while now.

For Bangladesh, the frequent natural disasters and the economic losses incurred pose a greater threat. The lack of suitable infrastructure makes the damage a couple of folds more damaging to the ongoing processes of development projects taken around the country. Hence, an unending cycle of development projects being taken and destruction of the development projects due to natural disasters takes place.

In Bangladesh flash floods and soil erosion go hand in hand every year when the rainfall exceeds the average rainfall by a meager amount. A 2015 World Bank Institute report states that 3.5 million people may be in danger from river flooding. Annually. Besides this, a report cited by the UN estimates around 17% of the country being submerged by 2050 leaving about 20 million people homeless .

However, projects and steps are being taken to ensure the proper disaster management practices and methods are being followed. Steps include the conversion Ministry of Disaster Management and Relief's Disaster Management and Relief Division (MoDMR). Regulatory frameworks have also been devised to incorporate better management practices.

1.2 Keywords:

Disaster management, ICT, warning system, natural disasters

1.3 Objective of the Paper:

The purpose of the paper is to analysis the available literature regarding the current disaster management system of Bangladesh and understand the depth of ICT incorporation in disaster management systems. Finally, suggesting methods and practices relevant to the scenario in Bangladesh.

1.4 Methodology:

The paper will be analysing the existing literature regarding the incorporation of ICT in disaster management practices. The paper will be studying the secondary data and come up with relevant suggestions suitable for Bangladesh.

1.5 Scope:

The study of ICT in disaster management will be confined to understanding the practices followed in relation to developing countries and the current condition of disaster management practices and methods prevalent in Bangladesh.

CHAPTER 2

Literature Review

2.1 Study Area:

Bangladesh is the study area, which is a large part of the Asia-Pacific area. A low-lying, riverine country in South Asia, Bangladesh has a 710 km long coastline that is largely covered in the swampy forest along the northern littoral of the Bay of Bengal. A deltaic plain created by the Ganges, Brahmaputra, and Meghna Rivers and their tributaries gave rise to Bangladesh. Despite being extremely fertile, Bangladesh's alluvial soil is especially vulnerable to hydro-meteorological hazards including floods and drought [4] [5] [6]. Hills only rise above the plain in the Sylhet Division in the northeast and the Chittagong Hill Tracts in the far southeast. Bangladesh has a tropical monsoon climate characterized by scorching summer temperatures, frequent heavy seasonal rains, and high humidity because it is on the Tropic of Cancer.

Figure 1: Map of Bangladesh (Study Area)

2.2 Climate Change and Natural Disasters:

According to German Watch's 2021 Global Climate Risk Index, Bangladesh is the seventh most vulnerable country to climate change while contributing only 0.56% of the world's emissions (CRI). To put it into numbers, the nation has had 185 extreme weather events, damages totalling $3.72 billion, between 2000 and 2019 .

The geographical factors, location, soil, and rainfall characteristics, and innumerable rivers that spread through all the corners of Bangladesh make it a breeding ground for natural calamities such as flash floods, and soil erosion. Being situated in the stable pre-Cambrian platform as well as the geosyncline basin, Bangladesh has not experienced earthquakes in recent times.

Among the problems that engulf Bangladesh due Sea level rise is a factor in climate change. Nearly two-thirds of the nation is located at or below 15 feet above sea level. According to estimates, one in seven citizens of the nation will be relocated as a result of climate change by 2050. This might be close to about 18 million people alone due to the rising sea level [7]. Rising sea level induces agricultural lands to be incapable of producing crops due to the process of salinization. The salt gets inside the land, and this hinders crop growth by limiting their ability to soak water.

Besides this, recently there are more instances of flash floods occurring due to slightly increased rainfall than average. Quite recently there has been a massive flood that engulfed the greater Sylhet region. In the flood, thousands of people from 93 unions of Sylhet suffered as humanitarian aid could not reach them. Initially, the death toll rose to 68 people within 24 hours [8]. The flood has been claimed to be the worst in a century severely affecting almost 7.2 million people. The flood has disabled communications systems making organizations unable to provide relief or any sort of support. This worsened the entire scenario.

The rural-to-urban migration for increased economic stability has become an inevitable future for many. The number of annual migrants is about 400,000 and most of these people must live in slums. These overall increases the harshening of weather and makes extreme weather more frequent [9] [10] [11].

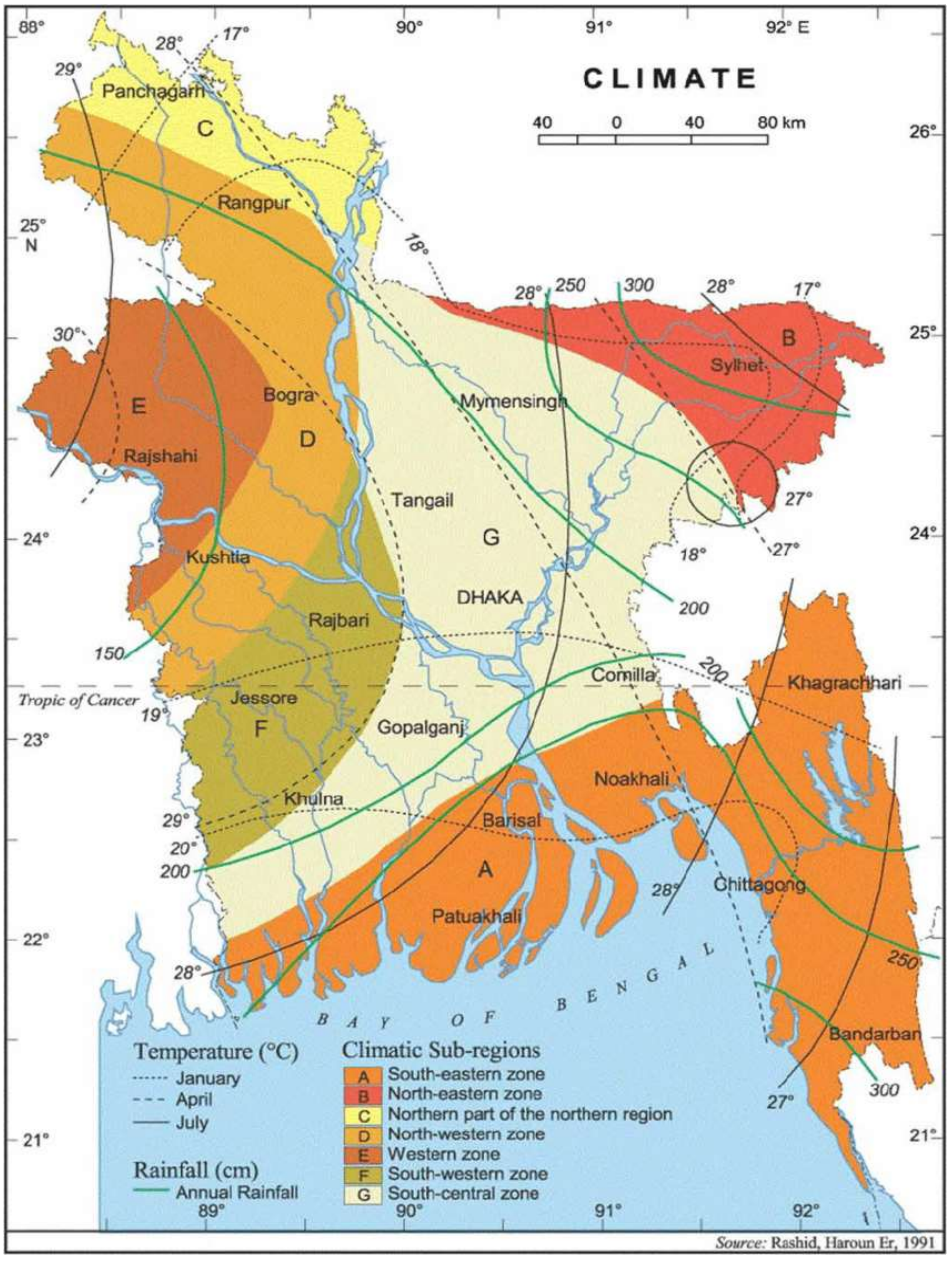


Figure 2.1: The weather in Bangladesh

2.3 Limitations of the Study:

Secondary information sources served as the main foundation for the report. As a result, as the report developed in some places, a ground survey was deemed required

to better assess the current situation of quickly evolving ICT means and tools. Contrarily, due to the spatial and time constraints of the report production, this was not feasible. However, the focus of additional research on the topic would effectively handle the problem to fit the continuously expanding far-reaching modernization and innovation trends in ICT that are imaginable.

2.4 Natural Disasters in Bangladesh:

According to the 2014 Global Climate Risk Index, Bangladesh is the world's fifth-most disaster-prone country. The country is very vulnerable to several types of disasters because of climate variability, catastrophic weather occurrences, high population density, a high prevalence of poverty and social inequality, weak institutional capability, insufficient funding, and inadequate infrastructure. These disasters cause major property damage, human casualties, and damage to the economy. At least one major catastrophe year has occurred in the country, and over the past ten years, it has lost an average of 3.02% of its GDP [12] [13] [14] [15].

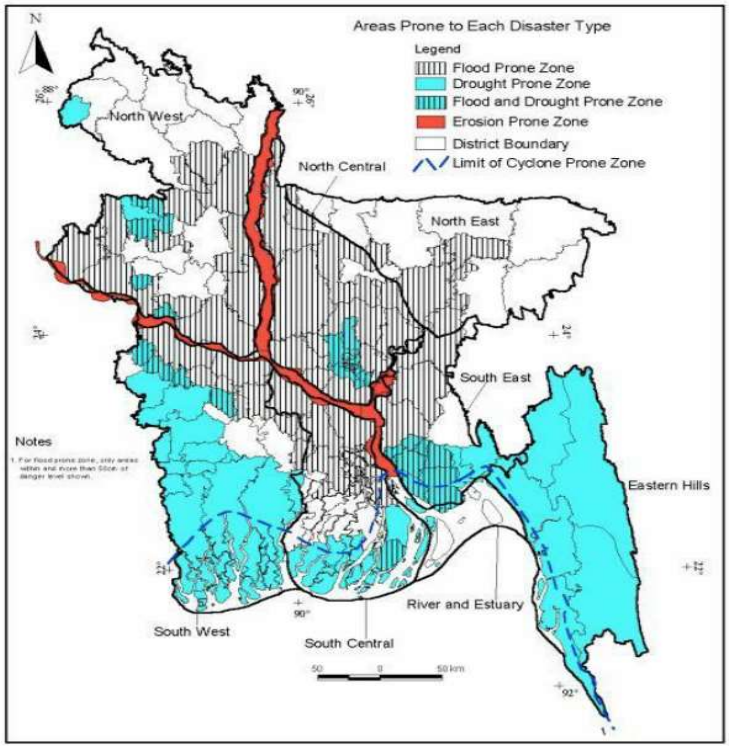
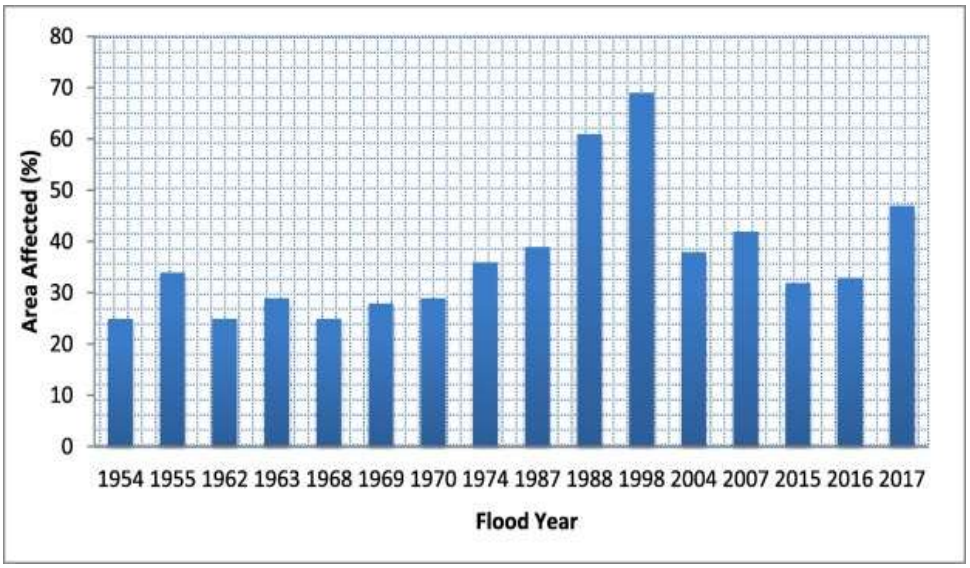


Figure 2.2: Areas Prone to each Type of Disaster



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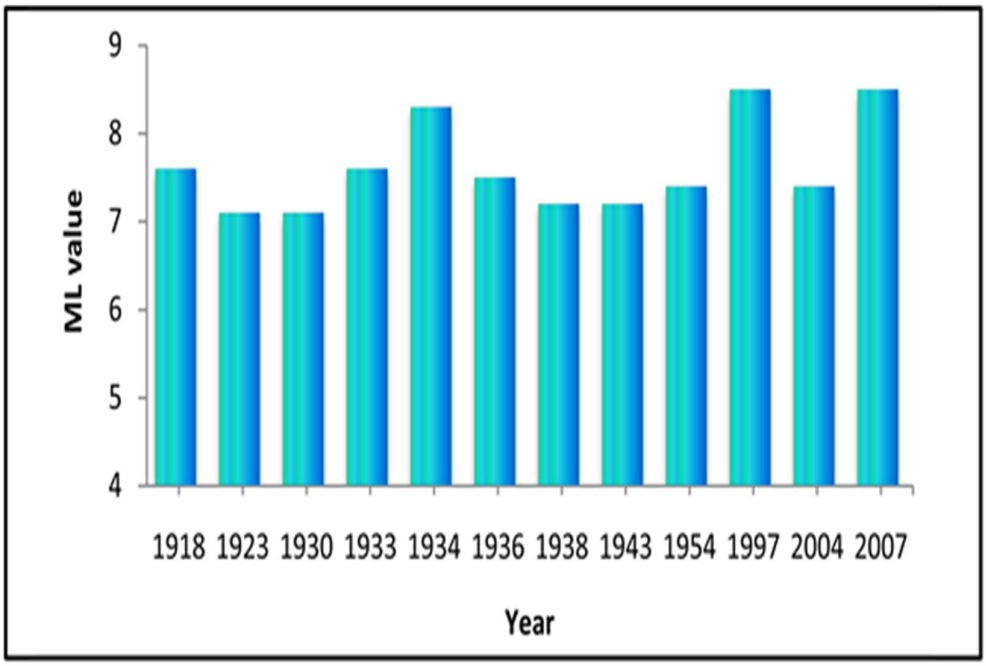

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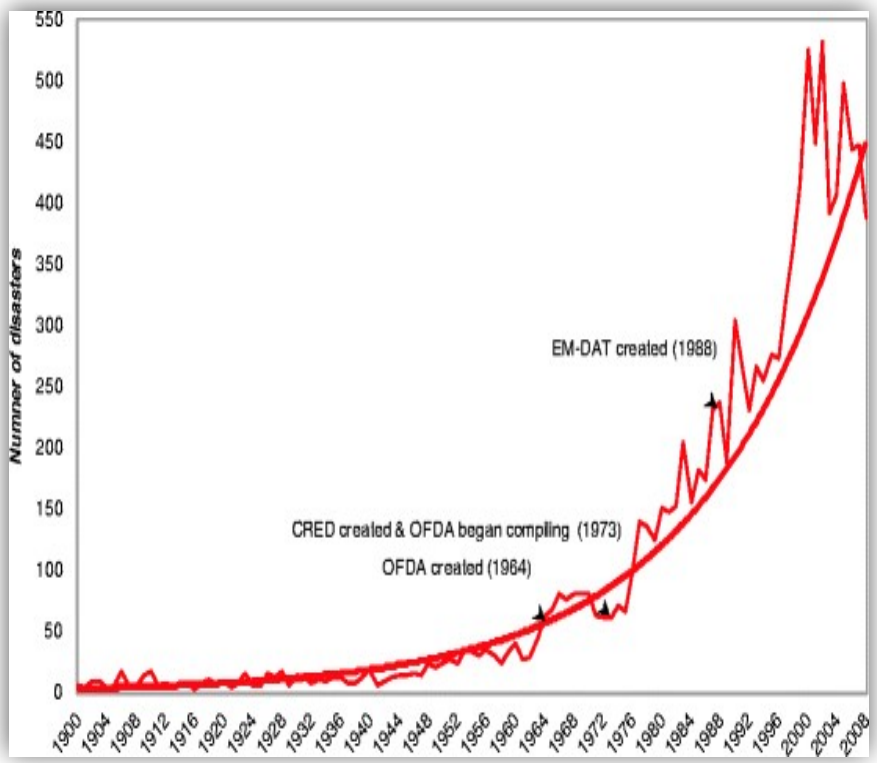

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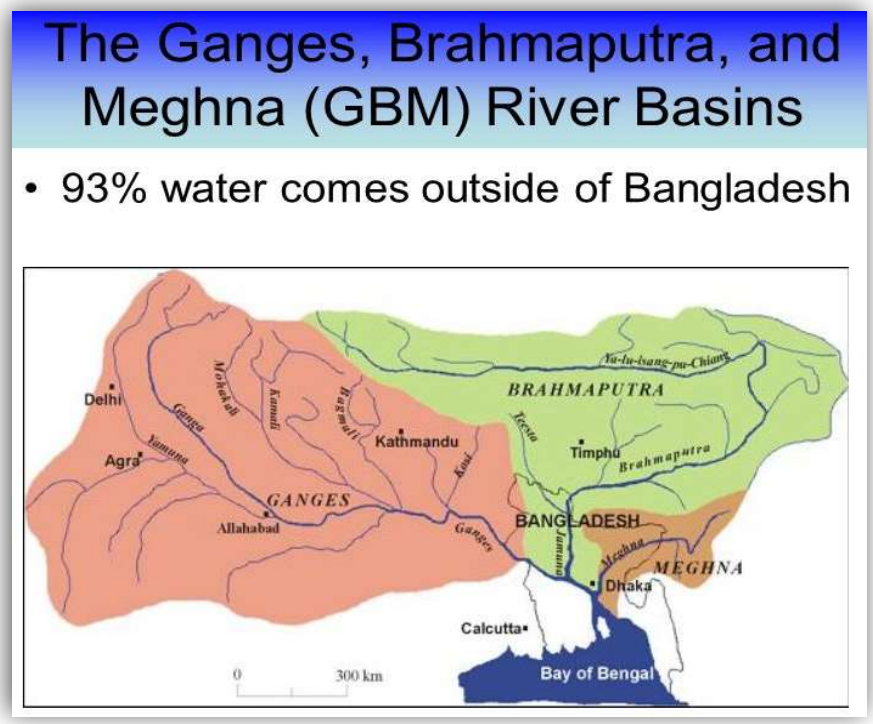

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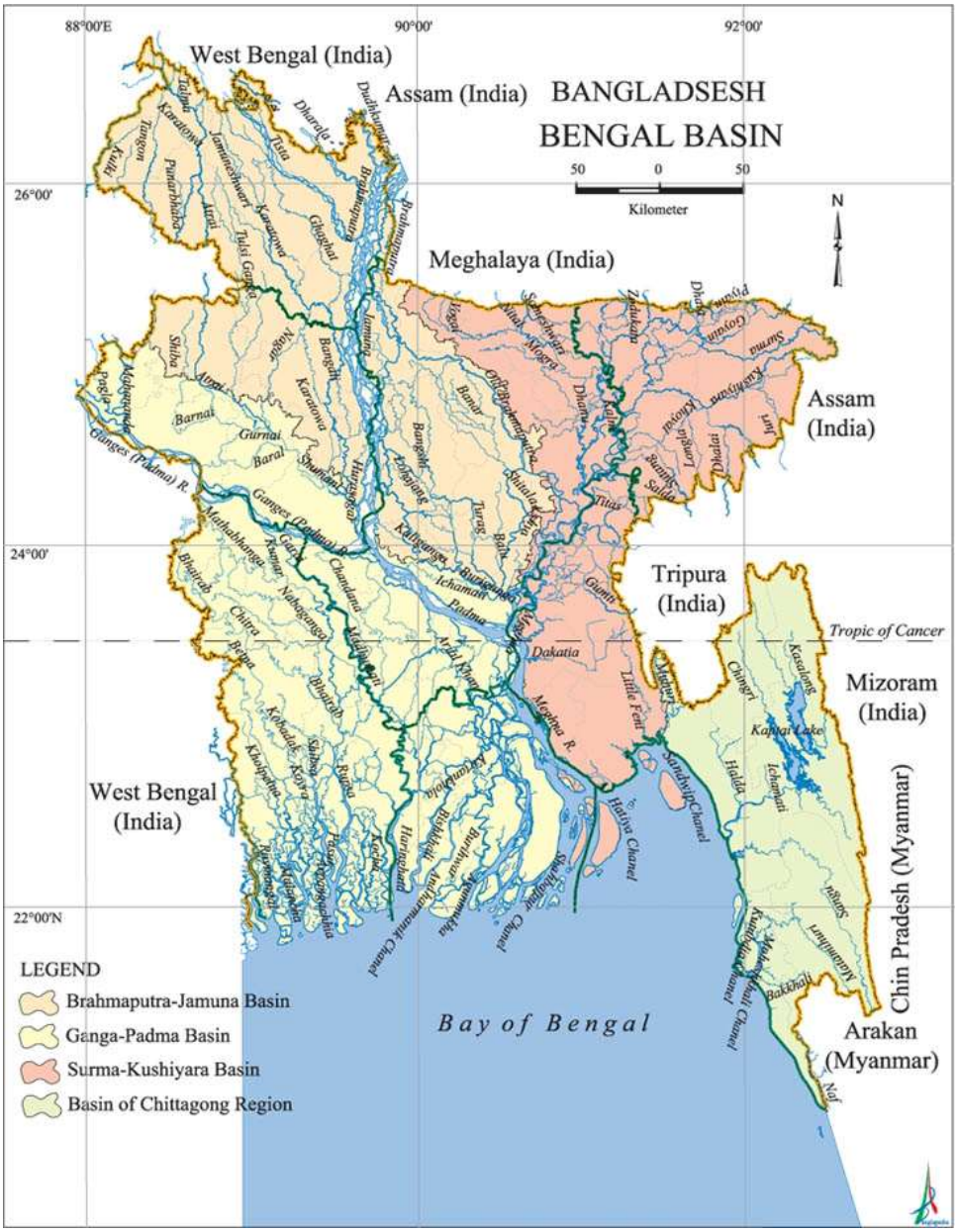

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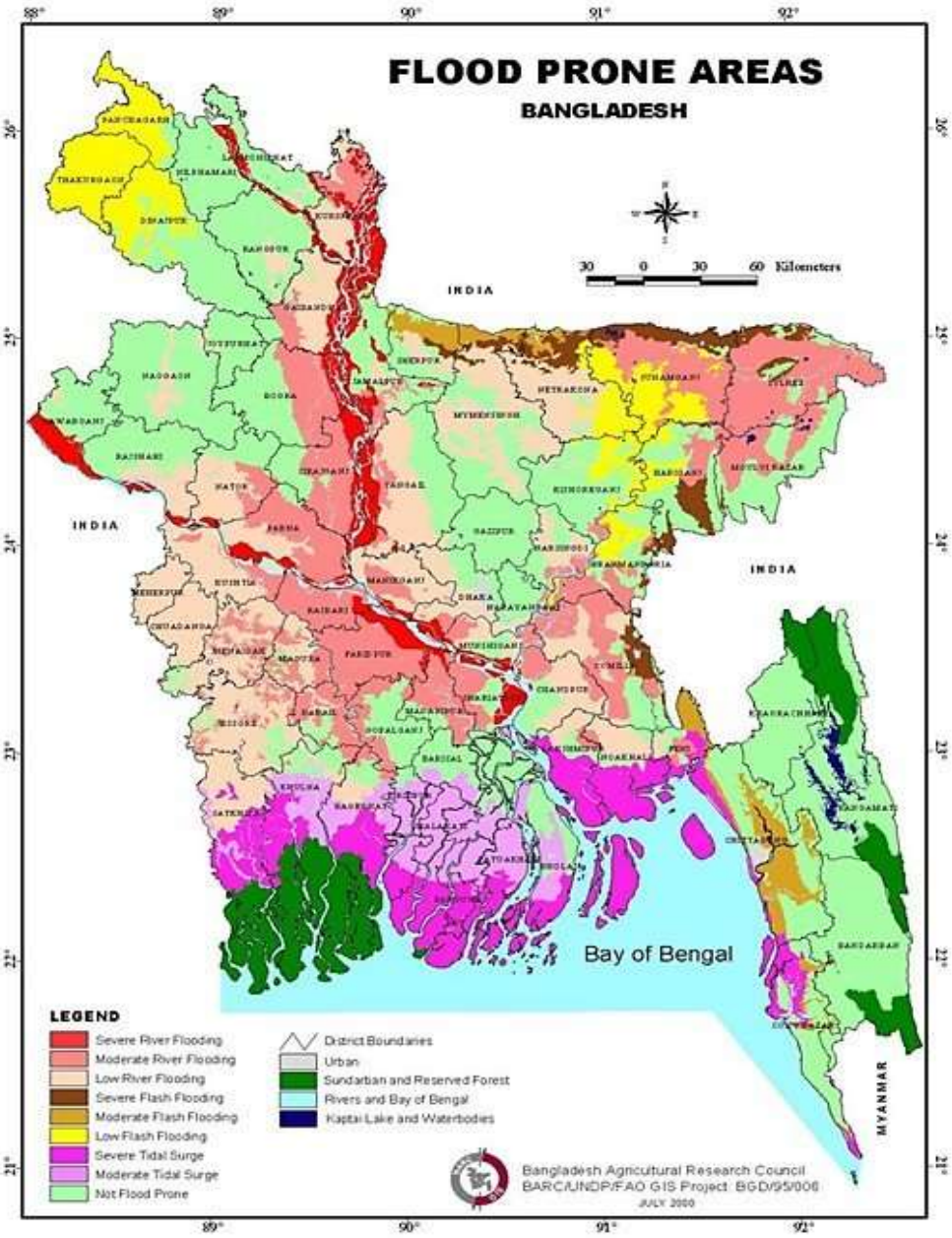

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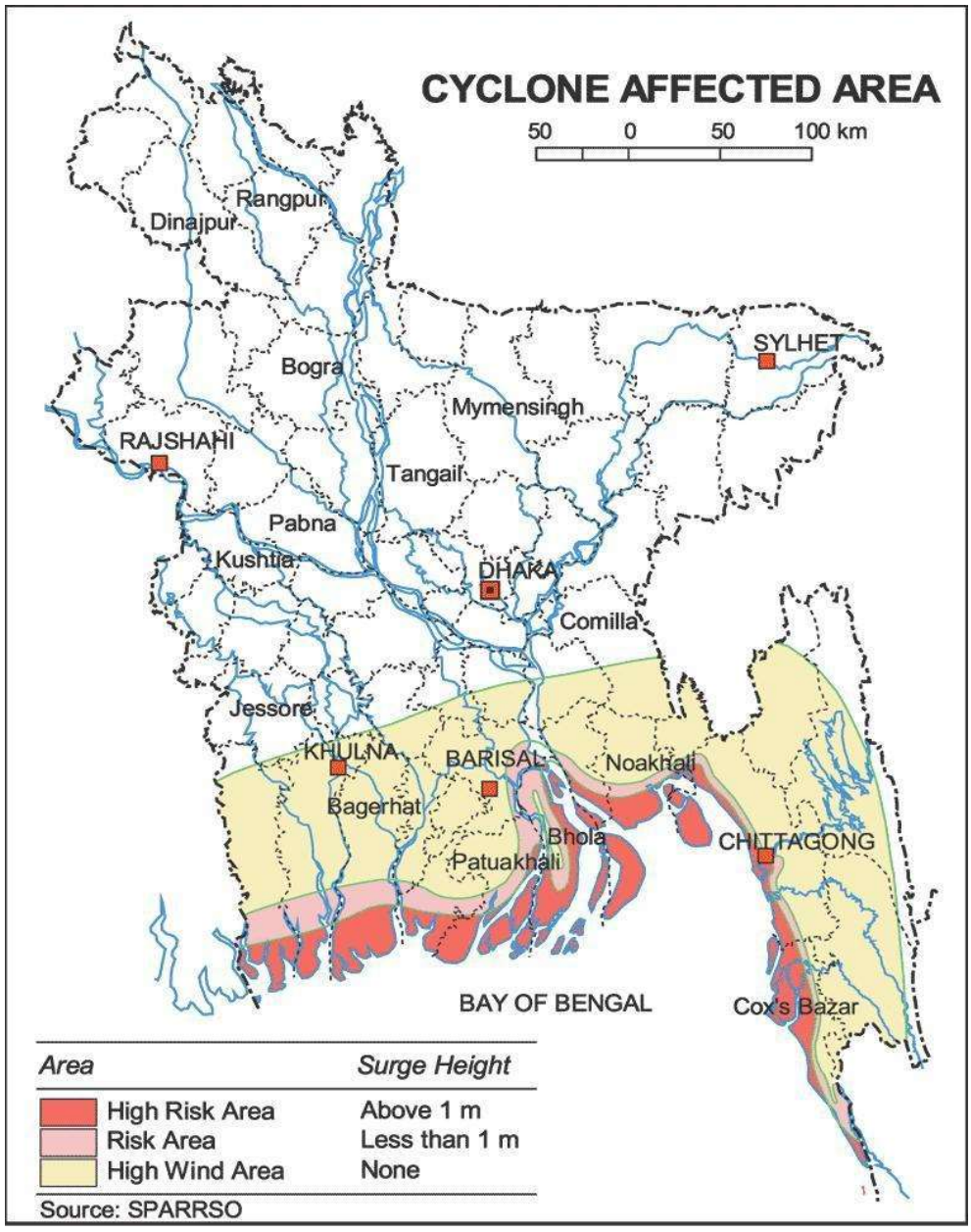


Figure 2.11: Bangladesh Cyclone-Affected Regions

Table 2.1: Tornadoes and destructive nor-westers strike Bangladesh

Date Tornado Strike	Location/Area
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)

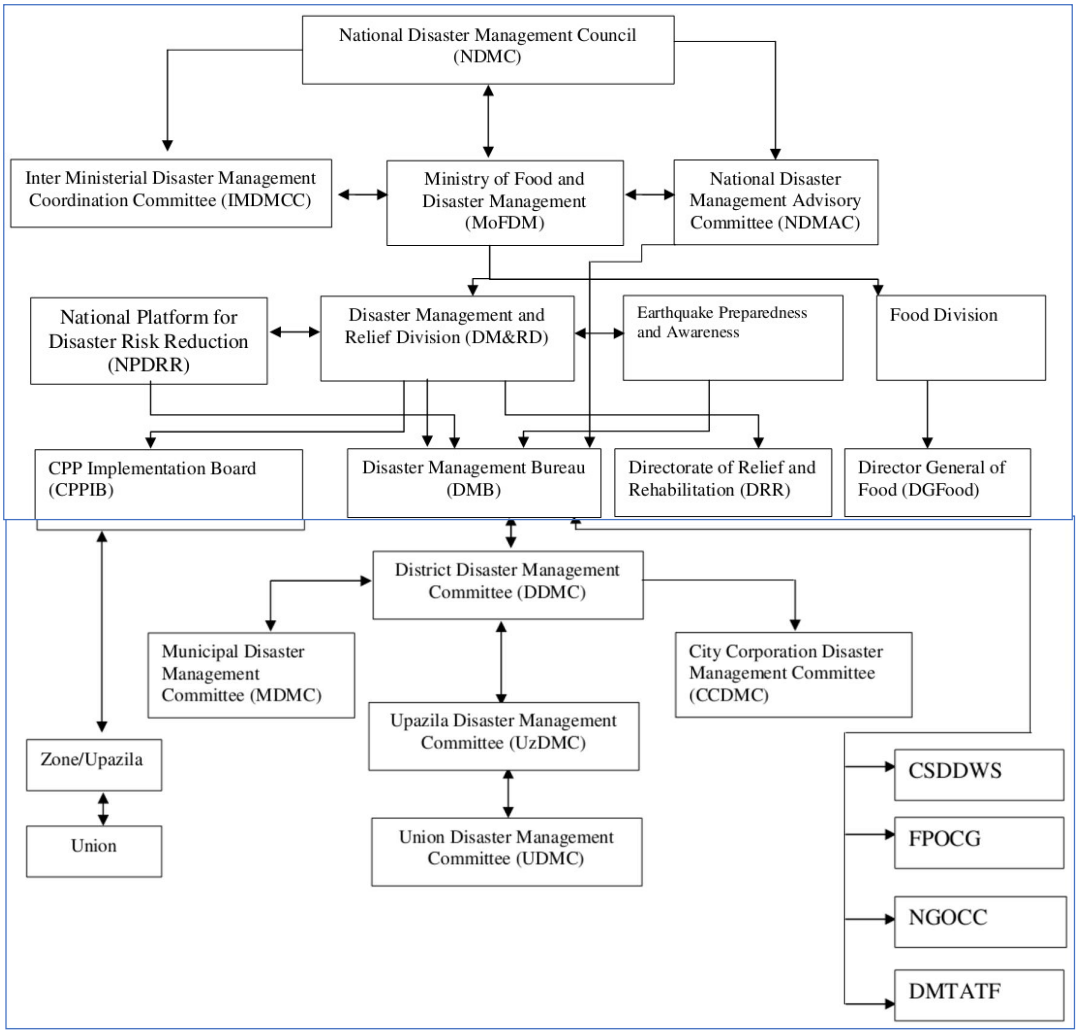


Figure 2.12: Bangladeshi Institutions to Manage Disasters

2.5 ICT and Disaster Management:

Manufacturing and service sectors that electronically acquire, transmit, and display data and information are together referred to as ICT [16]. In terms of disaster management, ICT reduces losses caused by disasters through Internet, GIS, remote sensing, and satellite-based communication technologies, and early warning systems. These systems are designed in ways to inform the affected about crucial information that can save their lives as well as reduce the post-disaster losses to a great extent.

These technologies when used efficiently and effectively by the knowledge powerhouses can create effective early warning systems that can help relocate people and crucial resources from disaster-prone areas.

Their phases can be identified in the case of any natural disaster: the pre-disaster preparedness which includes monitoring and alerting systems, during the disaster phase which includes sharing information with the mass people about the allocation of resources as well as the to-do's and don'ts for reducing the damage caused, and finally the post-disaster phase that includes activities that focus on recovery and reconstruction of resources and facilities that require immediate attention. During all these three phases, the dissemination of information is a crucial element for relevant stakeholders to be able to coordinate efficiently and effectively.

The three different stages of a disaster require different sorts of ICT support as the actions to be performed in the stages are distinct from one another. Proper allocation of such resources and support to help decrease the impact of these disasters requires a proper understanding of the distinction between the phases.
However, the effectiveness of a particular technology can be boiled down to how interconnected it can be with the entire communications system as well as the capacity to disburse information rapidly.

Incorporating ICT for disaster management starts with defining the key challenges associated with each of the stages. The key challenges and key questions asked cast light into how ICT can help reduce system loss and better disseminate the information in a particular case. A very general approach could start like this:

1. Questions: What could be done to improve the condition of each phase? What are the key actions that need to be taken to reduce damage? How can incorporating ICT reduce system loss as well as reduce damage while completing the mentioned key actions?
2. Challenge: Who are the key stakeholders working to alleviate the condition? How do we create/share information with the relevant stakeholders?
3. Technology: Which technology/tool is appropriate in completing the tasks that could be performed using ICT derived from the questions stage?

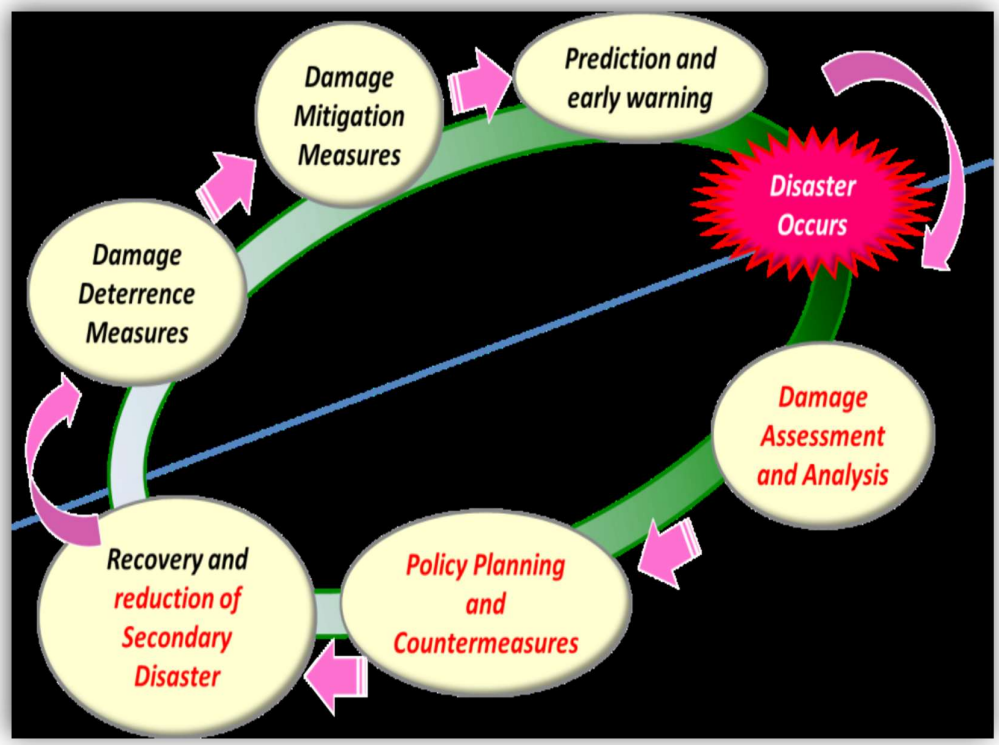


Figure 2.13: Flow of disaster risk management

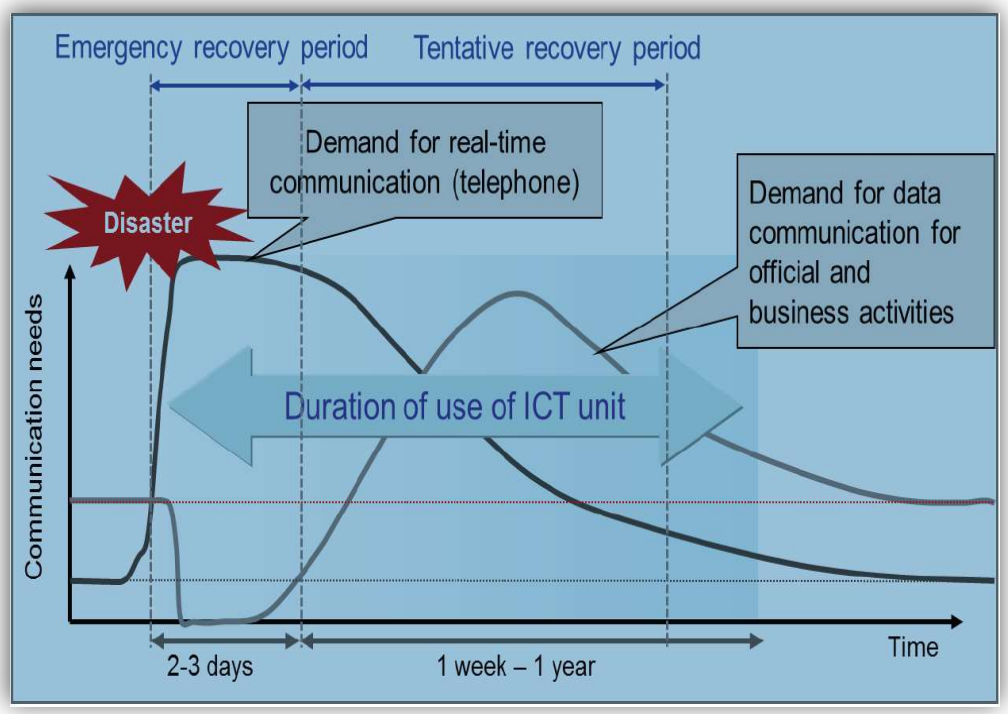


Figure 2.14: After a disaster, demand for ICT services

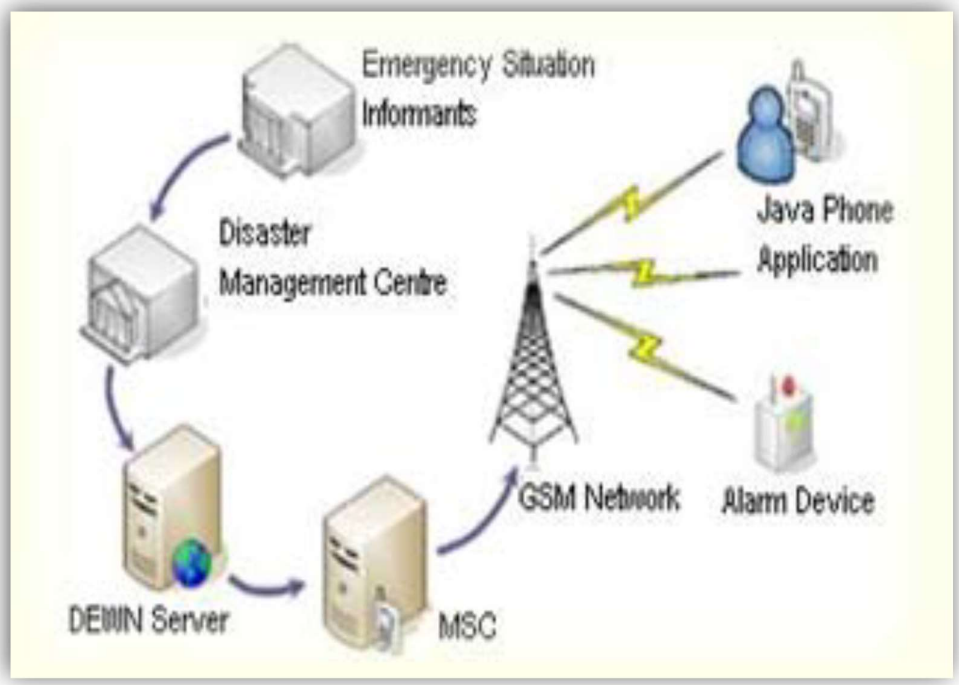


Figure 2.15: Disaster Management Using Cell Broadcasting

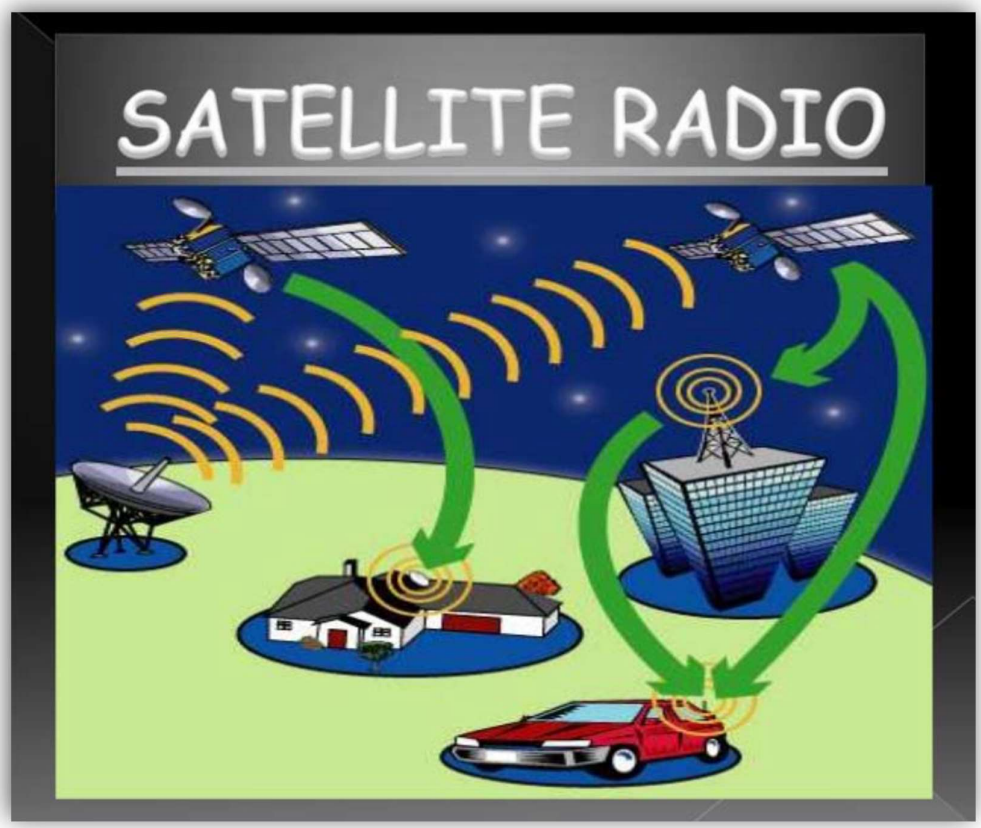


Figure 2.16: Radio via satellite

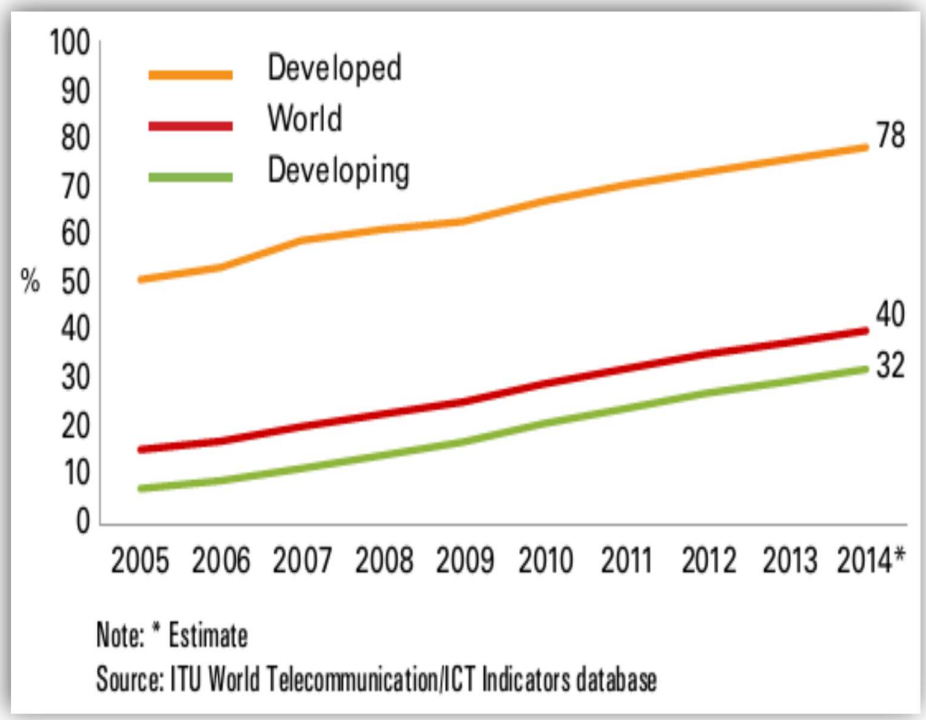


Figure 2.17: People who use Internet (Total and Percentage)

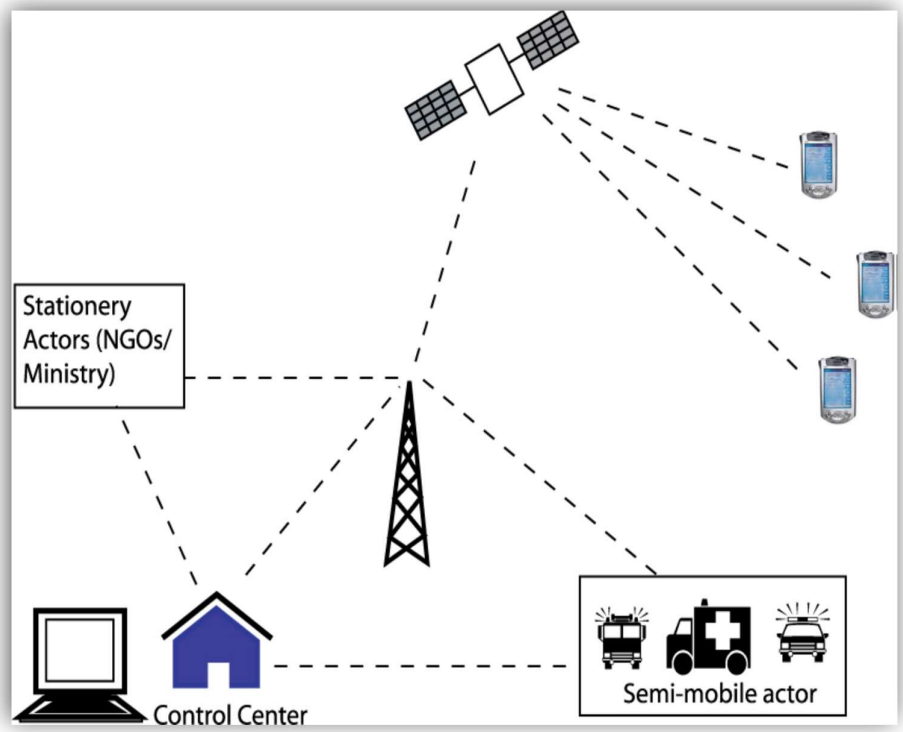


Figure 2.18: Disaster Management Using Satellite Communication

Table 2.2: Infrastructure Damaged by the Japan Earthquake and Tsunami: Recovery Time

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

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

Table 2.3: Contrasting ICT Tools

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

(Source: http://www.niccd.org)

USE OF ICT IN DISASTER RESPONSE

The most difficult period is right after a catastrophe. This issue calls for a prompt response in an incredibly short period of time. There will always be a substantial number of injured and/or displaced persons after a disaster. Many of them may still be dealing with the trauma they experienced. experienced, such as family member loss. Affected people might not have access to food or other necessities. They might be sitting around in makeshift shelters unsure of what to do next. Some people may require emergency medical care, and the environment following a tragedy makes excellent conditions for potential epidemics.

Authorities might be forced to leading the response with few resources and no clear strategies for how to deploy them or obtain more. They frequently require the assistance of a third party, which could consist of donors, both organizations and individual people. These organizations might be able to help, but they may not know how to because they are not connected to others who are engaged in the industry.
The case studies that follow demonstrate how ICT can be utilized to solve these issues quickly after a disaster.

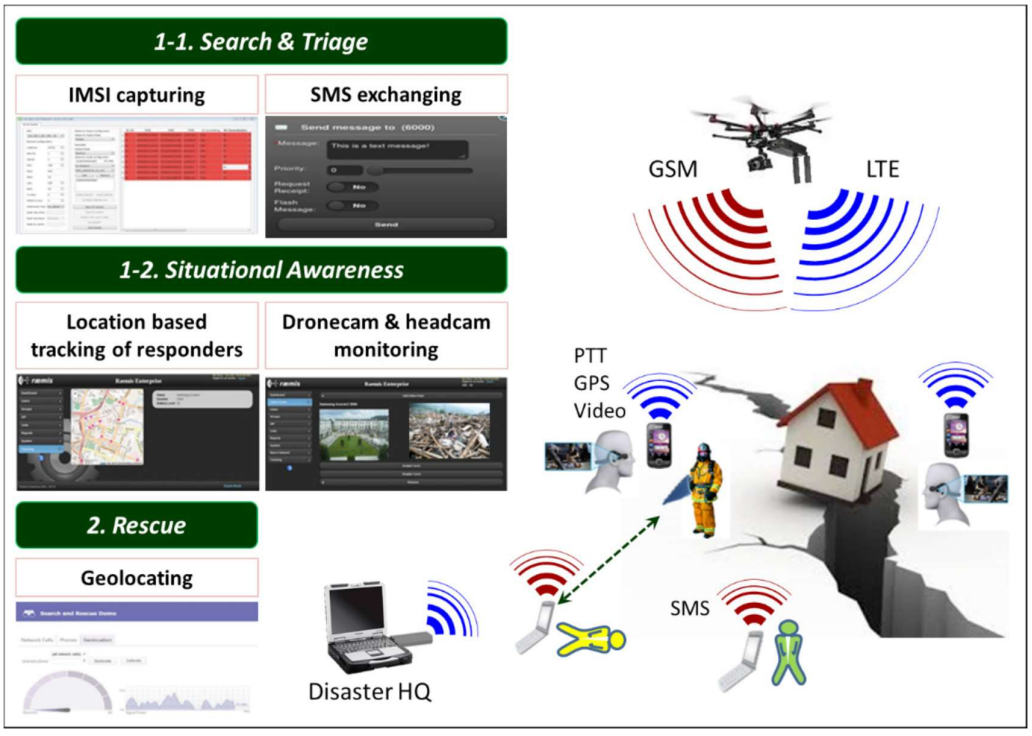
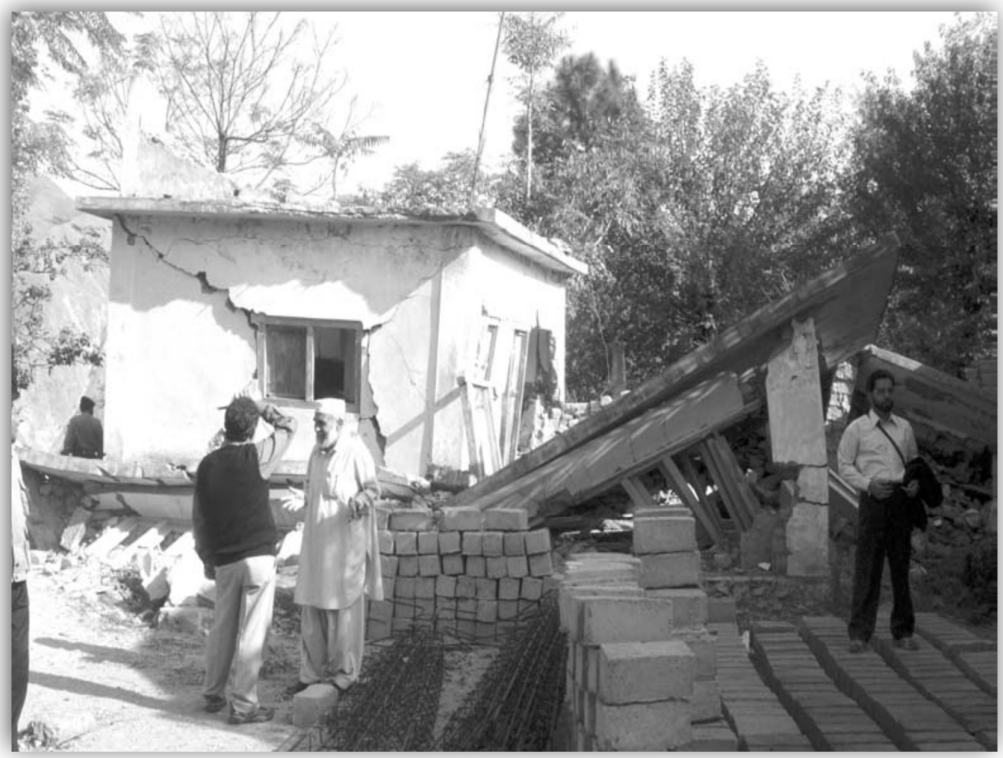


Figure 2.19: A search and rescue service as an illustration

Case Study 1: After the 2004 Indian Ocean Tsunami and the 2005 Pakistani Earthquake, Sahana Disaster Management System

A collection of web-based applications called Sahana, created by Lanka Software Foundation, is a free and open-source software (FOSS)-based system that offers solutions to the issues that arise in a post-disaster environment. The instances below demonstrate how Sahana helped victims of disasters. With the Pakistani earthquake the following year and the Indian Ocean tsunami in 2004.



Result of the powerful jolt caused by the Pakistan earthquake

Example 1: Tracing Missing Persons

There are frequently a lot of people missing after a calamity. Families are frequently dispersed, and kids are frequently separated from their parents. Outside family and friends, particularly those who reside abroad, naturally want to know the most recent details about the the state of their family members. Children may experience considerable psychological stress, thus it is crucial that they are reunited with their family as soon as is practical.

Helping sufferers get in touch with their loved ones as quickly as possible is one of Sahana's goals. An electronic form of a missing and found person bulletin board is Sahana's Missing Person Registry. It can record data on the missing individuals as well as about those who look for information on the missing, so raising the likelihood of their reunion. Any recognized NGO or civil society organization can easily link to the central site and offer that service in the regions they are working, even if the victims or relatives do not have direct access to this information.

Example 2: Bringing Donor Groups Together

Immediately following the tsunami that struck Sri Lanka in 2004, there was a significant outpouring of aid from foreign NGOs, local NGOs, and community organizations. There were at least 300 NGOs engaged in similar activity, albeit with varying methods. In a situation Response attempt must not be duplicated in situations where resources are scarce. If not, concerns like clogged supply lines, rivalry amongst non profits, multiple immunizations, and saturation of support given to some places while other afflicted areas are ignored could arise. As a result, goodwill can be lost. An authorized emergency controller cannot manually complete this coordinating duty due to its complexity.

Thus, an ICT solution may be the best choice. An electronic organization registry, for instance, can be quite helpful. It can efficiently keep tabs on who is doing what, where and when, but more significantly, it can determine whether there are any locations where services are insufficient. This knowledge can allow organizations and volunteers to spread themselves equally throughout the impacted areas.

Sahana has created a registry for such organizations. It keeps tabs on all the aid agencies and civil society organizations operating in the crisis area. In order to prevent overlap, it records information on both the locations where they operate and the variety of services they offer there.

Example 3: Locations of Temporary Camps and Shelters being Noted

There are typically no pre-determined places for camps and shelters in a catastrophe event. Anywhere and of any size, from a sizable government-maintained camp to a single house, can be a temporary shelter or camp. These variations make it necessary, to keep track of each camp's location and population. This is crucial for efficiently

dispersing help and making sure that no impacted areas are unintentionally missed. The Sahana system's sub-application tracks each camp's whereabouts throughout the area. Additionally, it keeps a rudimentary record of any available facilities and the occupants within them. If required, it can offer a GIS view to show where the camps are in the impacted area.

Case Study 2: Internet usage in Turkey after the earthquake in 1999

In Izmit, Turkey, a significant earthquake struck without warning on August 17, 1999, killing 15,000 people. On November 12 of that same year, Duzce saw a second earthquake that killed 1,000 people. In addition to these deaths, nearly twice as many individuals had to be relocated.

due to both occurrences. 120,000 homes in all sustained damage that was irreparable, while 50,000 homes suffered very minor damage.

Telecommunications infrastructure was severely destroyed by the Izmit earthquake, making it impossible to reach rescue services. Given the limited bandwidth of mobile phone networks, using public phones was all but impossible. Aside from that The earthquake had destroyed many of the microwave repeaters installed on residential complexes. The sole channel that could in this case connect the impacted areas to the outside world was the internet. Several Internet tools were employed in the post-disaster response, namely in two crucial areas: coordinating the distribution of relief and locating missing persons.

The Internet proved to be an invaluable resource since, as a result of system disruption, contributors frequently found themselves serving as both donors and distributors of help. In order for donors to discover the people who were most in need, NGOs were crucial in providing discussion lists for the coordination of donations. They were able to decide what they needed and, in some cases, how to get there. Information about the whereabouts of missing family members was also made available online. For instance, numerous groups established "message lines," which served as a database of persons located, their condition, or the extent of damage to the area where relatives resided .

The importance of information security and privacy in ICT-based humanitarian solutions cannot be overstated. Data privacy in these circumstances is not just a matter of encryption; it really can be the difference between life and death. Information might be used for rape and other sexual assaults, harassment, prostitution, ethnic cleansing, kidnapping, and trafficking of women and children if it fell into the wrong hands. This is particularly true when a disaster occurs in an area with a volatile ethnic and political climate, necessitating careful consideration of the local circumstances and tensions between various ethnic groups, factions, and non-state actors when developing and putting into practice technology and frameworks.

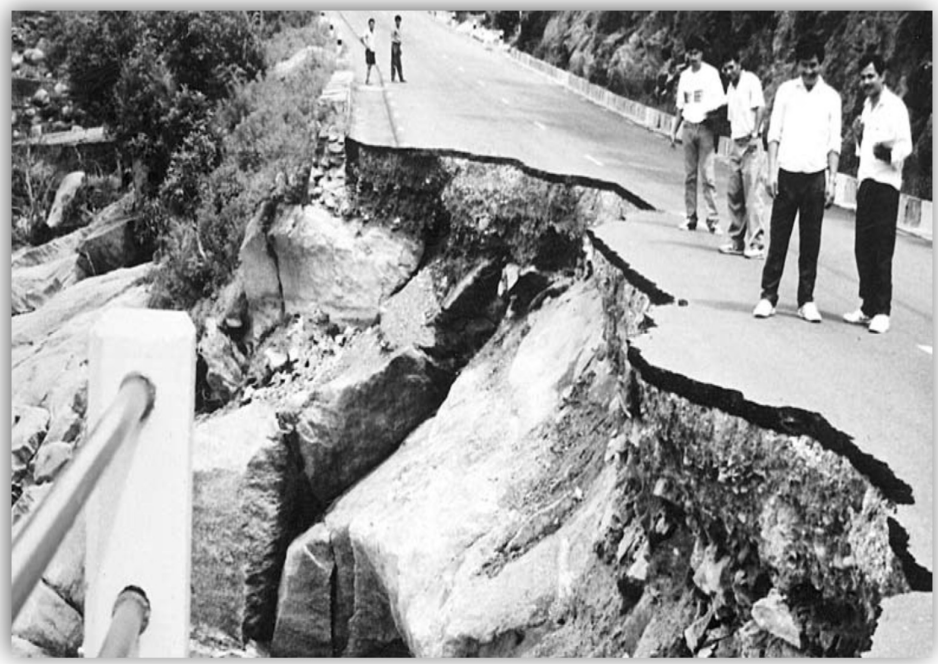
FOR DISASTER RECOVERY USING ICT

Disaster reconstruction must start as soon as the initial disaster clean-up is over. This is a difficult assignment that requires a variety of skill sets and in-depth knowledge of an ever-expanding range of instruments and methods Numerous software solutions are being employed to achieve these goals. Even though ICT's function in long-term disaster recovery is less clear than it is in disaster warning, there is no doubt that significant ICT use is accelerating these efforts.

Specific Disaster Management Software

Different software programs are used to gather, preserve, and analyse data regarding disasters, not only in the immediate aftermath but also as a long-term strategy to lower the risk of disasters. The DesInventar technique is one such approach.

DesInventar is a methodical means to collect and maintain data on the traits and impacts of various disasters, especially those that are invisible at the global or national dimensions. This makes it possible to monitor and analyze gathered information about these "invisible" disasters on a global or national level. DesInventar can be used to model disasters and analyze their effects. For instance, it is feasible to simulate a seismic event and examine the effects it has on a geographical.



Every year, floods and landslides destroy highways.

Case Study 1: Latin America

DesInventar was now being used for the first time in catastrophe preparedness procedures. The Network for Social Studies on Disaster Prevention in Latin America started the initiative in 1994. There are now National DesInventar disaster databases with up to 30 years of data.

Now in 17 North and South American nations. Included are small-scale catastrophes with limited direct effects, such the obliteration of a particular home or family losing a harvest to a frost. However, catastrophic disasters that can have a profound impact on people were the focus. The databases were developed with assistance from universities, scientific institutions, NGOs, international organizations, and national governments. Information is acquired from the press and government agencies.

Case Study 2: Orissa, India

In For the Indian state of Orissa, UNDP developed a database in 2002 that had a list of disaster events with a natural source. The goal of the project was to create a tool that would aid in the objective prioritization of expenses by decision-makers. For the

following stage, which calls for replication in four more Indian states and integration into a system of integrated disaster management, the Orissa project will serve as a pilot. resources managed by the national government. The methodology was altered in light of the experience gained from the Latin America effort. The database of catastrophic events was created utilizing data from news organizations and official government sources. Once a week, a historical database with data going all the way back to 1970 is updated.

Case Study 3: South Africa

The main project of the Disaster Mitigation for Sustainable Livelihoods Program at the University of Cape Town is the Monitoring, Mapping, and Analysis of Disaster Incidents in South Africa (MANDISA) initiative. MANDISA was launched in Cape Town as a test program. a city or large town in South Africa's Western Province between 1990 and 1999. The procedure was adjusted for the South African environment using DesInventar as a basis. The focus of MANDISA is on threats that can have an impact on South Africa, such as well as frequent "small" and "medium" fires, as well as significant urban "non-drainage" floods, wildfires, and strong wind occurrences.. When possible, environmental and socioeconomic risk variables that affect how disasters affect people are taken into account, allowing for the potential of tracking .

GIS and remote sensing for disaster management

A GIS is a group of hardware and software tools for storing, retrieving, mapping, and analyzing geographic data. Spatial features are stored using a coordinate system (latitude, longitude, state, plane, etc.) unique to a point on the planet.

Tabular traits and spatial properties are connected. Then, spatial data and associated attributes in the same coordinate system can be layered together for mapping and analysis. Resource management, research, and development planning are just a few applications for GIS.

In remote sensing, a phenomenon or object is measured or data about it is obtained using a recording equipment that is not in close proximity to or physical touch with it.

Remote sensing is actually the use of equipment from a distance, such as a satellite, spacecraft, or aircraft.

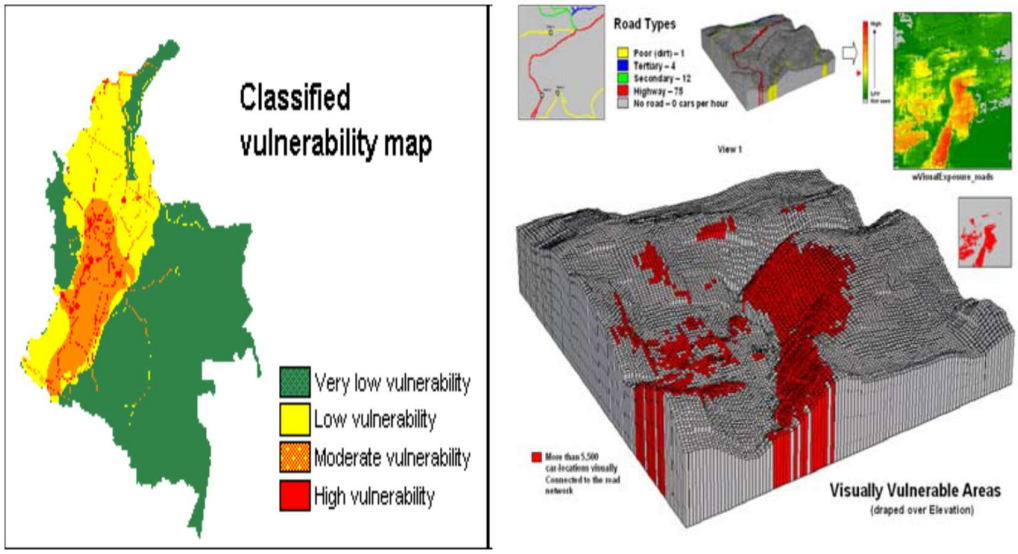


Figure 2.20: Differences between a regular (2D) map and a map with GIS input

2.6 Concepts that are prevalent worldwide:

According to the World Disaster Report 2000, more than a billion people endured hardship because of natural disasters in the twelfth and final decade of the 20th century. Direct economic damages from these catastrophes total $629 billion. Nearly 95% of all deaths brought on by these natural disasters occur in developing countries, where the infrastructure is least prepared to deal with them.

Every time a natural disaster strikes, the appointed governing organizations of nations throughout the world are prepared with the tools needed to act quickly. Executing these orders effectively and efficiently is the main obstacle, though. The use of relevant technology in the proper contexts is the second step in guaranteeing a proper disaster management procedure. Realizing the strategies developed by the experts in disaster management depends on using the relevant technologies and guaranteeing accurate information transmission.

For the aforementioned three stages of a natural disaster, there are specialized technology that can be used. In the past, sirens and radio were two of the more popular pre-disaster technology. A fairly dependable means for broadcasting such

warning messages is Tone Alert Radio (TAR). Other broadcasting tools include satellite radio, wireless mobile telephony (WMT) PA systems, and audio public address systems. Many countries around the world have used and continue to employ the majority of these technologies. A few of the tools are unique to the stage they will be. For example:

I. Risk Analysis: Hazus, SELENA, RiskScape, InaSAFE, CAPRA, OpenQuake.
II. Risk Visualization: WebGIS, spatial data clearinghouses, risk curves, etc.
III. Risk Assessment: event tree, semi-quantitative analysis, etc.

These tools are phase-specific and can aid in overcoming difficulties

Case Study: The Tsunami Early Warning System for Southeast Asia (TEWS)

Several Asian nations were unprepared for the tsunami that struck the Indian Ocean in December 2004. Before thousands of individuals mistakenly found themselves in the heart of enormous killer waves, there was almost any warning.

There have been several international conferences along the A gathering of the Indian Ocean rim has been planned in the wake of the tsunami to discuss how to jointly counter threats from similar disasters. Plans for a TEWS (tsunami early warning system) in the Indian Ocean and South-East Asia were found to be based on currently operating institutions, strengthen national capacities, integrate early warning with preparedness, mitigation, and response (end-to-end), and also must be integrated into current warning systems to promote a multi-hazard approach.

Participating nations in the project included Cambodia, China, Lao PDR, Myanmar,

By implementing programs and projects that lessen the effects of disasters on nations and communities, the Asian Disaster Preparedness Center (ADPC), a nonprofit organization, encourages safer communities and sustainable development.by: In Asia and the Pacific,

- developing and improving institutional frameworks, methods, and capacities for managing catastrophe risk, as well as aiding in the formulation and execution of government policies.
- facilitating the transfer of knowledge, experience, and information about disaster risk management; and

- raising awareness and improving knowledge and abilities in catastrophe risk management.

A regional meeting of the aforementioned nations was held by ADPC in March 2005 in cooperation with the Royal Thai Government and the United Nations Economic and Social Commission for Asia and the Pacific to determine if it would be feasible to implement a South-East Asia's Multi-Hazard Early Warning System.

In April 2005, Bangladesh and Sri Lanka indicated that they were interested in receiving similar assistance to increase their national early warning capability and capabilities. As a result, ADPC has been working with these governments and those in the Maldives to enhance emergency communication networks through a project that is supported by the ITU. In addition, as part of another UNDP-funded project, ADPC completed assessing Sri Lanka's early warning systems. The donor organizations for the TEWS implementation include the World Bank, the UNDP, and The Danish National Development Agency [17].

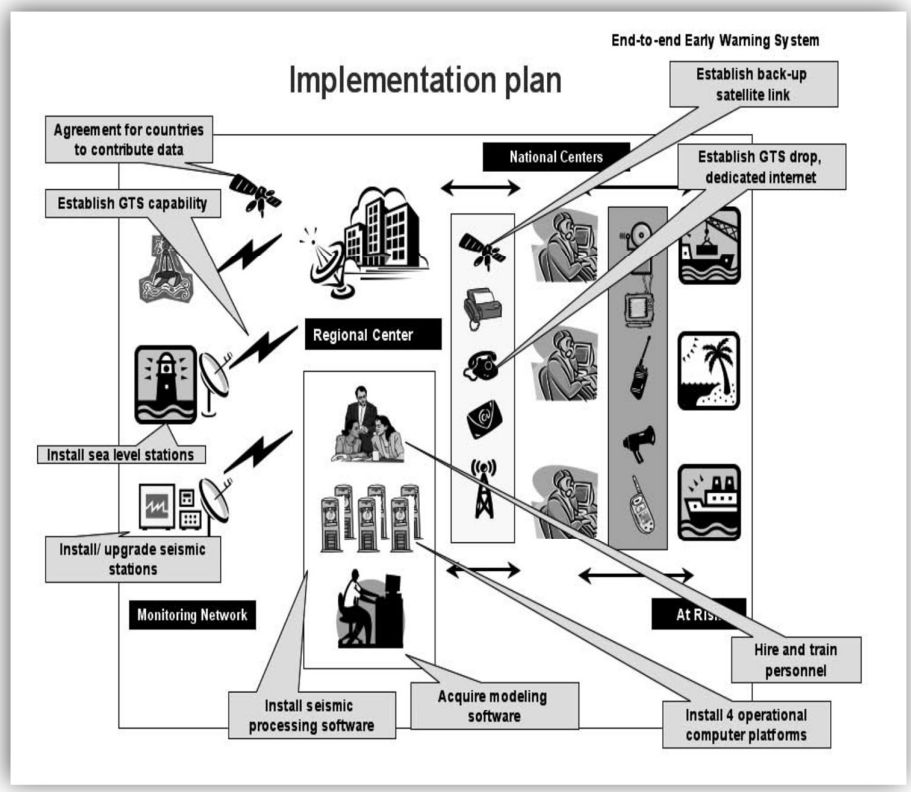


Figure 2.21: Early Warning System for Tsunamis Implementation Plan

Box 3: Disaster Warning: The Media's Role: Reuters AlertNet

A successful example of an ICT/media project that aids in early disaster warning and management is Reuters AlertNet. on a worldwide scale. The Reuters Foundation, a charity that supports education and humanitarianism, founded AlertNet in 1997 .

Reuters uses its core strengths of responsiveness, accuracy, and objectivity to the sector's advantage. The objective of this news network, which is based on a well-known website, is to inform aid workers and the general public about humanitarian situations occurring throughout the world [18] .

More than ten years have passed since the launch of AlertNet. Following the crisis in Rwanda in 1994, Reuters Foundation was established. concerned about media reports of poor coordination amongst emergency aid organizations on the ground.

It surveyed charity to find out what could be done to remedy this. It was concluded that the following service was necessary: Deliver operation-critical information to aid organizations around the world.

- Encourage information sharing between relief organizations; and
- Increase public knowledge of humanitarian emergencies.

These connected objectives are summed up by Reuters AlertNet's tagline, "Alerting humanitarians to emergencies.".

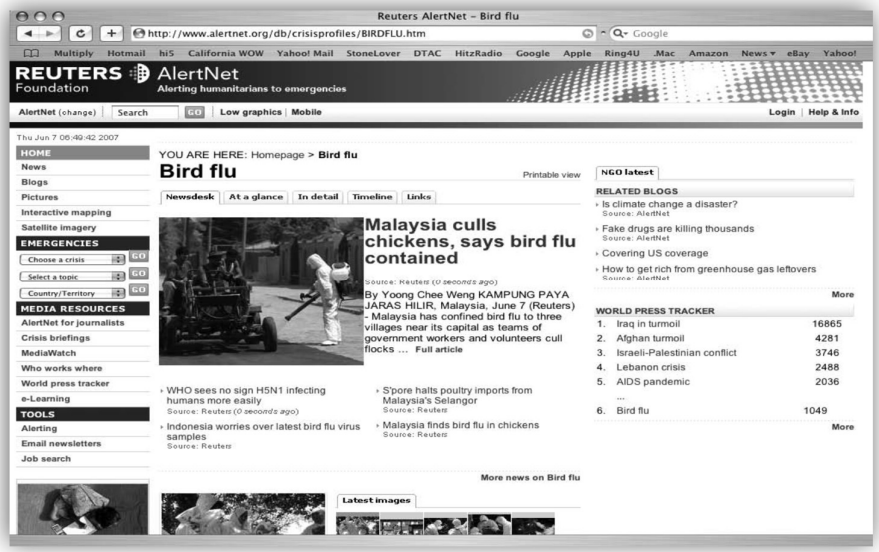


Figure 2.22 : AlertNet Website

Conflict, food-related, sudden-onset, and health-related emergencies are the four categories into which AlertNet separates emergencies. In practice, emergencies frequently overlap in a convoluted fashion that makes it it's challenging to tell causation from effect from consequence. These overlaps are intended to be evident in AlertNet's display of emergency information.

Reuters is the main information source for AlertNet, albeit it is not the only one. AlertNet also collects data from a wide range of sources. They accomplish this with with a limited number of full-time employees.

All crises for which credible information is available are monitored by AlertNet. Coverage of so-called "forgotten" or "hidden" emergencies—emergencies that, for a variety of reasons, only sporadically receive media attention—can be found. emergencies. For instance, the northeastern Indian state of Assam

2.7 International Organizations & Scenario in developing countries:

Developing nations often do not have strong infrastructures that can mitigate the losses caused by natural disasters. The core reason behind this is the lack of skill development and capacity-building programs for developing and empowering the organizations and government bodies that are responsible for the task.

For developing the overall scenario in these developing nations, many organizations have been working for years. The latest development The Sendai framework was developed by the United Nations Office for Disaster Risk Reduction (UNDRR) for such disaster risk reduction infrastructure. The Post-2015 Development Agenda's first significant agreement is represented by this. The framework outlines 7 worldwide objectives to be met by 2030:

I. Increasing:
    a) The number of nations have local and national catastrophe risk reduction plans.
    b) International assistance to underdeveloped countries.
    c) Access to and availability of multihazard early warning systems.

II. Decreasing:
    a) Disaster mortality on a global scale.
    b) The number of persons affected globally.
    c) The direct economic loss as a percentage of GDP.
    d) Basic services are disrupted and key infrastructure is damaged as a result of a disaster.

The World Bank manages the Global Facility for Disaster Reduction and Recovery (GFDRR), a global collaboration that provides financial and technical support for DRM across the World Bank Group. The GFDRR came up with the Green, Resilient and Inclusive Development (GRID) approach to empower the member countries with green development projects and capacity-building programs. Various themes have been chosen by the GFDRR for supporting GRID via the World Bank Group's Climate Change Action Plan (CCAP) 2021-2025[19]. Some of the themes include resilient infrastructure, nature-based solutions, reducing shocks, and developing early-warning systems. The programs along with the Bank's annual DRM investments realize these programs and equip countries with the capacity to develop their infrastructure.

Apart from the infrastructure side of disaster management, the incorporation of ICT tools and technologies into the overall disaster management practices is another important side of disaster management. The existing technologies used in the developing nations include but are not limited to:

I. Delay Tolerant Networking (DTN)
II. Portable Emergency Communication Systems (PECS)
III. GIS technologies

Some of these technologies are very common in developing countries such as the GIS technologies. Some of this software come for free.

2.8 The Bangladeshi Perspective:

Bangladesh has taken on various initiatives for empowering the disaster management infrastructure all over the country. In terms of responding to international efforts,

Bangladesh has been following the 2005–2015 Hyogo Framework for Action, aiming at reducing the loss of life as well as social, economic, and environmental losses caused by natural disasters. Bangladesh has also responded very positively to the Sendai Framework. UNDP has hailed Bangladesh is a global leader in terms of the institutional structure it has in place for reducing disaster risk and promoting sustainable development. several government policies and programs. However, the statistics show how vulnerable Bangladesh is to natural catastrophes According to UNDP, it was estimated almost 14% of the Every year, disasters have an impact on GDP.. The report highlighted the issue of overpopulation leading to unplanned cities. This increases the risk for mass destruction in the case for earthquakes. Earthquake Disaster Risk Index has ranked Dhaka, the capital of Bangladesh, to be among the top 20 cities most vulnerable to earthquakes around the world [20].

Regarding the ICT aspect of disaster management, the National ICT Policy in 2009 stressed the issue of incorporating environment-friendly technologies to ensure early warning systems, minimize disaster response delay, coordinate disaster management activities, etc. The Center for Disaster Management Information (DMIC) was established with the aim of making reports as well as coordinating other departments' activities in the case of an earthquake, tornado, flood, etc. In all 64 districts and 235 high-risk upazillas, the department has sub-centers with the requisite ICT hardware installed.

SPARRSO and CEGIS are engaged in RS and GIS-based modelling covering almost all areas. The key information regarding each area includes weather, environment, climate change impact, flood assessment, soil erosion assessment, etc. The information helps guide forecasting natural disasters as well as prepare for the incumbent disasters. For example, the CEGIS model can be used to predict soil erosion months before it takes place. DMB with the help of CEGIS prepares GIS-based maps about disaster-prone areas and takes action accordingly [21] [22].

There is a web portal for DMIC that shares, coordinates, and disseminates disaster management-related information among the stakeholders as well as the mass people. Some of the stakeholders include government offices, NGOs, and other departments and organizations working in disaster management. Some of the major features

include early warning systems for cyclones and floods, information exchange, situation reports, risk reduction plans, open-source GIS/map server etc. DMB has developed the Cyclone Shelter Management Information System (CYSMMIS) with a comprehensive database regarding 2895 cyclone shelters [23]. MoFDM has developed earthquake vulnerability micro zones databases.

The technology to tackle the challenges related with disaster management are existent in Bangladesh. However, the efficient implementation of these tools is yet to be ensured. Besides this, the way how people use technology has evolved through the years. Nowadays, more and more people are using cell phones and many people are always connected to the internet. Thus, there is room for development as to how early-warning systems can be made more efficient in delivering mass messages [24] [25].

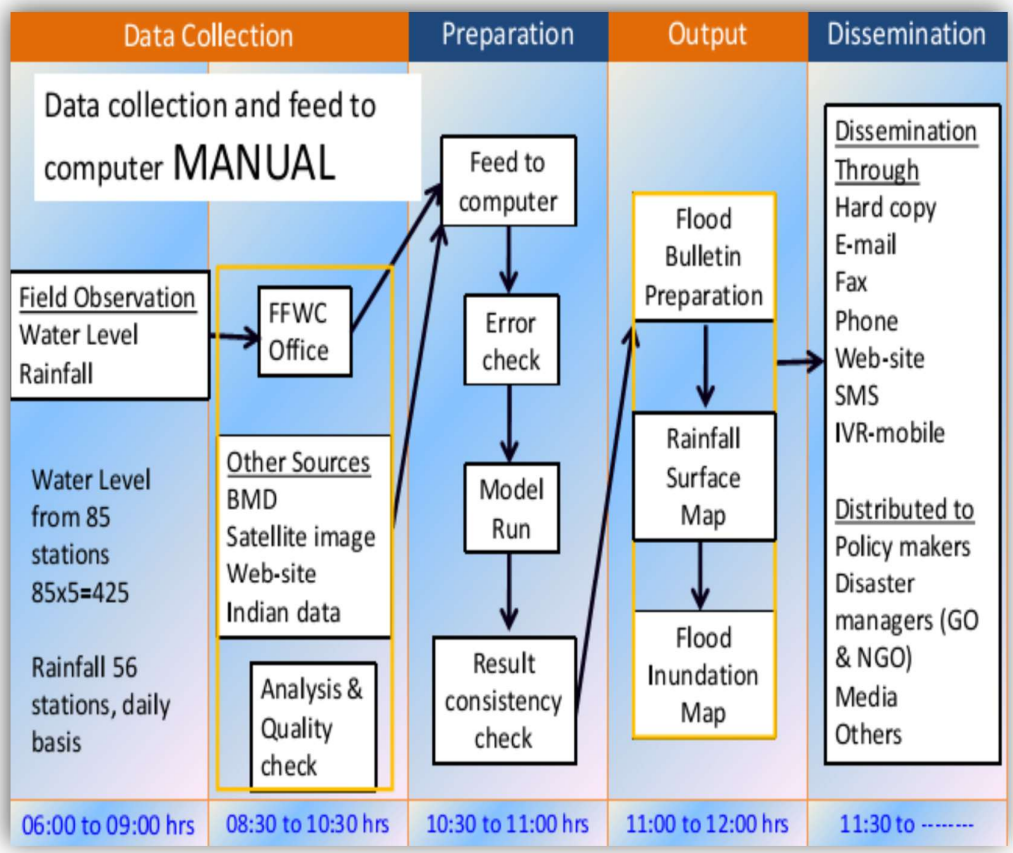


Figure 2.23: Forecasting and warning activities for flooding

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

Figure 2.24: Institutional Early Warning Mechanism

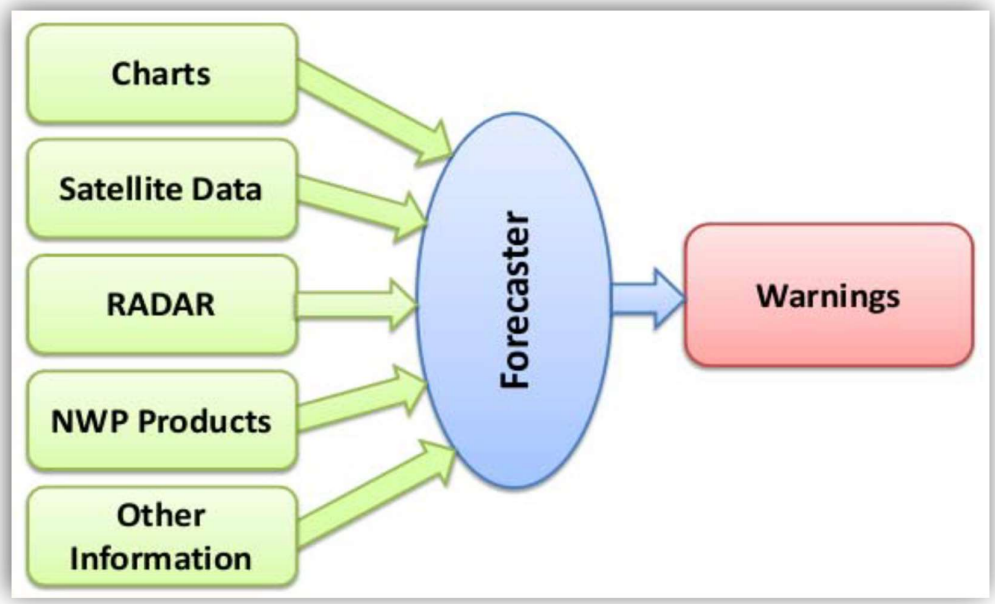


Figure 2.25: Formulation of Warnings

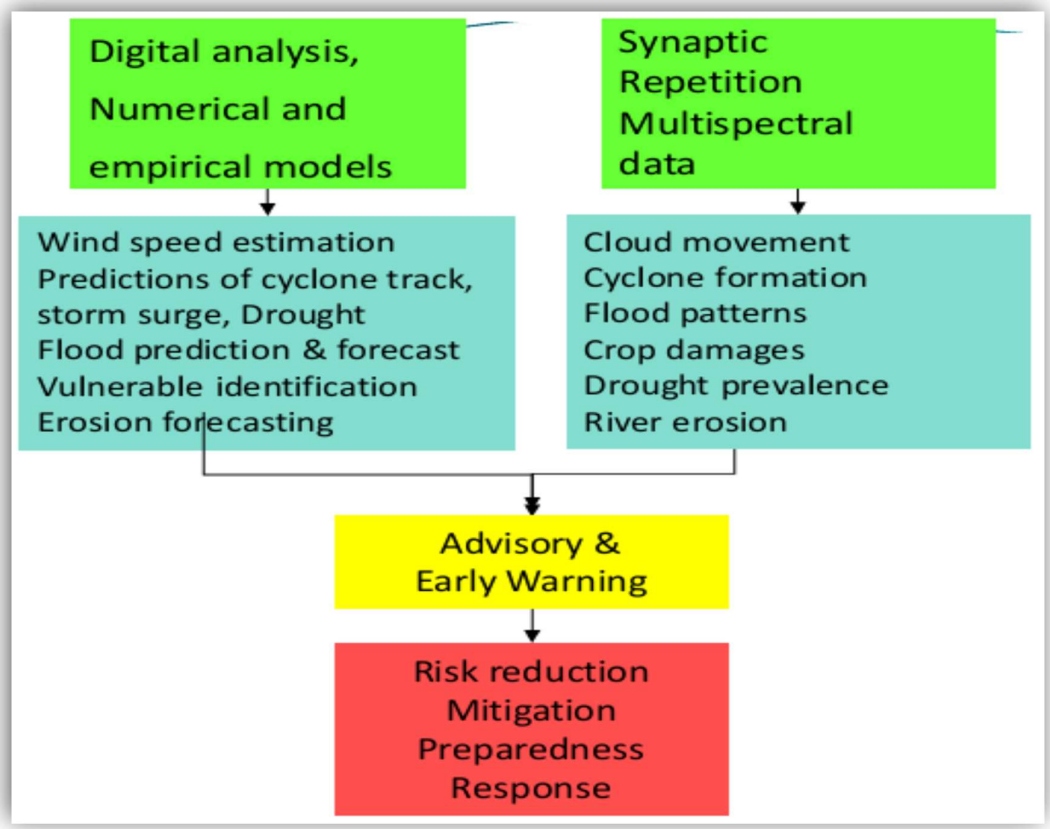


Figure 2.26: Mechanism for Warning Configuration

2.9 Procedural Developments:

Bangladesh has developed the National Plan for Disaster Management (2010-2015) and updated the Standing Order for Disasters in terms of creating regulatory frameworks (SOD). The Comprehensive Disaster Management Programme [26], the Poverty Reduction Strategy Papers (PRSP 2013), the National Action Plan on Adaptation (NAPA 2005), and Bangladesh Climate Change Strategy and Action Plan (BCCSAP) are just a few other regulatory frameworks that have been developed.

To lower the danger of losses brought on by natural catastrophes, the Ministry of Food and Disaster Management's Disaster Management and Relief Division has been renamed the Ministry of Disaster Management and Relief (MoDMR). The Disaster Management Bureau (DMB), Disaster Relief and Rehabilitation (DRR), Local Government Division (LGD), and Local Government Engineering Department are

some of the organizations assisting the MoDMR (LGED). As a result, it is possible to guarantee that institutional power is adequate.

There are some other offices that help the MoDMR in outlining its activities and support it in undertaking those actions. The Disaster Management Information Centre (DMIC) is the department that deals with creating and sharing information with all other relevant offices. CDMP, I focused on forming the foundations for institutionalizing risk reduction practices. CDMP II aimed at increasing the interconnectedness between the offices working for disaster management. The combination of these two projects helped improve the overall scenario of disaster management in Bangladesh [26].

The Water Resources Ministry (MoWR) is at the forefront in dealing with flood damage mitigation. Some of the initiatives taken by the ministry include Flood Early Warning System, National Water Management Plan, Flood Action Plan, Flood Hydrology Study, etc. The National Water Policy is routinely updated by the Water Resources Planning Organization (WARPO) to aid in the management of water resources across the nation. The Ministry of Environment and Forest (MoEF) is in charge of adapting to climate change. The Climate Change Cell (CCC) was given the responsibility of assisting international discussions, putting together documents about the region's most vulnerable to climate change, and coordinating with the necessary parties.

These offices operate with the core aim of reducing the risk to people and property and establishing a capable and effective emergency response system of tackling natural disasters common in Bangladesh. In order to better equip the departments working to achieve this vision, efforts need to be spent at the grassroots level.

2.10 Early warning system in Bangladesh:

Weather forecasts on different natural disasters are mainly provided by the Storm Warning System (SWC) and the other parameters related to the weather such as temperature, humidity, and water vapor are provided by BMD. BMD applies Direct to Home (DTH) technology for spreading weather information. It has digitized 35 observatories and connects all these together to provide accurate weather information.

There is an automated weather station which is expert in measuring weather parameters like rainfall, precipitation, temperature, humidity, and such other factors with pinpoint accuracy, greatly decreasing the room for human error.

Flood Forecasting and Warning Service (FFWS), a division of the Bangladesh Water Development Board, was created in 1972 to provide flood forecasting and early warning systems. Later, when there was more potential for advancement, the "Consolidation and Strengthening of Flood Forecasting and Warning Services (CSFFWS)" project was put into action between 2000 and 2004. The experiment revealed crucial information on how the 48-hour advance time is insufficient for implementing timely response efforts since there is insufficient coordination among the pertinent entities [27].

FFWS disseminates messages related to flood warnings among the masses through electronic media, newspapers, and their official website. Two projects were run for improving the early flood warning systems. Environmental Monitoring and Information Network (EMIN) was conducted during 2000-2007. It was an information network connecting the decision-makers regarding the flood-prone areas of the Brahmaputra-Jamuna River basin. EMIN carried out detailed information assessments and developed a system to disseminate the gathered information to the masses. Another project was the Community Flood Information Systems (CFIS) which was conducted during 2001-2006. The project developed an information software called WATSURF. This software could be used to forecast the water surface and could be used to relay information related to the severity of the flood to the public. The project was successful in making the public aware about the flood forecasts and warnings. The project deployed representatives from the public and used simple symbols for the rapid spread of information.

However, while conducting the projects, a serious issue that arose was the lack of coordination among the different offices that worked for disaster management and the associated risk reduction.

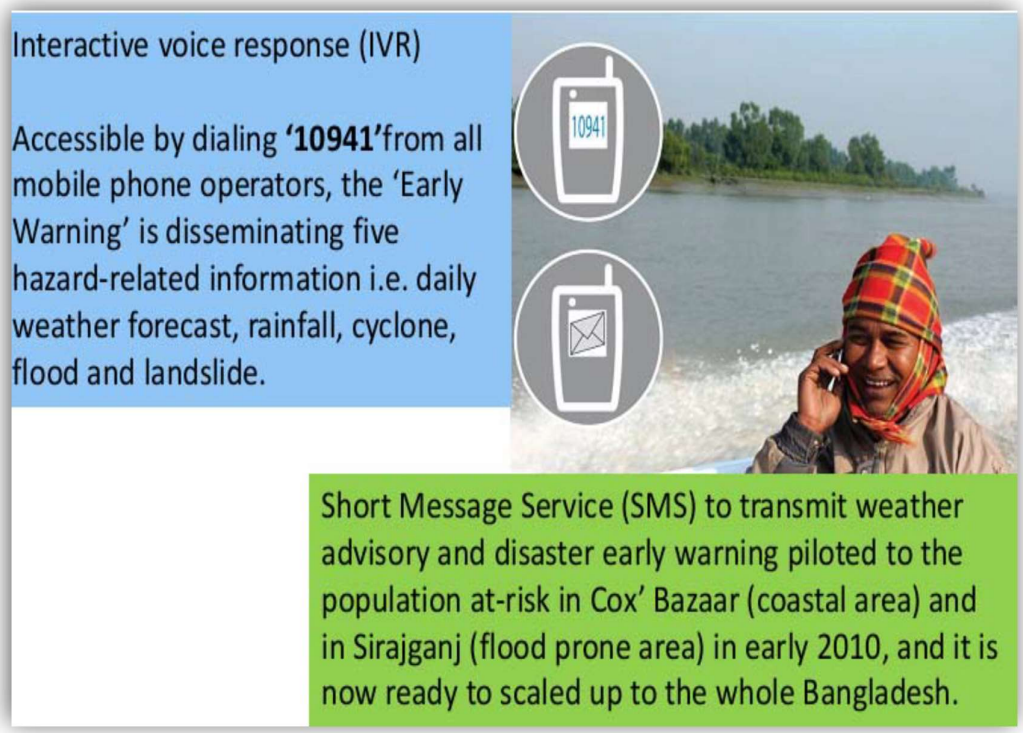


Figure 2.27: ICT in EWS to Reach Community Level's Last Mile

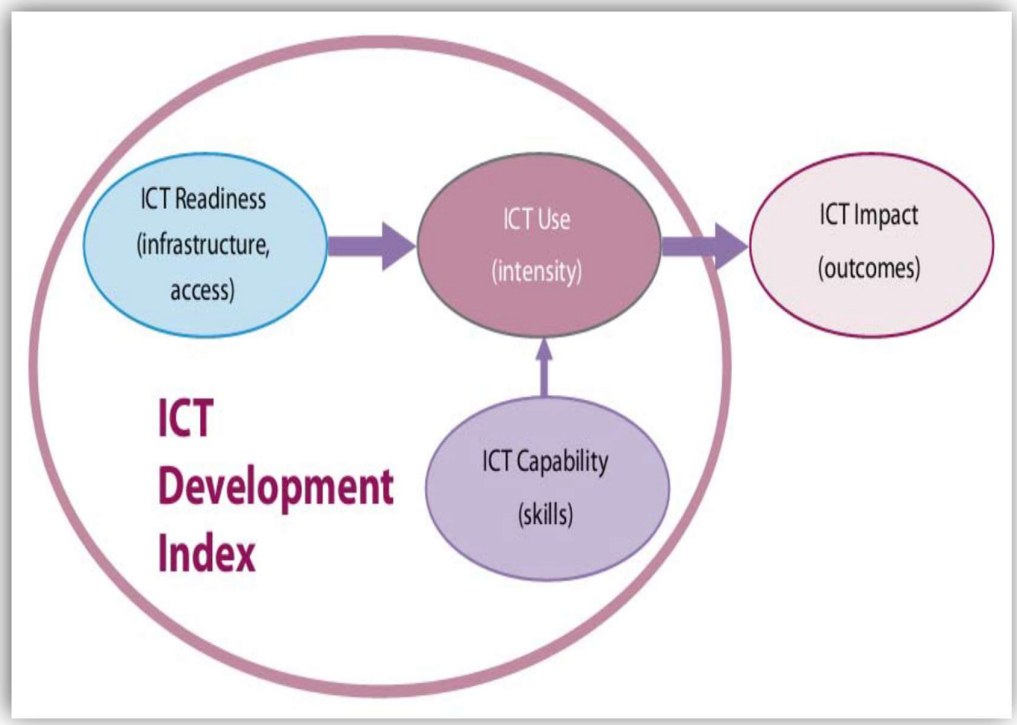


Figure 2.28: Three Steps in the Development of IDI

CHAPTER 3

Findings

3.1 Problems Identified:

The literature review section has defined the existing scenario of infrastructure as well as the extent to which ICT is incorporated with the disaster management practices. The establishment of offices, policies, frameworks, and projects for developing the overall capacity of tackling the natural disasters can be hailed as an example for any country. The multiple offices and the interconnectedness between the departments serve to be important in realizing comprehensive programmes and initiatives aimed at risk reduction.

Several policies endorsed by international organizations like UNDRR, and the World Bank have been seriously incorporated among the offices and departments. The implementation of projects, for learning the flood warning systems, EMIN and CFIS denotes the level of dedication to improving the overall scenario of the disaster management wing. Components of the Sendai framework have also been highlighted in the recent actions taken by the government.

However, the literature review related to the two flood warning systems-based projects indicates an important implication for further development. The issue with multiple offices working for the same objective is almost always about the efficiency with which the offices can work in synergy to accomplish the given task or attain a certain objective. The same is the case with the offices and departments working for catastrophe management and risk reduction.

The lack of a cohesive structure adds system loss and information gaps to the entire system. This paves the path for inefficiency and delayed realization of initiatives. There are several offices that have a common scope of work. For example, both the MoDMR and MoEF are tasked with the reduction of risk to lives and property in the case of a natural disaster. For this reason, there needs to be a high level of coordination and connection among the entities regarding the information available as

well as the scope of any particular activity, initiative, or program. Without strong coordination among the offices that have a common scope of work, it is quite hard for such entities to be working together for a common goal.

Besides this, another key issue is how the technology used to disseminate information needs to be reformed to some extent to make the spread of information faster and more effective in reaching all segments of life. Nowadays, more and more people are using cell phones and are connected with one another via the internet. This gives us an opportunity to make sure information can be spread to each inoecddividual.

Another key challenge is empowering the grassroots workers and the capacity development of the shelter centers. Once the ICT, as well as the infrastructure, have been developed to tackle the challenges brought by natural disasters, it is important that the grassroots workers appointed by the government are skilled in tackling large-scale natural disasters. The shelter centers also need to have adequate resources for the relocation of masses affected by such natural disasters and equip them with the necessities.

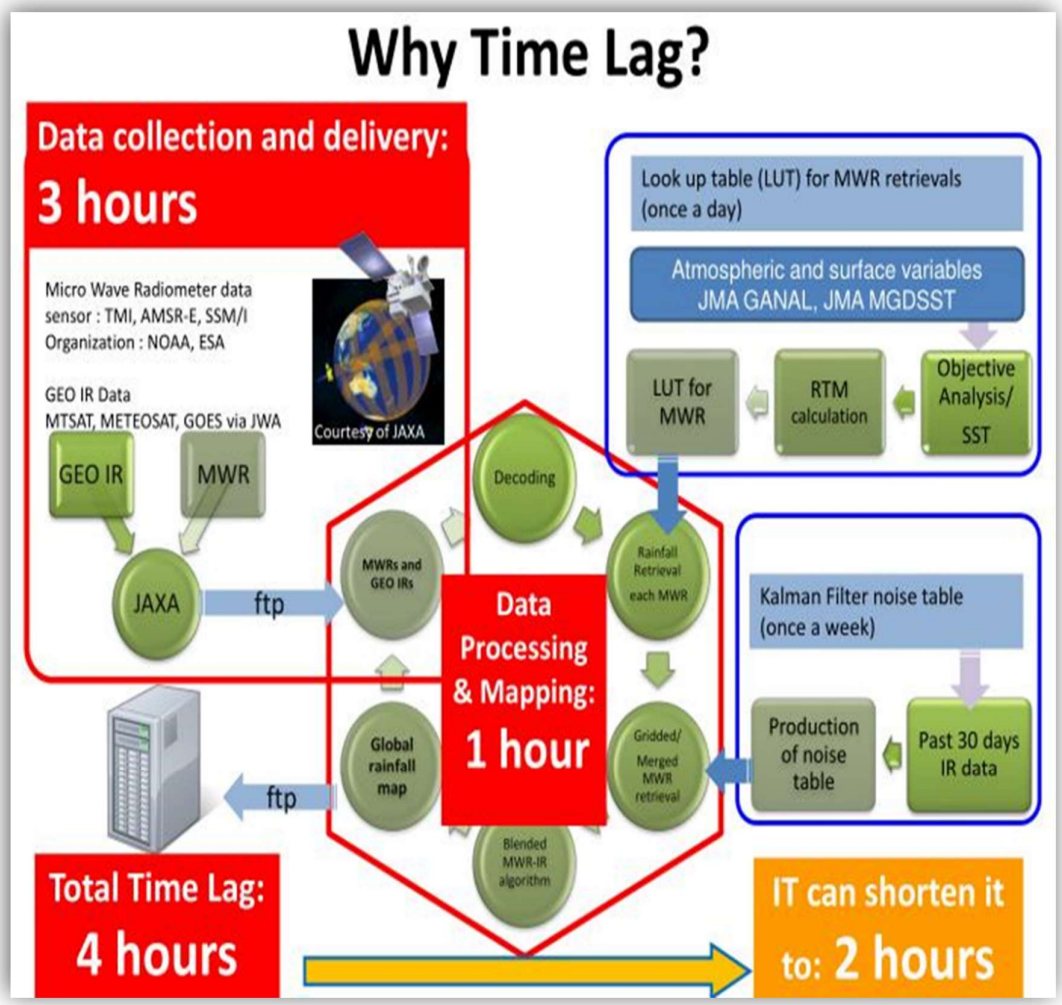
3.2 Challenges:

Four Key challenges

- Reducing the time needed to gather and analyze crucial (i.e. for forecast & warnings)
- Integrating disaster information systems vertically to meet the needs of various users
- Bridging the information gap horizontally to coordinate
- Constructing a practical system in response to new technology

Challenge 1

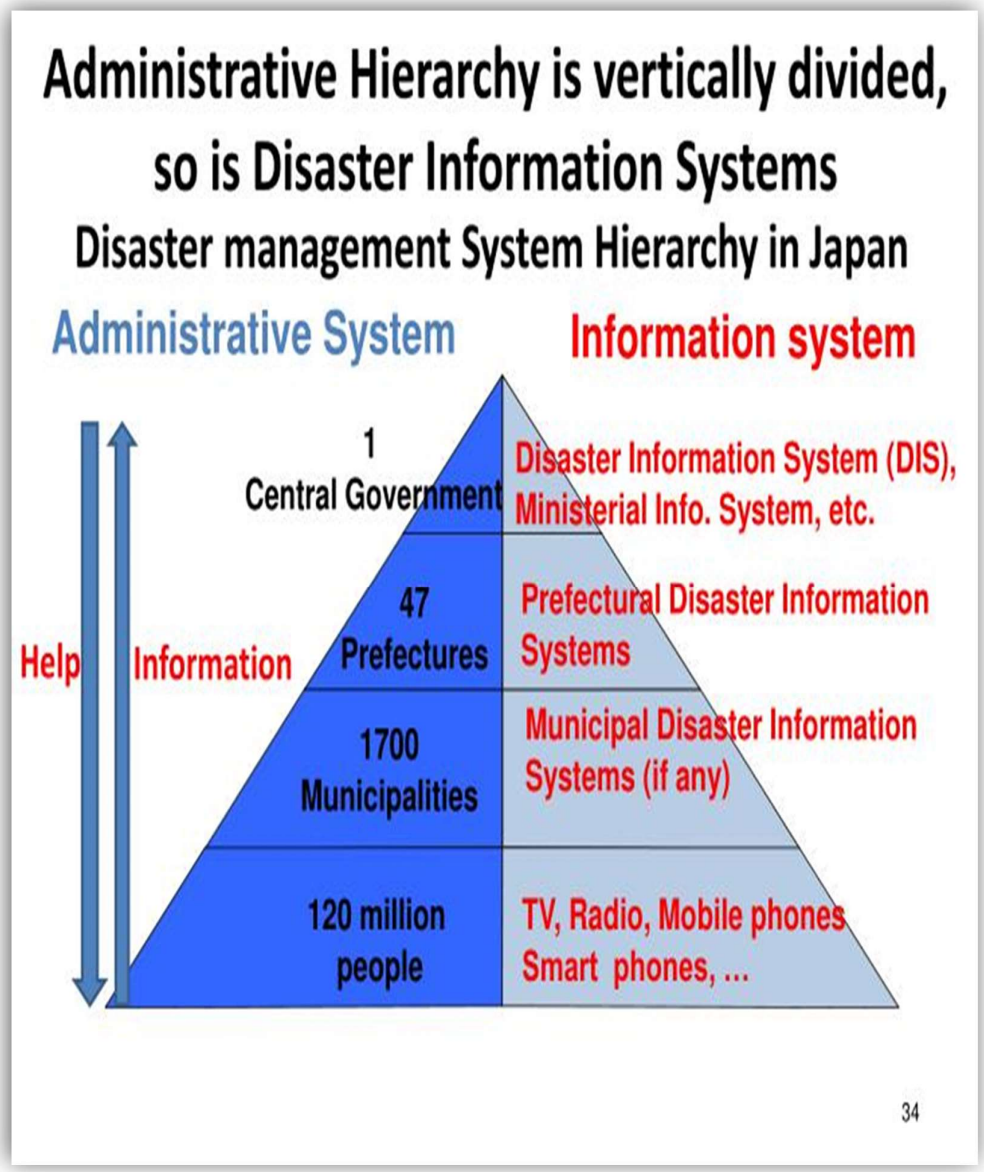
Reducing the time needed to gather and analyze crucial (i.e. for forecast & warnings)



IFAS faces a challenge: four crucial hours Rainfall observation to forecast delivery takes 4 hours for IFAS because: It takes 3 hours from the time the observation data signal is collected to the time the data set is delivered. To create a rainfall map, data analysis must be run for an hour.

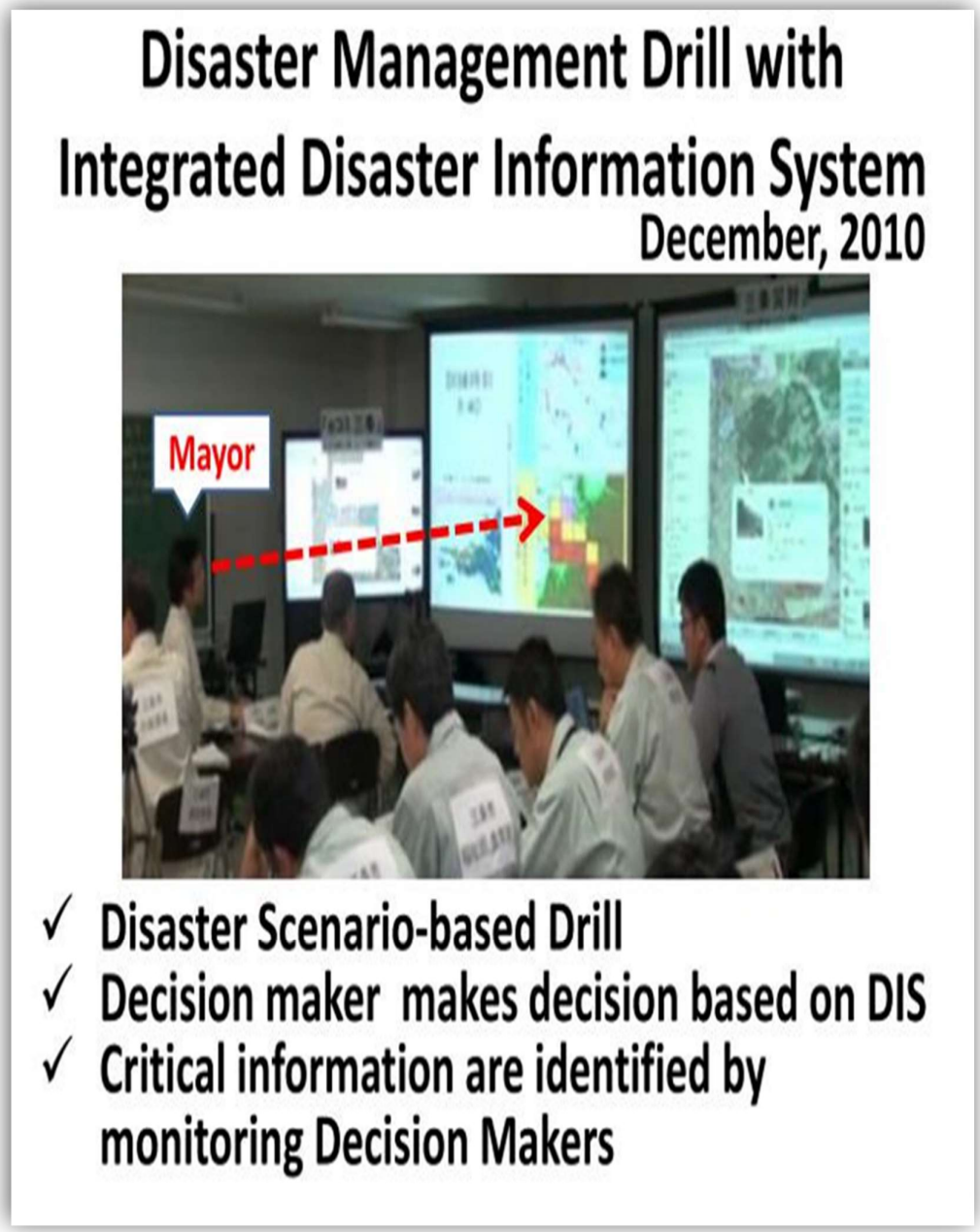
Challenge 2

Integrating disaster information systems vertically to meet the needs of various users



Challenge 3

Bridging the information gap horizontally to coordinate

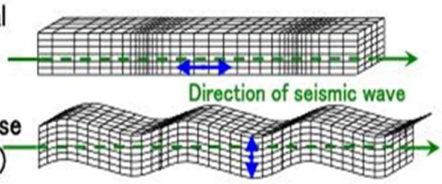


Challenge 4

Emergency Earthquake Warning System (EEWS)

EEWS: A system to give emergency warning a few – ten seconds before Major Earthquake

■ Primary Wave (P-Wave): Minor, longitudinal seismic wave that moves faster (6 km/sec.)



■ Secondary Wave (S-Wave): Major, transverse seismic wave that moves slower (3.5 km/sec.)

- ✓ Speed difference between P- and S-Waves enables emergency earthquake warning a few- 10 seconds prior to arrival of major tremor
- ✓ Primary waves can be detected near epicenter through seismic gaging station network (inland and sea) in Japan
- ✓ JMA started full-scale EEW over Japan in 2007
- ✓ Warning is given through TV, Radio, mobile phones, household interphones and internet

3.3 Disasters and ICT relevant solutions:

As mentioned before, the implementation of a specific ICT tool depends on the phase of the disaster as well as the type of the disaster. The different phases of any disaster have been defined differently by different scholars. However, the core three phases are pre, during, and post-disaster scenarios. These major phases can be later on divided into subsegments, where a specific action is stressed more.

As the particular stages of a disaster are distinct and have distinct requirements and challenges, it is important to allocate an appropriate number of resources for ensuring proper coordination and a more comprehensive initiative. Mentioned below are some of the challenges and responsibilities for specific stages of a disaster that can be dealt with by having proper ICT tools and technologies in place [28].

Latest ICT Applications for Enhanced DRR

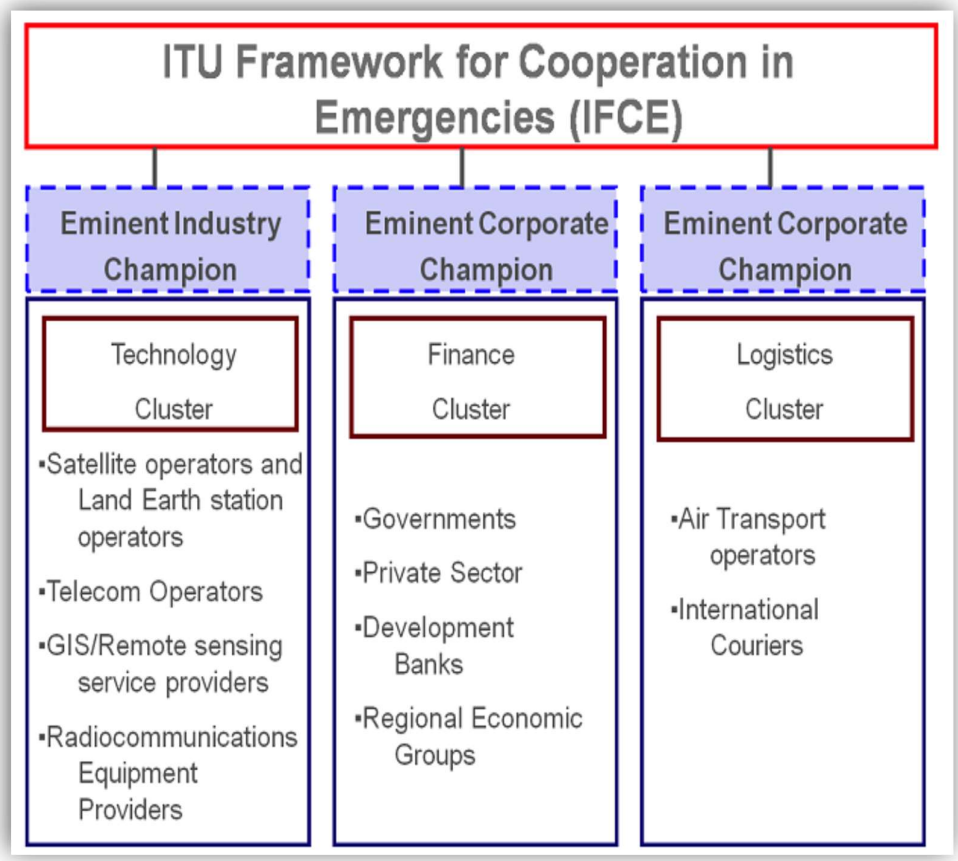


Figure 3.1: Stakeholders in the IFCE (ITU, 2015)

Figure 3.2: Getting an MDRU to a Disaster Site in the Distance (ITU, 2015)

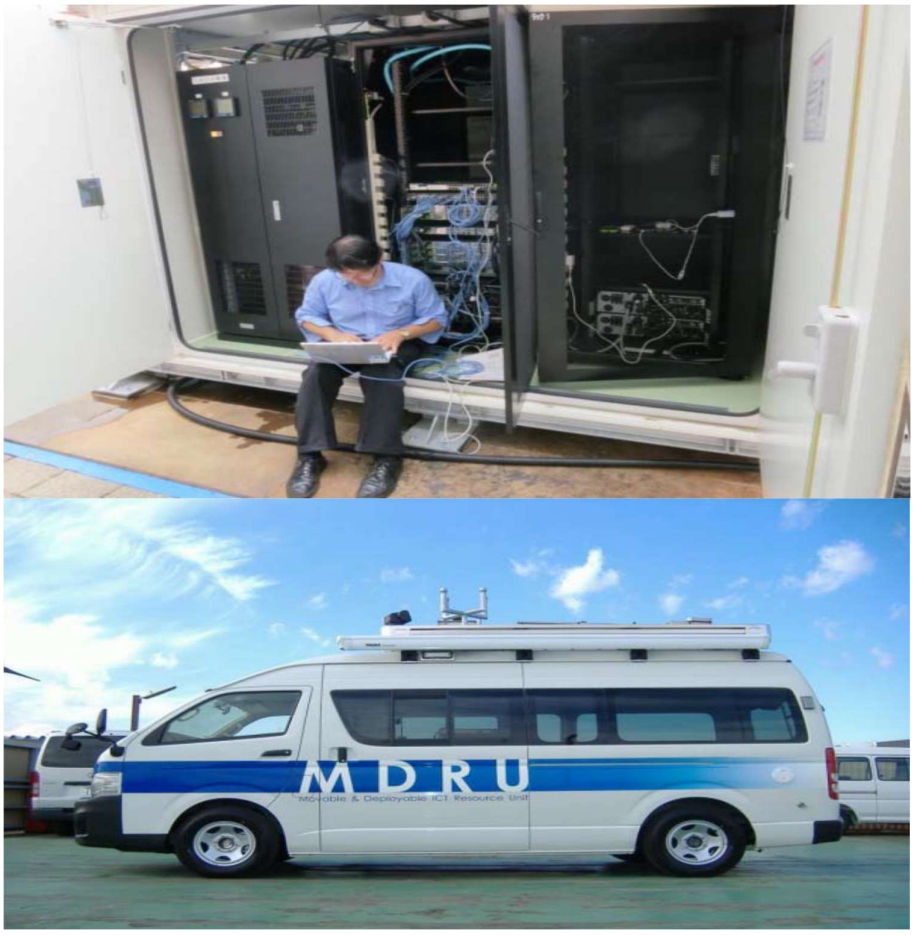


Figure 3.3 Components of MDRU and MDRU-equipped vehicles (ITU, 2015)

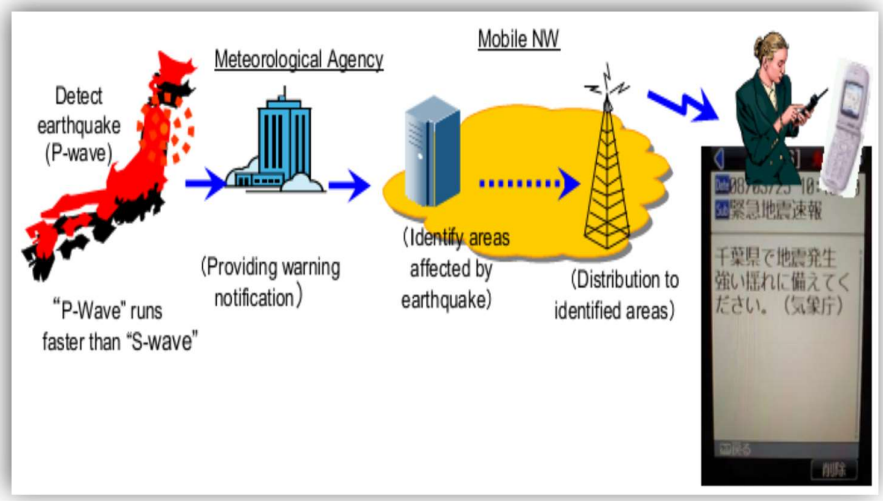


Figure 3.4: Japan's Tsunami Mobile Early Warning System

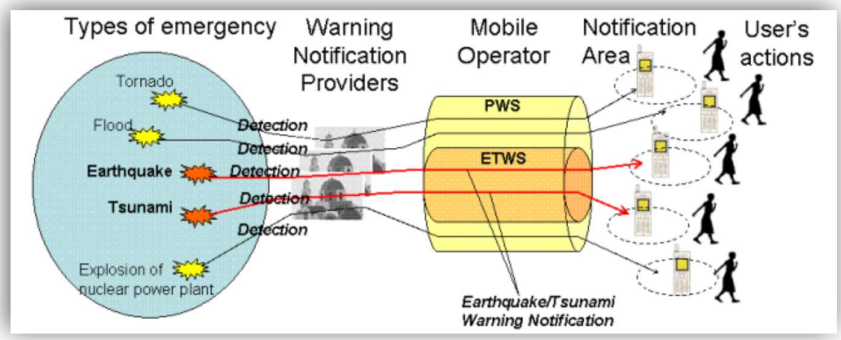


Figure 3.5: Disaster Warning System with ICT (Source: ITU, 2015)

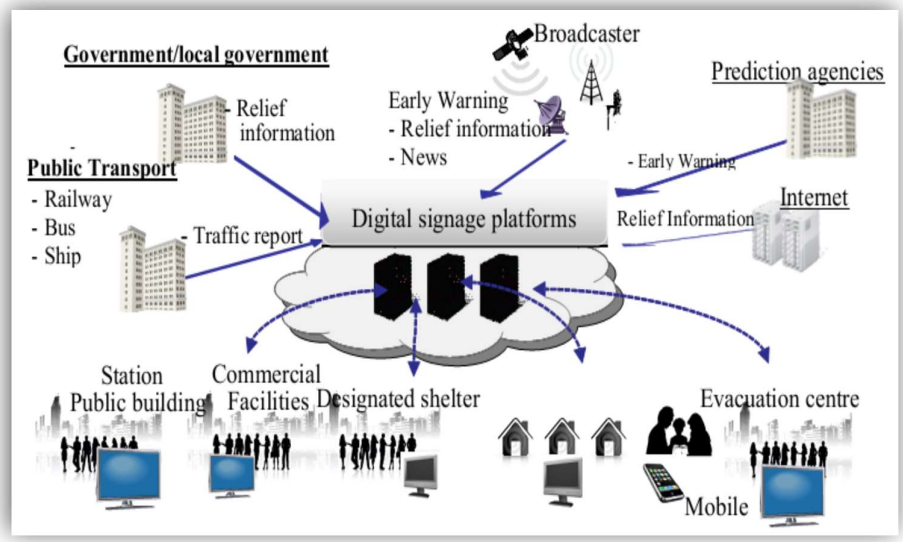


Figure 3.6: Disaster-Ready Digital Signage

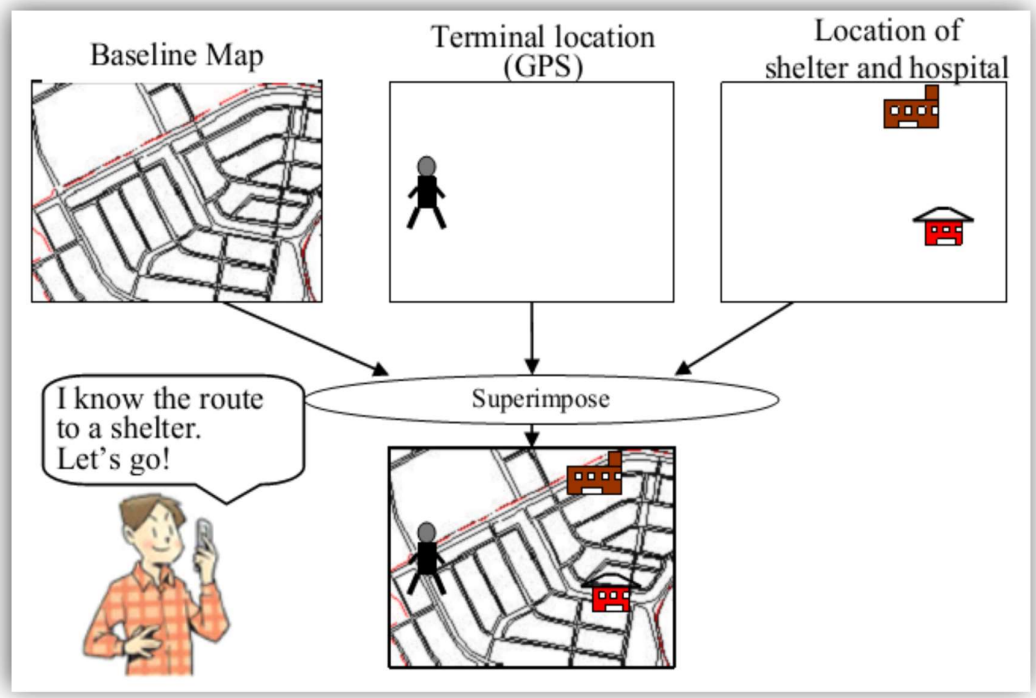


Figure 3.7: Disaster Response Guidance Service (Source: ITU, 2015)

3.3.1 Pre-Disaster:

During the pre-disaster conditions, the roles and responsibilities carried out by the ICT tools focus mainly around creating information as well as sharing them with the concerned authorities who can make impactful decisions out of them. Some of the main responsibilities include:

I. Collecting and historical data accessible.
II. Planning communications networks.
III. Identification and evaluation of hazards.
IV. Identification of the material and logistic needs.

3.3.2 During the Disaster:

During the disaster, it is more important to be able to communicate with the masses effectively because unless the mass people get clear instructions during the disaster then the damage to lives and property will be much more. During this phase, it is

more important to be able to reach the public in the shortest time possible. Responsibilities include:

i. Prioritization of activities depending on the nature of the disaster.
ii. Planning communication channels and communicating with the public.
iii. Ensuring alarming systems are in place and are in good condition.
iv. Verifying access procedures.
v. Collecting information and disseminating it through the selected media channels.
vi. Alarming the first responders.

3.3.3 post-Disaster:

After the disaster is over, it is more important to ensure resources are allocated as per need. This requires mapping the available resources as well as collecting information and understanding where the impact of the disaster has been the hardest. Prioritization of certain needs and affected people is a prime characteristic of the activities conducted during this phase. Some of the other responsibilities are

i. Retrieving archives and updating the information.
ii. Collecting information about the impact of the disaster.
iii. Long-term restoration plans.
iv. Planning pre-disaster modules after learning from the disaster.

3.4 First Steps and Other that Follow:

The very first steps to reduce disaster impact is to understand the potential risk and identify measures through which the number of losses can be minimized. In order to do this, there needs to be adequate planning done from the offices at the top. The implementation of the frameworks, capacity-building programs, and other such projects depends on how the grassroots-level offices have realized the plans and actions recommended by the top officials. The union's Disaster Management Committees and upazila level need to be provided with the resources for accurate early warning systems as well as disaster prediction tools.

ICT can be utilized in a variety of ways for reducing the risk of disasters. Following are some of the areas where ICT can significantly improve the condition:

A. **Forecasting and Prediction:** Latest technologies enable us to identify disaster hazards and risks way before they become reality. For example, GIS technology can be utilized to understand soil erosion hazards and predict the timeline in which the soil erosion might take place. Prediction of rainfall and other such forecasting are nowadays very common.

B. **Resource Allocation:** Understanding the disaster risks and the hazards involved give us an understanding of the amount of resource that needs to be allocated at a certain place. ICT helps us in conducting such what-if scenarios and help us allocate resources to places that require them the most.

C. **Early Warning Systems:** Through ICT tools and technologies, it is possible to predict disasters and hazards. This in turn helps develop early warning systems that can help us alarm many people at once and instruct them with necessary instructions regarding the disaster and how to minimize the losses.

D. **Evacuation Activities:** Use of ICT can help us evacuate and relocate communities that are prone to disasters within a short time. Disseminating the messages regarding helping the communities and informing them about the resources and where to find them can be done efficiently and effectively. It has to be mentioned here that, the number of losses rises significantly after the disaster when the recovery activities are not efficient and effective.

CHAPTER 4

Discussion

4.1 Media Channels:

ICT has evolved throughout the years changing how information is collected and spread from both ends of the spectrum. As such, the way how technology has been used by the mass people have evolved a lot since the 2000s and even from the early 2010s. Therefore, dissemination of information requires a revision and a close observation as to what the trends seem like and where they are all heading.

Currently, more and more people are using cell phones and are connected to the internet. This is an important indication of how early-warning systems can revise how the information gets disseminated to the public. Following are some of the other more traditional channels that help reach all segments of people:

4.1.1 Short Messaging Service:

Since a lot of people are now using cell phones, a cheap and effective way to reach all of these people is via short messages. Bulk SMS is a feature regularly used by marketing departments to reach many people. Similarly, a large number of people using different cell carriers can be reached and notified regarding the upcoming disaster.

4.1.2 Radio:

Radio stands as a prime way of reaching people from rural regions. Though currently, radios are not very popular sources of information, they can help reach the remote regions that the cellular network has not reached yet. Such regions include the hilly tracks of Chittagong. Amateur radio broadcasters are allowed to broadcast use different radio spectrums. Almost 12 initiators for installation and operating radio systems have been granted licenses by the Government of Bangladesh. A major drawback of utilizing this media is that the effectiveness of this media channel decreases significantly when the device is switched off.

4.1.3 Sirens:

Even though it is a quite old-aged technique, the effectiveness of this method in relaying the information is high. Usually, the sirens are used immediately before a disaster so that people are alerted and make informed decisions and prepare themselves for the disaster. Utilizing the sirens well before the disaster can make sure the people are aware of the severity of the upcoming disaster and take necessary steps in reducing the amount of damage.

4.1.4 Internet:

As mentioned before, since a lot of people are now connected to the internet, it will be very effective to warn people to know about disasters through the internet. This method has a high chance of making it to the mass people. Therefore, for any disaster warnings from now onwards, the use of the internet to reach the mass people should be considered.

4.1.5 Television:

Television still serves as a major source of information as well as entertainment for a large demographic of Bangladesh. To a large number of people, this is a medium for gathering information about the country as well as the world. Thus, broadcasting warning messages on television can reach a large number of people.

4.1.6 Telephone:

Simple telephone During the 2004 tsunami in South Asian nations, warnings helped save countless lives.A simple message, notifying the people about the impending disaster and how to prepare for it, can help minimize the damage to a large extent. However, these messages need to be written in local languages so that people not understanding English can understand the information relayed and act accordingly.

4.2 Capacity Building of Offices Involved:

Incorporating ICT in all the steps taken by the disaster management authorities poses a number of requirements to be met in the first place. The first and foremost is a clear

understanding of the roles and responsibilities that need to be performed and outlining the relevant stakeholder responsible and the scope of work. This requires extensive research and study, however, once completed makes performing the other steps relatively easier.

Once everybody understands the scope of work and the roles and responsibilities, it is simply a matter of coordination and execution. However, coordination can serve to be a major challenge as more and more entities are involved. Ensuring the smooth flow of activities without any system loss is a great challenge for any country, let alone Bangladesh.

Smooth coordination, however, affects the beforehand outline of the scope of work. Not all departments are equipped with adequate and the same resources for performing the tasks. In many cases, the execution of activities by a certain entity gets affected due to the lack of resources of another entity. This is a natural phenomenon. For this reason, understanding the resources and the capacity of the concerned office/authority is a key point while outlining the scope of work.

4.3 Policy recommendations:

For government entities

1. Information and communication are essential to managing disaster relief and recovery effectively, and they are always involved in such efforts. The outcomes will be better if this awareness is converted into real-world systems and practices that are implemented before the tragedy.
2. Prior to the occurrence of a disaster, all public and private entities with responsibility for disaster management should deploy suitable disaster management software packages, including prior entry of and other relevant records, and make sure that staff members are trained. An example of this is New York City's deployment of Sahana.
3. Data collection from the field should be prioritized, and field staff should, whenever possible, be given access to mobile devices that will be utilized for post-disaster data collecting and communication. Drills and simulations should ideally be undertaken often.

4. Periodic meetings with telecom operators should be held to evaluate how resilient their networks are to the worst-case scenarios of disasters (e.g., cyclones would be at the top of the list in some countries, earthquakes in others).
5. Building standards, redundancy requirements, insurance, and sector-specific SOPs for efficient response during emergencies and disasters should all be prescribed in order to establish incentives for robust telecommunication infrastructure.
6. The upkeep and regular updating of approved contingency plans for post-disaster recovery should be required of telecommunication service providers. Critical databases and systems should have complete redundancy and backups in the plans.
7. The sharing of telecommunications infrastructure should be promoted by regulators while taking redundancy and resilience into consideration. Regulations for important facilities and infrastructure, such as underwater cable stations, should be created while taking the requirement to reduce disaster risk into mind.
8. Governments should designate areas that are least susceptible to disasters and make sure that ICT infrastructure providers have access to them, especially in small island nations where there won't be many of the most ideal locations.
9. Governments and regulators should bolster the business community to deploy multiple technologies and diversify the locations of essential infrastructure, for instance by guaranteeing that satellite connectivity is maintained even after fiber connectivity is introduced to a nation. Wherever practical, terrestrial cables should be used to counterbalance the use of submarine cables. Another goal of policy should be to diversify the cable routes.
10. Governments should think about supporting terrestrial cable networks that parallel the Trans-Asian Railway Network and the Asian Highway.
11. Governments should establish standards for designating a "state of exception" in which special ICT sector norms will apply, such as accelerated customs clearance for communication equipment and domestic roaming. It is crucial to specify the circumstances under which the exception status ends.
12. Every nation should have access to satellite phones for direct satellite communication among disaster management.

13. For various network segments, performance and reliability measurements should be created. Operators should be required to provide performance metrics to the regulator in order to gather data on the system resilience.
14. First aid personnel should have access to secure, reliable communication methods that aren't fully integrated into societal networks. Spectrum accessibility for such public security systems have to be guaranteed.
15. Governments ought to take into account the possibility of cell broadcasting over public mobile networks for supplemental first-responder communications and for post-disaster communication to residents in particular localities.
16. In the early wake of disasters, governments may consider public education campaigns to inform people about how to utilize public communication networks responsibly; methods for load-shedding based on priority number blocks may also be taken into consideration.
17. Governments should support social media sites that let people affected by disasters contact authorities with their concerns.
18. Governments should use mobile payment networks to transfer money to those affected by disasters as part of relief and recovery efforts.

For operators

1. To lower the chance of a network failure, operators should implement mesh topologies for their networks to the greatest extent possible, with ring topologies as the minimum.
2. Operators should be encouraged to bury cables as much as possible and should be obliged to report the number of aerial cables they deploy, especially in crucial backhaul portions.
3. Developing redundant solutions for power supplies to essential ICT infrastructure should receive special attention. Depending on the country, different options will be best.
4. Interoperability may be required in states of exception if it is not possible to convince all cell operators to create compatible mobile payment systems.
5. A paradigm should be developed to allow the repurposing of existing call centres (customer contact centres) that are equipped to handle the communication requirements following a disaster and have enough capacity and resources to do so. To serve the general public, this duty, however, primarily depends on correct information that must originate from governmental (or trusted) bodies.

CHAPTER 5

Conclusion

ICT integration has the potential to enhance a wide range of activities. ICT is capable of handling a range of tasks, from spotting hazards to ensuring that communities have access to enough resources for recovery. However, since managing coordination and the level of incorporation are the main issues, it is crucial that ICT be broadly adopted by all relevant bodies. Coordination must also be established among them to ensure that no entity's activity causes an obstruction to another entity's ability to carry out its own activity.

Given that the tools and technology have only been partially adapted, Bangladesh faces a barrier in using ICT. This is the difficulty of digitizing any activity. The longer the country takes to partially outfit offices with appropriate ICT tools, the greater the likelihood that it won't deliver on its promises. For emerging nations like ours, where we are still making significant investments while waiting to reap the full benefits, partial incorporation is challenging. This necessitates the government's long-term commitment and attention to putting the right processes and practices in place for decreased disaster risk and improvement disaster management.

APPENDIX

Following is the figure of the Bangladesh is experiencing large earthquakes (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	7.6	Dabigiri, India
6 March, 1933	India Bangladesh earthquake	8.3	India Bangladesh border
15 January, 1934	Bihar-Nepal Earthquake	7.5	Bihar-Nepal border
11 February, 1936	Bihar earthquake	7.2	North Bihar, India
16 August, 1938	Manipur Earthquake	8.5	Manipur, India
15 August, 1950	Assam Earthquake	7.4	Hojai Assam, India
21 March, 1954	Manipur-Myanmar earthquake	7.1	Manipur-Myanmar border
21 November 1997	Bandarban earthquake	7.0	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

Figure A1: Major Earthquakes Affecting Bangladesh (1548-2009)

Source: Bangladesh National Plan for Disaster Management 2010-2015

(http://www.dmb.gov.bd/reports)

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	10	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	33,400	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	29	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

Figure A2: Bangladesh Flood Affected Area Yearly

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

Severe Cyclones Affecting Bangladesh (Since 1960)

Month	Year	Max. Wind Speed (km/h)	Storm Surge Height (meter)	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

Figure A3: Bangladesh is impacted by cyclones.

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

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