DISASTER EARLY WARNING SYSTEM FOR COX'S BAZAR

Prepared for

United Nations Office for Project Services (UNOPS) through Comprehensive Disaster Management Programme (CDMP) under the Ministry of Food and Disaster Management, Government of the People's Republic of Bangladesh

Under the Project
"Development of a Disaster Preparedness Programme for Earthquake and Tsunami Hazards in Cox's Bazar Area"

Department of Civil Engineering
Bangladesh University of Engineering and Technology (BUET)
Dhaka-1000

DISASTER EARLY WARNING SYSTEM FOR COX'S BAZAR

A Report to

Comprehensive Disaster Management Programme (CDMP)
Ministry of Food and Disaster Management
Government of the People's Republic of Bangladesh

Project Director:

Dr. Ashutosh Sutra Dhar
Associate Professor, Department of Civil Engineering, BUET

Co-Researcher:

Dr. Mehedi Ahmed Ansary
Professor, Department of Civil Engineering, BUET

Research Assistants:

Rajan Saha
A. B. Afifa Imtiaz
Kalyani Sutradhar
Mahfuza Shamim

June 2008
Department of Civil Engineering
Bangladesh University of Engineering and Technology (BUET)
Dhaka-1000

Executive Summary

Early Warning System is one of the most effective measures for Disaster Preparedness. Well-functioning of such a system is needed to deliver accurate information dependably and on-time. It should also be people-centered to empower communities' preparedness against natural hazards. Recent series of disasters in Bangladesh and neighboring countries have posed an added concern on the importance of emergency alerts. In the present research the existing early warning systems for disasters in Cox's Bazar district of Bangladesh, especially the cyclone warning system have been reviewed. A new satellite based warning dissemination system was then set up across the district.

To develop a comprehensive awareness program regarding Earthquake and Tsunami Hazards, effectiveness of the existing Early Warning Dissemination System of Cyclone Preparedness Program has been evaluated for its applicability to other natural disasters. Two sets of questionnaire were developed one for individual level study through Key Information Interview (KII) and the other for group level evaluation through Rural Rapid Appraisal (RRA). The Early Warning Dissemination System has been evaluated based on the response of the local vulnerable groups through these participatory questionnaire surveys. Finally GIS has been used to determine the location of the existing cyclone shelters, the early warning systems and their area of coverage. The accessibility of the local people to those shelters was then examined so that Evacuation Plans for the significant shelter-locations can be prepared.

The existing global tsunami warning systems have also been reviewed to identify the key features of the systems. On the basis of the knowledge accumulated and analyses performed, the new satellite based early warning system, WorldSpace AREA Solution, has been procured. Twenty sets of the system have been deployed in Dhaka and Cox's Bazar on a Pilot basis. The system is capable of disseminating messages to the community within 10 seconds after issuing alert. Finally, the technologies and devices proposed for earthquake warning in some countries has been discussed

Acknowledgement

The authors acknowledge the funding of this research project by United Nation Office for Project Service (UNOPS) through Comprehensive Disaster Management Program (CDMP) of the Ministry of Disaster Relief and Rehabilitation of Bangladesh Government.

TABLE OF CONTENTS

	Contents	Page No
	Executive Summary	4
	Acknowledgement	5
	Table of Contents	6
	List of Figures	8
	List of Tables	9
1	Introduction	10
2	Warning System in Bangladesh	11
3	Scope of CPP work	11
4	Warning Equipment and Logistics	12
5	Operational Method	14
6	Signaling System	16
7	Evaluation of Existing Disaster Preparedness System	19
	7.1 Overview of Cyclone Shelters	20
	7.2 Key Information Interview	22
	7.2.1 Development of Questionnaire	22
	7.2.2 Participatory Survey	24
	7.2.3 Location of the Inhabitants and Shelters	26
	7.2.4 Emergency Facilities	30
	7.2.5 Live Stock Facilities	30
	7.2.6 Early Warning Signals	30
	7.2.7 Warning Dissemination System	30
	7.2.8 Peoples' Participation in Shelter Management	31
	7.2.9 Usefulness of Cyclone Shelters and Effectiveness of Warning Dissemination	32
	7.2.10 Applicability to Earthquake and Tsunami Disasters	32
	7.3 Rural Rapid Appraisal	32
	7.3.1 Development of Questionnaire	33
	7.3.2 RRA Data Analysis	35
	7.3.3 Local Inhabitants near to the cyclone shelter	37
	7.3.4 Initiatives of Local Administration and Other Organization	40
	7.3.5 Role of NGO's	41

TABLE OF CONTENTS (contd.)

8	Review of Tsunami Warning Systems		41
	8.1	Existing Tsunami Warning Systems	42
	8.2	Tsunami Warning in Pacific Ocean	43
		8.2.1 Pacific Tsunami Warning Centre	43
		8.2.2 West Coast and Alaska Tsunami Warning Centre	46
		8.2.3 Japan Meteorological Agency	47
	8.3	Indian Ocean Tsunami Warning System	50
	8.4	Tsunami Warning in North Eastern Atlantic, The Mediterranean and connected seas	51
9	Development of Regional Warning System		52
	9.1	Concept of Operations	52
	9.2	Community Training	53
	9.3	Challenges	53
	9.4	Addressable Radio for Emergency Alert (AREA)	55
	9.5	Operation	58
	9.6	Installation of AREA in Bangladesh	58
10	Earthquake Warning		58
11	Summary		31
	REFERENCES		62
	APPENDIX A		
	APPENDIX B		
	APPENDIX C		

LIST OF FIGURES

Figure 1: CPP Network
Figure 2: BMD's Dissemination Network
Figure 3: Governmental Organizational Chart
Figure 4: Operational Method
Figure 5: CPP Warning System
Figure 6: Volunteer conducting KII
Figure 7: Participants' response
Figure 8: KII in questionnaire form
Figure 9: Distance of nearest cyclone shelter
Figure 10: Time to reach nearest cyclone shelters
Figure 11: Response of people after getting warning
Figure 12: Volunteer conducting RRA
Figure 13: People's participation
Figure 14: RRA in paper format
Figure 15: Population near to the cyclone shelter
Figure 16: Warning Dissemination time before cyclone
Figure 17: Understanding the meaning of warning surveyed
Figure 18: Number of roads connecting houses and shelters
Figure 19: Utility of cyclone shelter at the disaster moment
Figure 20: DART Buoy System
Figure 21: Location of DART in the Pacific Ocean
Figure 22: DART Station owners
Figure 23: Observation Network and transmission of Tsunami Warning in Japan
Figure 24: Schematic of WorldSpace Satellite System
Figure 25: AREA –C Configuration
Figure 26: Different Configuration of the AREA solution
Figure 27 Different Types of waves
Figure 28: Earthquake Warning System

LIST OF TABLES

Table 1: Warning System for Maritime ports

Table 2: Warning system for river ports

Table 3: Meanings of Flag Numbering System

Table 4: Key Information Interview format in Bengali

Table 5: Distribution of Age Groups of People Surveyed

Table 6: Distance of House from Sea shore

Table 7: Distance of the nearest Cyclone Shelter

Table 8: RRA in questionnaire form

Table 9: Population Distribution

Table 10: Role of Local Administration

Table 11: Role of other Organization

Table 12: Role of Govt. Organization

1. Introduction

Bangladesh is a disaster prone country where many lives are lost and properties are damaged every year due to natural disasters. The city of Cox's Bazar is located in the south eastern part of the country which falls in the High Risk Zone for tropical cyclone. Development of a Cyclone Preparedness Program (CPP) in the country for the area has resulted in a reduction of loss due to cyclone. However, the earthquake and related tsunami have recently appeared as additional natural threats to this region.

Natural hazards in Bangladesh are costing millions of Taka in the form of lives lost and public and private properties destroyed. Many disasters like floods, droughts, cyclones, earthquakes, tornadoes, struck the country almost every year. In the recent years, earthquakes and related tsunamis have appeared as most devastating natural disasters in the south and south-east Asia. Bangladesh also anticipates facing the adverse effects of those disasters. The country is situated in a moderate earthquake zone. Naturally the country needs to develop a disaster reduction program as the Nation's commitment to reduce the impacts of hazards and enhance the safety and economic well being of every individual and community.

Cox's Bazar, located in the south eastern part of Bangladesh, is a strategically and economically important city of the country. The longest sand beach of the world is located at Cox's Bazar. However, the area is exposed to most devastating natural disasters of the country. Cox's Bazar and the nearby area fall in the High Risk Zone for tropical cyclone. The Multipurpose Cyclone Shelter Program by the Government of Bangladesh in 1993 has resulted in the development of many cyclone shelters in the area, which has reduced the loss due to cyclone significantly. However, the earthquake and related tsunamis has recently appeared as additional threats to this region. Therefore, it is essential to develop an earthquake and tsunami preparedness program for the region in order to reduce the potential losses expected from those disasters.

The existing sheltering system and warning mechanism in Cox's Bazar has been evaluated through participatory methods for their suitability to use for earthquake and tsunami. The existing shelters were developed in the area as a cyclone preparedness program after the devastating cyclone in 1991. The Early Warning Dissemination System and the usability of the cyclone shelters were evaluated on the basis of a questionnaire survey involving the local community. Aspects of warning mechanism for different types of disaster were then reviewed. Based on the study a satellite based multi hazard warning system has been introduced in the Cox's Bazar area.

2. Warning System in Bangladesh

Bangladesh Meteorological Department (BMD) under the Ministry of Food and Disaster Management play the key role in generating warning in Bangladesh. Bangladesh Meteorological Department is responsible for generating warning for all hazards, disseminating the warning through public media and different preparedness units and to follow up the warnings at periodic intervals. For dissemination of the warnings BMD uses existing cyclone warning network. The network was established in 1973 as Cyclone Preparedness Programme (CPP) which was developed as a joint venture program of Bangladesh Red Crescent Society (BDRCS) and the Ministry of Food and Disaster Management and the Government of Bangladesh. CPP (Cyclone Preparedness Programme) and BMD (Bangladesh Meteorological Department) mainly work together for disaster warning generation and dissemination of the warning to the root level people in Bangladesh.

3. Scope of CPP work

Cyclone preparedness Program was developed with a goal to develop and strengthen the disaster preparedness response capacity of coastal communities vulnerable to cyclones, to increase the efficiency of volunteers and officers, and to maintain and strengthen the warning system ensuring effective response in the event of a cyclone. In order to achieve the goal, CPP is involved with number of pre-disaster, during disaster and post-disaster activities.

The following main activities of the program are being implemented to fulfill the objectives of the Cyclone Preparedness program:

1. Disseminate cyclone warning signals issued by the Bangladesh Meteorological department to the community people.
2. Assist people in taking shelter.
3. Rescue distressed people affected by a cyclone.
4. Provide First Aid to the people injured by a cyclone.
5. Assist in relief and rehabilitation operations.

6. Assist in the implementation of the BDRCS Disaster Preparedness Plan.
7. Assist in participatory community capacity build-up activities.
8. Assist in the co-ordination of disaster management and development activities.

4. Warning Equipment and logistics

a. Warning Equipment:

As discussed earlier, Bangladesh Meteorological Department is primarily responsible for generating warnings for hazards which is disseminated to the vulnerable community through the administrative network of Bangladesh Government along with the infrastructure of the Bangladesh Red Crescent Society where CPP is a project of the BDRCS. BDRCS and the CPP units receive messages of warning from BMD through high frequency satellite radio. The unit Team Leaders of CPP is provided with a transistor radio for receiving the messages. CPP then disseminate the warning signals among the villagers through megaphones, sirens, public address equipment, signal lights etc. Signal flags are also provided to each volunteer's teams where number of flags on a mast indicates the severity of the event.

b. Volunteers' Gears

To facilitate the Volunteers movement in the adverse weather, they are provided with rain coats, gum boots, hardhats, life jackets and torch lights. Besides these, the first aid and rescue Volunteers are provided with first aid and rescue kits.

c. Telecommunication Network:

The Cyclone Preparedness Programme operates an extensive network of Radio communications facilities, in the coastal areas, linked to its Head Quarter (Head Quarter of BDRCS) at Dhaka. The network consists of a combination of High Frequency and Very High Frequency radios, which covers most of the high risk cyclone areas.

The telecommunication network of the Cyclone Preparedness Programme is composed of three elements as follows:

a) High Frequency (HF) Transceiver Radio:
   - With a main base station located at the Dhaka Headquarter
   - To transmit information related to the cyclone and the preparedness.
   - Field stations send the progress and effects of the cyclone to the headquarter
b) Very High Frequency (VHF) Transceivers:
   - To receive and transmit messages from HF field stations to Sub-Stations locate at Union/Islands.
c) Transistor Radio:
   - Used by each unit Team leader (2760 teams)
   - Receive Meteorological information, cyclone warning signal and special Weather transmitted by Radio Bangladesh on regular basis.

CPP operates a total of 142 Radio stations, among those 64 stations are placed in cyclone shelters, built by the BDRCS, in the high risk cyclone prone areas (CPP, BDRCS, 2002). These radio stations are powered by solar panels and also storage battery. 26 stations have both HF and VHF Radio transceivers operating, and 10 stations where only HF Radio transceivers operating. Only VHF Radio transceivers are located and in operation in 106 stations. Figure 1 shows CPP Network in Cox's Bazar District.

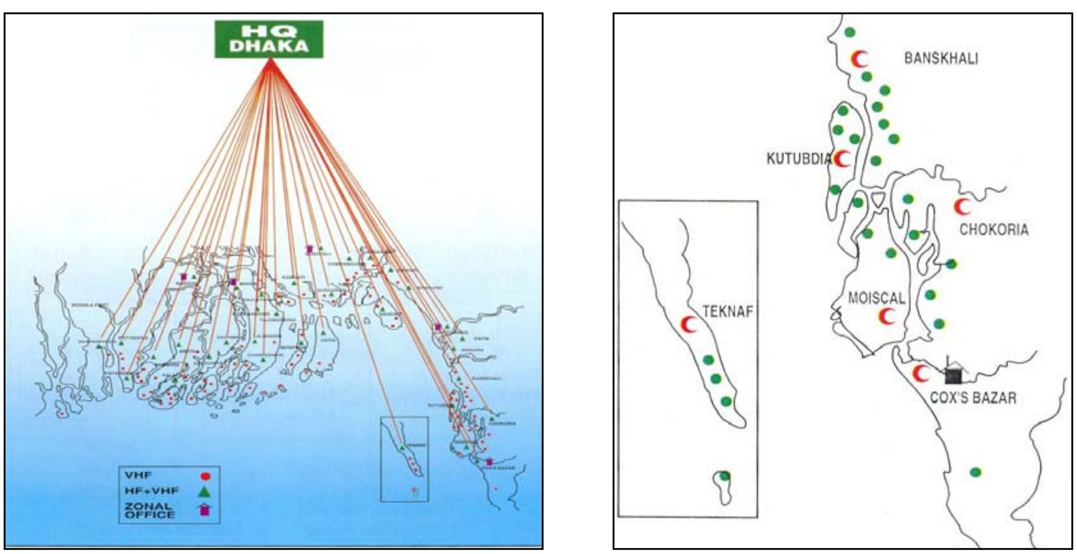


Figure 1: CPP Network (CPP, BDRCS, 2002)

5. Operational Method

BMD monitors hazard around the country round the clock and disseminate warning through the organizational network of Bangladesh Government and BDRCS. Figure 2 shows the BMD's dissemination network. Different institution of Bangladesh government is immediately informed about the disaster. The institutions of the government then participate on the dissemination through its organization network. Figure 3 shows the organizational chart of Bangladesh government that reveals how the warning is disseminated to the local community through the governmental network. Information directly to CPP from BMD also acts parallel. Figure 4 shows operational method of CPP through BMD. BMD is responsible for:

- Observing different meteorological parameters both for surface and upper air all over Bangladesh round the clock.
- Preparing and analyzing all weather charts and to make interpretation on the basis of analyses.
- Providing weather forecasts for public, farmers, mariners and aviators on routine basis and also to issue warnings for severe weather phenomena such as tropical cyclones, tornadoes, nor'swesters, heavy rainfall, etc.
- Maintaining surveillance of weather radars for probing impending tropical cyclones, nor'swesters and tornadoes.
- exchanging meteorological data, forecasts and warnings to meet national and international requirements
- Receiving round the clock satellite imageries for timely use in operational meteorology.
- Extracting maintain quality control, process, archive and publish climatic data for use of various interested agencies at home and abroad.
- Providing meteorological data, radar echoes and Satellite imageries and weather forecast for flood forecasting and warning centre.
- Monitoring micro seismic events and earthquake round the clock.
- Conducting special studies required for the policy makers and for the development of Hydrometeorology and Meteorological sciences in the region.

BMD possess different observational facilities such as 35 First Class Surface Observatories, 10 Pilot Ballon Observatories, 3 Rawinsonde Observatories etc.

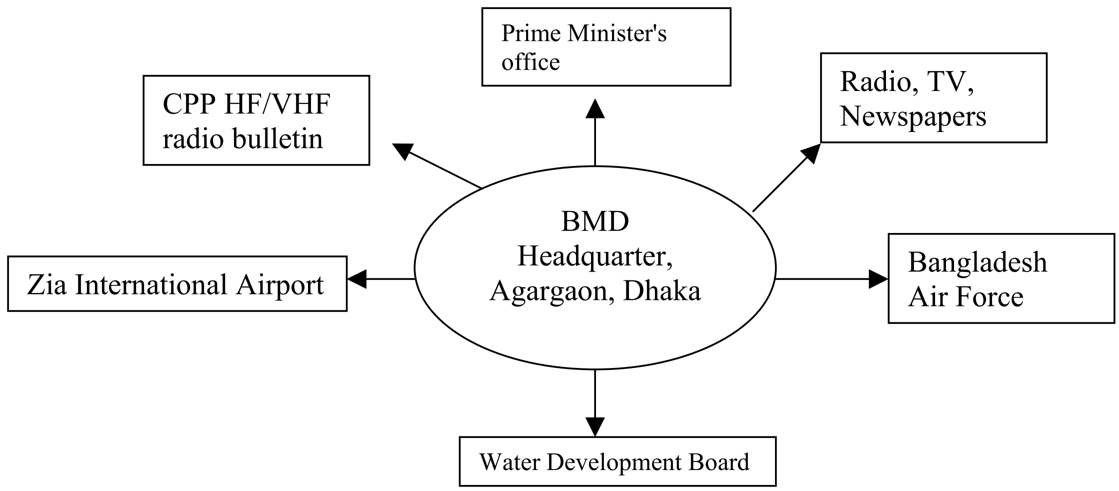


Figure 2: BMD's Dissemination Network

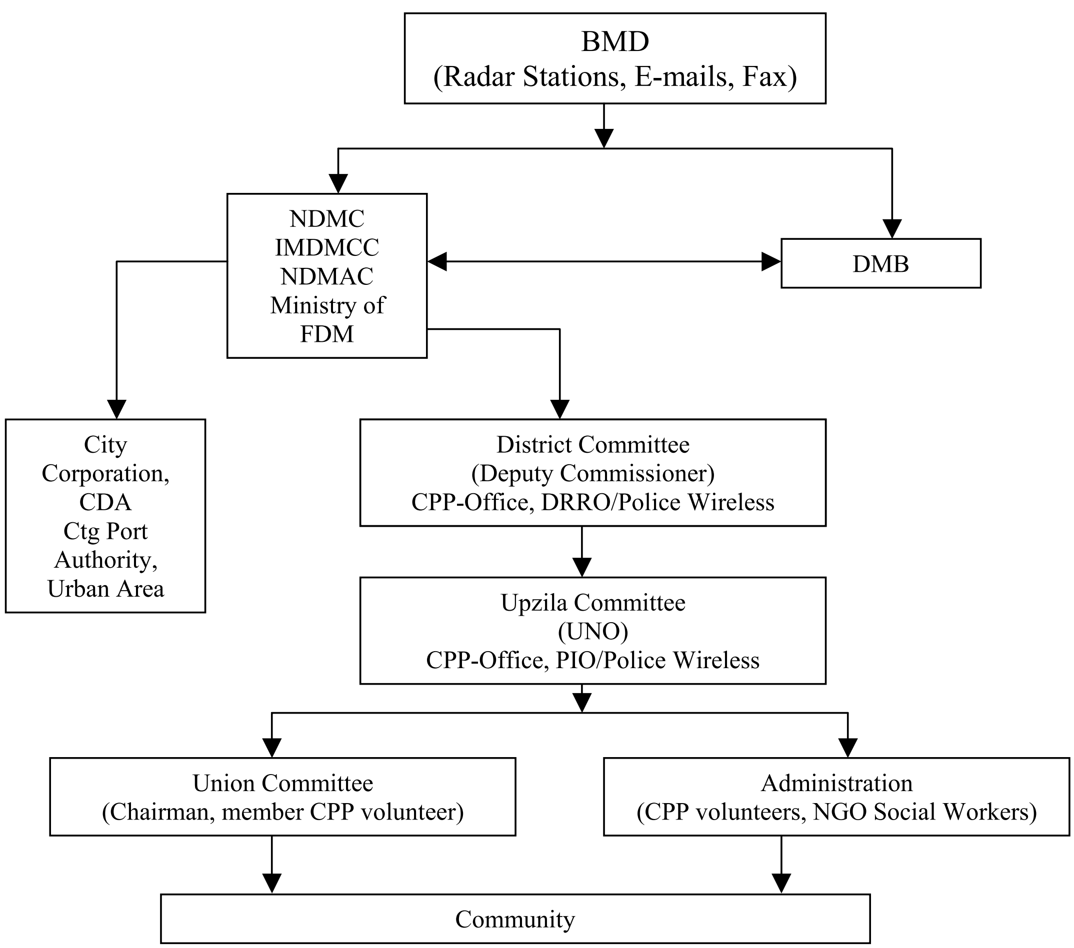


Figure 3: Governmental Organizational Chart for Disaster Warning

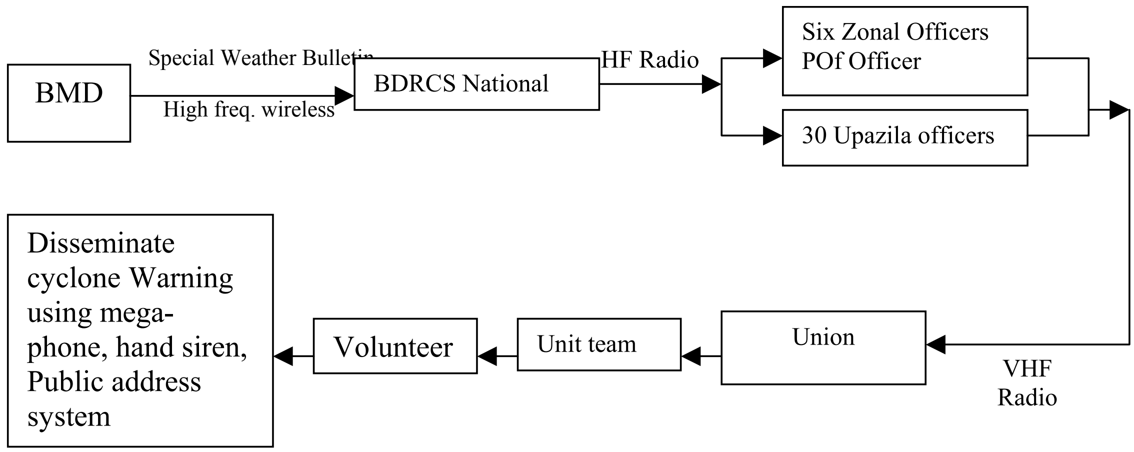


Figure 4: Operational Method of BDRCS

6. Signaling System

Bangladesh Meteorological Department (BMD) is responsible for all kinds of weather forecasting. Cyclone warning system is the only one and well known warning system used in Bangladesh. The signaling system curren tly used for cyclone warning was inherited from British India which were developed for maritime and river ports of British India. There were 11 numbers of signals for Maritime ports and 4 numbers of signals for river ports to indicate the severity of weather conditions. Table 1 and 2 reveal the meanings of the signal numbers for maritime ports and river ports respectively. However, the meanings of these signals, which were developed for port system, have been ambiguous to the local community.

Table 1: Warning System for Maritime ports (Bangladesh Meteorological Department)

Signal	Meanings
1. Distant Cautionary Signal No.1	There is a region of Squally weather in the distant sea where a storm may form
2. Distant Warning Signal No.2	A storm has formed in the Distant area
3. Local Cautionary Signal No. 3	The port is threatened by squally weather
4. Local warning Signal No. 4	The port is threatened by a storm but it doesn't appear that the danger is as yet sufficiently great to justify extreme precautionary measures
5. Danger Signal No. 5	The port will experience severe weather from a storm of slight or moderate intensity that is expected to cross the coast to the south of Chittagong or Cox Bazaar and to the east of the port of Mongla port.
6. Danger Signal No. 6	The port will experience severe weather from a storm of slight or moderate intensity that is expected to cross the coast to the north of the port of Chittagong or Cox Bazaar and to the west of the port of Mongla
7. Danger Signal 7	The port will experience severe weather from a storm of light or moderate intensity that is expected to cross over or near the port.
8.Great Danger Signal No.8	The port will experience severe weather from a storm of great intensity that is expected to cross the coast to the south of the port of Chittagong or Cox Bazar and to the east of the port of Mongla.
9.Great Danger Signal No.9	The port will experience severe weather from a storm of great intensity that is expected to cross the coast to the north of the port of Chittagong or Cox Bazar and to the west of the port of Mongla
10. Great Danger Signal No.10	The port will experience severe weather from a storm of great intensity that is expected to cross over or near the port.
11.Failure of Communication No.11	Communication with the Meteorological Warning Center have broken down and considered as devastating cyclone.

Table 2: Warning system for river ports (Bangladesh Meteorological Department)

Signal	Meanings
1. Cautionary Signal No. 1	The Area is threatened by squally winds of transient nature.
2. Warning Signal No. 2	2.A storm is likely to strike the area (Vessels of 65 feet and under in length are to seek shelter immediately)
3. Danger Signal No. 3	3. A storm will strike the area (all vessel will seek shelter immediately)
4.Great Danger Signal No.4	4. A violent storm will soon strike the area (all vessels will take shelter immediately)

CPP has simplified the signaling system through introducing flagging system corresponding to maritime signals. Three flags have been developed to represent the whole range of Maritime Port Signaling System of British India. Meanings of first flag correspond to signal numbers 1 to 3, second flag corresponds to signal number 4 to 7 and the third flag correspond to signal numbers 8 to 11 of Maritime Port signals (Table 3). While understanding of the meanings of these flags still remain questionable, increase in the number of flag on a mast generally indicates a greater severity of the cyclone event to the local community. Table 3 shows flag numbers and corresponding maritime port signals.

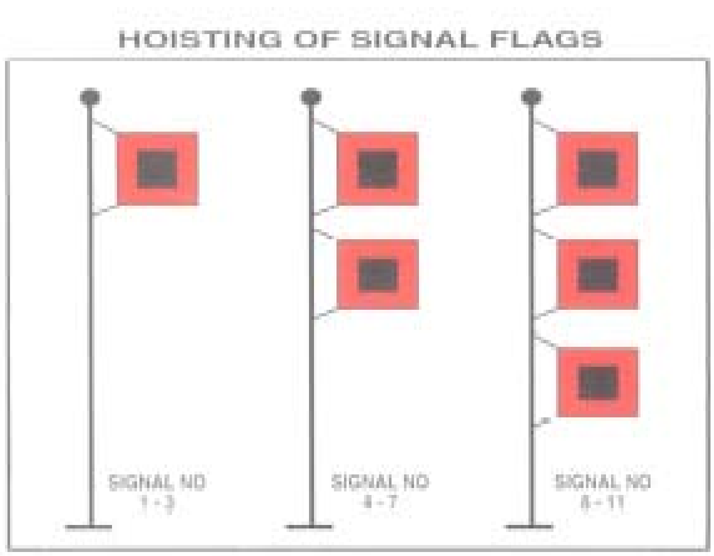


Figure 5: CPP warning system (CPP, BDRCS, 2002)

Table 3: Meanings of Flag Numbering system

Flag Number	**Meaning**
1	Signal No 1-3
2	Signal No 4-7
3	Signal No 8-11

7. Evaluation of Existing Disaster Preparedness System

Cox's Bazar is situated in the southeastern part of Bangladesh, beside the Bay of Bengal. It is a coastal district and famous for its natural beauty and as a tourist place. It was established as a district in the year 1984. The district consists of 8 Upazilas namely Cox's Bazar Sadar, Kutubdia, Maheshkhali, Ramu, Teknaf, Ukhia, Chokoria and Pekua. According to the parameters of Land based zonation of Coastal Region, all these Upazilas are under Exposed Coastal Area. One fourth of the district is island and the major ones are Kutubdia, Maheshkhali, Saint Martin and Shonadia. The district is very much disaster prone. Cyclone, Tidal Surge, Flash Flood, Earthquake is very common here. From the year 1960 to 1995, seven major cyclones hit the district. The most devastating cyclone of the last century hit Cox's Bazar on November 1970. In 1991, another deadly cyclone hit there. People live on agricultural work, fishing in the sea, and salt cultivation. Many people are engaged in tourism and hotel business. The literacy rate in Cox's Bazar is the least among other coastal districts.

Disaster management preparedness along the coastal belts and in offshore areas is in a poor shape as there are not enough cyclone shelters in the region. Following cyclones in the 1960s, a plan was taken to build cyclone shelters for the people living along the coastal region. Staggering loss of about half a million lives in the calamity on November 12, 1970 fuelled the demand for the construction of cyclone shelters. Nearly 238 cyclone shelters were built along the coastal belt between 1972 and 1992. After the cyclone in 1991, in which about 140,000 people were killed, the government constituted a committee to assess the safety measures of the coastal people. The committee suggested construction of at least 3,500 cyclone shelters in this region to accommodate people during the time of tidal surges, cyclone, flood and other types of hazards. But 1,841 cyclone shelters have been built so far to house about 10 per cent of the total coastal population. There are about 1.76 million people living in Cox's Bazar District (B.B.S. 2001), vulnerable to cyclones, tidal surges and other natural calamities. There are 455 cyclone shelters in different places of the district (L.G.E.D. 2003). These are used for sheltering people during the cyclones and are used as schools or food storage at normal times. They can accommodate 52% of the population. The rest of the people are left to face the onslaught of hostile weather.

Most of the shelters of the area were built after the 1991 cyclone with the help of Donor countries and agencies where Saudi Cyclone grant has the prominent share and European Commission, IFAD grant, World Vision, Japan, BRAC, Red Crescent Society are the other significant contributors. All the shelters belong to the government of Bangladesh except NGO-owned ones.

The Early Warning Dissemination System and the usability of the cyclone shelters were evaluated on the basis of a questionnaire survey involving the local community. Two sets of questionnaire were developed, one for individual level study thru Key Information Interview (KII) and the other for group level evaluation through Rural Rapid Appraisal (RRA).

7.1 Overview of Cyclone Shelters

The existing cyclone shelters are usually two to three storied keeping the Ground Floor totally open. Stairway is attached within the building. Saudi Grant cyclone building has two stairways, which facilitates entrance at the time of emergency. There are also attached toilets but no provision of water supply facility exists in the building.

The physical condition of the shelters is quite good so far as their ages range within 12 to 15 years. There are few cases where cracks, damping, broken doors and windows can also be seen. As the Shelters are being used mainly as primary schools, the teachers and other staffs of the school also take care of the building. It has been observed that the buildings with good outlook attract small children and motivate the parents to send their children to school. Moreover, strong-looking buildings give mental strength and feeling of safety to the local people. On an average every shelter is capable of accommodating 1000 to 1200 people at disaster period. At the crisis moment the crowd that gathers in a shelter makes very unhealthy condition there. Due to lack of proper ventilation, light, water supply and sanitation facilities along with lack of sufficient space cause great sufferings.

The problem of access for women is also very important. There is no allocation of separate space for male and female in any cyclone shelter which is also another major problem as Cox's Bazar area is religiously conservative enough to maintain distinction between male and female. When cyclone shelters are used for exclusively male activities (mosques or madrasahs in particular) women do not believe themselves to have sanctioned access and will not enter. Women fear for their safety en route to the shelters. This condition demotivates the women to take shelter. Again most of the times the women feel very insecure and vulnerable in the mass where there is also possibility of physical assault. After a devastating cyclone in 1991 which left almost 140,000 people dead, a study carried out by the Red Crescent and other organizations, revealed that 90% of the victims were women and children. Despite the existence of some cyclone shelters, the communities living around them were not aware of their purpose or didn't feel it was safe to take refuge in them.

Where the land for the shelter donated, issues of access and ownership of shelter arise which limit their effectiveness. Social conflicts may erupt when people have to cross land owned by people inadequately compensated when the land was acquired. The owners of the land where the shelter was built always has a strong influence and tries to take extra advantages from the building and obstacle the entrance of general people. Access to shelters is dominated by the elites and inactive shelter management committees. Minority groups and others may not be granted entry and at the same time, religious centers of minority groups are often not open to outsiders. Besides this, people are discriminated on the basis of their economic condition which sometimes acts as a discouragement for the rich people to take shelter with the general mass.

The absence of connecting road to the shelter also discourages the families to move to shelter. On the other hand the evacuation order disseminates in such a time that it becomes difficult to cross the road and reach the shelter with children and female in a real bad weather.

By the order of Bangladesh government, UNO (Upazila Nirbahi Officer) has the authority of all these shelters and perform its entire works through Union Disaster Management Committee. In practice, Union Disaster Management Committee does not play any effective role in shelter management works.

According to the government order Upazila Disaster Management Committee (UzDMC) has the responsibility of the entire repair and maintenance works of cyclone shelters. Though there is a provision of financial support from the authorized Ministry, but in practice they do not response to the requirements of UzDMC.

7.2 Key Information Interview

7.2.1 Development of Questionnaire

Objective of the KII survey was to evaluate the effectiveness of the cyclone shelters from the view point of individuals of the local community and hence to examine the potentiality of using those shelters for earthquake and tsunami disasters. For earthquake and tsunami disasters, major concern is the time to reach the shelter after receiving of the warning, since the time lag between tsunami appearance and recognition of tsunamigenic earthquake is expected to be less. Thus, the issues of warning mechanism, time for warning and evacuation, medium used etc were focused during development of questionnaires.

The questionnaires were developed in such a manner so that they become useful tools to judge the involvement of the community in sheltering and warning systems of the study area. To assess the condition of the cyclone shelters, questions of the survey was developed on the basis of the following considerations,

- Security condition of the shelters
- Sustainability
- Capacity
- Comfortability
- Accessibility
- Connectivity

Table 4 shows a sample questionnaire developed for the participatory survey with the questions asked.

Table 4: Key Information Interview format in Bengali

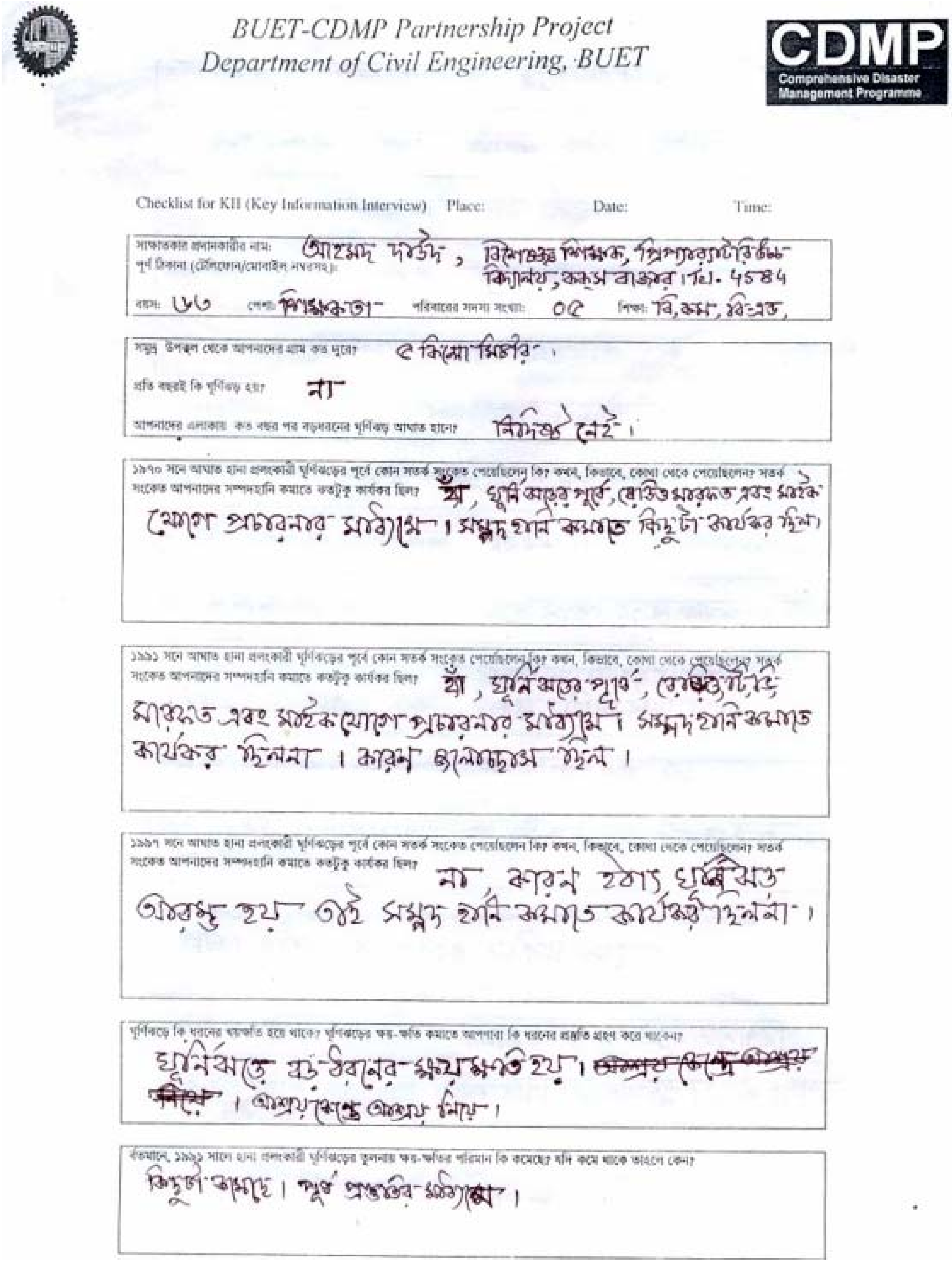
1. mv¶vZ c`vbKvixi bvg : cY wVKvbv (†Uwj‡dvb/†gvevBj b¤imn*)  eqm : †ckv: cwiev‡ii m`m¨ msL¨v: wk¶v:
2.1 mg` DcKj †\_‡K Avcbv‡`I Mvg KZ `‡i? 2.2 cwZ eQiB wK NwYSo nq ? 2.3 Avcbv‡`i GjvKvq KZ eQi ci ci eoai‡bi NwYSo AvNvZ nv‡b?
3. 1970 m‡b AvNvZ nvbv cjqsKix NwYS‡oii c‡e †Kvb mZK ms‡KZ †c‡qwQ‡jb wK? KLb, wKfv‡e, †Kv_v †_‡K †c‡qwQ‡jb? mZK ms‡KZ Avcbv‡`I m¤ú`nwb Kgv‡Z KZUK KvhKi wQj?
4. 1991 m‡b AvNvZ nvbv cjqsKvix NwYS‡oi c‡e †Kvb mZK ms‡KZ †c‡qwQ‡jb wK? KLb, wKfv‡e, †Kv_v †_‡K †c‡qwQ‡jb? mZK ms‡KZ Avcbv‡`I m¤ú`nwb Kgv‡Z KZUK KvhKi wQj?
5. 1997 m‡b AvNvZ nvbv cjqsKvix NwYS‡oi c‡e †Kvb mZK ms‡KZ †c‡qwQ‡jb wK? KLb, wKfv‡e, †Kv_v †_‡K †c‡qwQ‡jb? mZK ms‡KZ Avcbv‡`I m¤ú`nwb Kgv‡Z KZUK KvhKi wQj?
6. NwYS‡o wK ai‡bi ¶q-¶wZ n‡q _v‡K? NwYS‡oi ¶q-¶wZ Kgv‡Z Avcbviv wK ai‡bi c¯wZ Mnb K‡i _v‡Kb?
7. eZgv‡b, 1991 mv‡j nvbv cjqsKvix NwYS‡oi Zjbvq ¶q-¶wZi cwigvb wK K‡g‡Q? hw` K‡g _v‡K Zvn‡j †Kb?
8. Avcbviv NwYSo AvNvZ nvbvi KZ¶b Av‡M ms‡KZ †c‡q _v‡Kb?
9. Rxe‡b KZevi Avcwb/cwievi Avkq‡K‡›` wM‡q‡Qb?
10. †K ev Kviv Avcbv‡`I Avkq‡K‡›` †h‡Z mnvqZv K‡i / K‡iwQj?
11. ms‡KZ cvIqvi KZ¶‡bi g‡a¨ gvbI Avkq‡K‡›` hvq?
12. Avkq‡K‡›` hvIqvi mgq mv‡_ wK wK wb‡q hvb?
13.1 ewo †_‡K Avkq‡K‡›`i `iZ KZ?
13.2 ewo †_‡K Avkq‡K‡›` †h‡Z KZ mgq jv‡M?
14. GjvKvi Avkq‡K›`wU ¶q-¶wZ Kgv‡Z wK fwgKv iv‡L?
15. ¯vfwweK mg‡q Avkq‡K›`wU wK wK Kv‡R e¨envi Kiv nq?
16. NwbS‡oi ¶q-¶wZ Kgv‡Z mZK ms‡KZ wK fwgKv iv‡L?
17. Avkq‡K‡›` wK ai‡bi Amweav †gvKwejv Ki‡Z nq?
18. NwYSo mZKms‡KZ cPvi, cvjb Ges Z`viwK‡Z Avcbv‡`i gZvgZ I civgk Mnb Kiv nq wK?
19. Avkq‡K›` Kviv Z`viwK K‡i _v‡Kb? Z`viwK‡Z Avcbv‡`i gZvgZ, civgk, AskMnb Av‡Q wK?
20. NwYSo mZKms‡KZ Ges Gi e¨e¯vcbv wK iKg n‡j ¶q-¶wZ †gvKwejvq c‡qvRbxq c¯wZ MnY Kiv AviI mnR n‡e?
21. NwYSo Qvov Avi wK ai‡bi `‡hvM ev Zvi Avkskv Av‡Q?
22. fwgKv¤ú/mbwg wK? Avcbviv G m¤ú‡K wK Rv‡bb?

7.2.2 Participatory Survey

The survey was conducted in different areas covering whole of the Cox's Bazar District. The sample population surveyed was chosen in a random manner but the inclusion of people from different age, class and profession was ensured. The survey was conducted among teachers, businessmen, housewives, fishermen, service holders, day laborers and people from other minor professions. Figure 6 shows a volunteer conducting questionnaire survey and Figure 7 shows the participant's response. Figure 8 shows Participants' response to KII questionnaire. Sample database prepared based on KII survey are given in Appendix A. Table 5 shows the distribution of age groups of peoples surveyed in different areas.

Figure 6: Volunteer conducting KII

Figure 7: Participants' response



BUET-CDMP Partnership Project
Department of Civil Engineering, BUET

CDMP
Comprehensive Disaster Management Programme

Checklist for KII (Key Information Interview) Place: Date: Time:

সাক্ষাতকার প্রদানকারীর নাম: আহম্মদ দাউদ, বিশেষজ্ঞ শিক্ষক,
পূর্ণ ঠিকানা (টেলিফোন/মোবাইল নম্বরসহ): কিয়ামত বাজার
বয়স: ৬৩ পেশা: শিক্ষকতা পরিবারের সদস্য সংখ্যা: ০৫ শিক্ষা: বি,কম, বি-এড,

সমুদ্র উপকূল থেকে আপনাদের গ্রাম কত দূরে? ৫ কিলোমিটার।
প্রতি বছরই কি ঘূর্ণিঝড় হয়? না
আপনাদের এলাকায় কত বছর পর বড়ধরনের ঘূর্ণিঝড় আঘাত হানে? নির্দিষ্ট নেই।

১৯৭০ সনে আঘাত হানা প্রলয়কারী ঘূর্ণিঝড়ের পূর্বে কোন সতর্ক সংকেত পেয়েছিলেন কি? কখন, কিভাবে, কোথা থেকে পেয়েছিলেন? সতর্ক সংকেত আপনাদের সম্পদহানি কমাতে কতটুকু কার্যকর ছিল? হ্যাঁ, ঘূর্ণিঝড়ের পূর্বে, রেডিও মারফত এবং মাইকিং প্রচারনার মাধ্যমে। সম্পদ হানি কমাতে কিছুটা কার্যকর ছিল।

১৯৯১ সনে আঘাত হানা প্রলয়কারী ঘূর্ণিঝড়ের পূর্বে কোন সতর্ক সংকেত পেয়েছিলেন কি? কখন, কিভাবে, কোথা থেকে পেয়েছিলেন? সতর্ক সংকেত আপনাদের সম্পদহানি কমাতে কতটুকু কার্যকর ছিল? হ্যাঁ, ঘূর্ণিঝড়ের পূর্বে, রেডিও, টিভি মারফত এবং মাইকিং প্রচারনার মাধ্যমে। সম্পদ হানি কমাতে কার্যকর ছিলনা। কারণ জলোচ্ছ্বাস ছিল।

১৯৯৭ সনে আঘাত হানা প্রলয়কারী ঘূর্ণিঝড়ের পূর্বে কোন সতর্ক সংকেত পেয়েছিলেন কি? কখন, কিভাবে, কোথা থেকে পেয়েছিলেন? সতর্ক সংকেত আপনাদের সম্পদহানি কমাতে কতটুকু কার্যকর ছিল? না, কারণ হঠাৎ ঘূর্ণিঝড় আরম্ভ হয়। তাই সম্পদ হানি কমাতে কার্যকর ছিলনা।

ঘূর্ণিঝড়ে কি ধরনের ক্ষয়ক্ষতি হয়ে থাকে? ঘূর্ণিঝড়ের ক্ষয়-ক্ষতি কমাতে আপনারা কি ধরনের প্রস্তুতি গ্রহণ করে থাকেন? ঘূর্ণিঝড়ে সব ধরনের ক্ষয়ক্ষতি হয়। ~~আশ্রয় কেন্দ্রে আশ্রয় নিয়ে~~। আশ্রয় কেন্দ্রে আশ্রয় নিয়ে।

বর্তমানে, ১৯৯১ সালে হানা প্রলয়কারী ঘূর্ণিঝড়ের তুলনায় ক্ষয়-ক্ষতির পরিমান কি কমেছে? যদি কমে থাকে তাহলে কেন? কিছুটা কমেছে। পূর্ব প্রস্তুতির মাধ্যমে।

Figure 8: KII in questionnaire form

Table 5: Distribution of Age Groups of People Surveyed

Sl. No.	Area	18-30 Yr		31-45 Yr		46-60 Yr		60+ Yr		Total No.
		no.	**%**	**no.**	**%**	**no.**	**%**	**no.**	**%**	
1	Cox Bazar Sadar	1	2.2	31	67.4	14	30.4	0	0.0	46
2	Middle Tekpara, Cox's Bazar	7	12.3	19	33.3	20	35.1	11	19.3	57
3	Peskarpara, Cox's Bazar	63	31.3	73	36.3	43	21.4	22	10.9	201
4	Naniarchara, Cox's Bazar	0	0	55	55	25	25	20	20	100
5	Choufoldondi, Cox's Bazar	87	43.5	99	49.5	13	6.5	1	0.5	200
6	Kolatoli, Cox's Bazar	33	33	34	34	21	21	12	12	100
7	Kosturaghat Govt. Primary school, Cox's Bazar	3	3	37	37	54	54	7	6.9	101
8	Shafirbil Govt. Primary School, Cox's Bazar	2	2.17	37	40	35	38	18	20	92
9	Central Govt. Primary School, Cox's Bazar	34	57.6	18	31	7	12	3	5	60
10	Ukhya	1	1.4	41	58.6	20	28.6	8	11.4	70
11	Ramu	0	0	32	49.23	28	43.1	5	7.5	65
12	Pallan Para, Teknaf	0	0	0	0	93	93	7	7	100
13	Shamlapara, Teknaf	0	0	0	0	63	70	27	30	90
14	Paschim mach bazar, Teknaf	5	9.1	21	38.2	23	41.8	6	11	55
15	Shah Porir Dwip, Teknaf	11	9.5	41	35.3	45	38.8	19	16.4	116
16	Gorakghata, Moheskhali	0	0	4	4	72	72	23	23	100
17	Kalarmachara, Moheskhali	3	3.3	37	39.77	43	49	10	11.37	91
	Total									**1644**

Among the surveyed population of 17 locations in the Cox's Bazar District, total 1644 questionnaire were considered for analysis.

7.2.3 Location of the Inhabitants and Shelters

People of Cox's Bazar live near to shore. Table 6 shows the distances to the households from the shoreline. It indicates that overall more than 50% of the people surveyed live within 2 km of the shoreline except Cox's Bazar Sadar, Middle Tekpara, Ukhya and Pallanpara. The Shelters are also built very close to the sea. Table 7 shows the distance of the cyclone shelters from the community.

Table 6: Distance of House from Sea shore

Sl. No	Area	0-2 km		2-4 km		4-6 km		6+ km		no info	
		no.	%	no.	%	no.	%	no.	%	no.	%
1	Cox's Bazar Sadar	13	28.3	19	41.3	5	10.9	8	17.4	1	2.2
2	Middle Tekpara, Cox's Bazar	11	19.6	39	69.6	5	8.9	1	1.8	0	0
3	Peskarpara, Cox's Bazar	136	67.3	57	28.2	4	2.0	5	2.5	0	0
4	Naniarchara, Cox's Bazar	100	100.0	0	0.0	0	0.0	0	0.0	0	0
5	Choufoldondi, Cox's Bazar	196	98.0	3	1.5		0.0		0.0	1	0.5
6	Kolatoli, Cox's Bazar	96	96.0	0	0.0	0	0.0	0	0.0	4	4
7	Kosturaghat Govt. Primary school, Cox's Bazar	48	47.5	46	45.5	7	6.9	0	0.0	0	0
8	Shafirbil Govt. Primary School, Cox's Bazar	92	100.0	0	0.0	0	0.0	0	0.0	0	0
9	Central Govt. Primary School, Cox's Bazar	32	53.3	15	25.0	5	8.3	8	13.3	0	0
10	Ukhya	1	1.4	0	0.0	5	7.1	64	91.4	0	0
11	Ramu	64	98.5	0	0.0	0	0.0	0	0.0	1	1.5
12	Pallan Para, Teknaf	6	6.0	26	26.0	59	59.0	9	9.0	0	0
13	Shamlapara, Teknaf	88	97.8	1	1.1	0	0.0	0	0.0	1	1.1
14	Paschim mach bazar, Teknaf	53	96.4	1	1.8	0	0.0	0	0.0	1	1.8
15	Shah Porir Dwip, Teknaf	74	63.8	35	30.2	1	0.9	0	0.0	6	5.2
16	Gorakghata, Moheskhali	98	98.0	0	0.0	0	0.0	0	0.0	2	2
17	Kalarmachara, Moheskhali	47	51.6	27	29.7	8	8.8	9	9.9	0	0

Table 7: Distance of the nearest Cyclone Shelter

Sl. No	Area	0-2 km		2-4 km		4-6 km		6+ km		no info	
		no.	%	no.	%	no.	%	no.	%	no.	%
1	Cox's Bazar Sadar	36	78.3	5	10.9	0	0.0	0	0.0	5	10.9
2	Middle Tekpara, Cox's Bazar	55	96.5	0	0.0	0	0.0	0	0.0	2	3.5
3	Peskarpara, Cox's Bazar	185	92.0	5	2.5	0	0.0	0	0.0	11	5.5
4	Naniarchara, Cox's Bazar	0	0.0	15	15.0	81	81.0	4	4.0	0	0.0
5	Choufoldondi, Cox's Bazar	200	100.0		0.0	0	0.0	0	0.0	0	0.0
6	Kolatoli, Cox's Bazar	85	85.0	15	15.0	0	0.0	0	0.0	0	0
7	Kosturaghat Govt. Primary school, Cox's Bazar	99	98.	2	2.0	0	0.0	0	0.0	0	0
8	Shafirbil Govt. Primary School, Cox's Bazar	91	98.9	0	0.0	0	0.0	0	0.0	1	1.1
9	Central Govt. Primary School, Cox's Bazar	44	73.3	7	11.7	4	6.7	0	0.0	5	8.3
10	Ukhya	67	95.7	0	0.0	0	0.0	0	0.0	3	4.3
11	Ramu	45	69.2	20	30.8	0	0.0	0	0.0	0	0
12	Pallan Para, Teknaf	71	71.0	26	26.0	3	3.0	0	0.0	0	0
13	Shamlapara, Teknaf	90	100.0	0	0.0	0	0.0	0	0.0	0	0
14	Paschim mach bazar, Teknaf	55	100.0	0	0.0	0	0.0	0	0.0	0	0
15	Shah Porir Dwip, Teknaf	90	77.6	6	5.2	0	0.0	0	0.0	20	17.2
16	Gorakghata, Moheskhali	100	100.0	0	0.0	0	0.0	0	0.0	0	0
17	Kalarmachara, Moheskhali	89	97.8	0	0.0	0	0.0	0	0.0	2	2.2

Almost all about 85.3% (as shown in Figure 9) of people responded at as the cyclone shelters within 2 km from their house. At the time of disaster the way to the shelter becomes very unsafe for the people. Average distance from one shelter to another is 2 to 3 km.

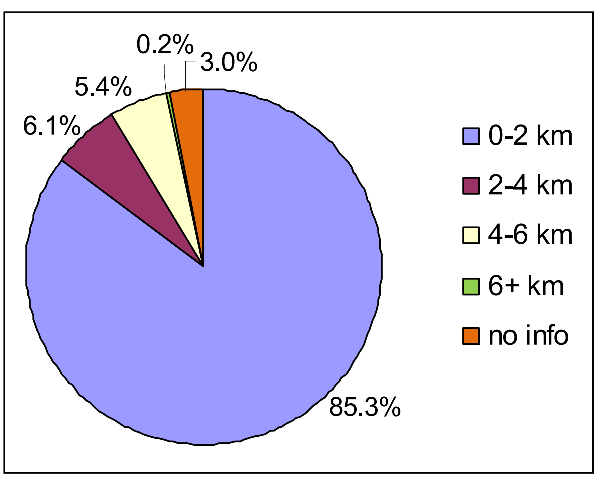


Figure 9: Distance of nearest cyclone shelter

Time to reach the cyclone shelters have been revealed in Figure 10. It is indicated that it takes zero to 15 minutes to reach the nearest cyclone shelters according to most of the respondent (about 51%). About 29% of the participant reported that they need 16 to 30 minutes to reach the cyclone shelters. Thus, if tsunami warning can be issued at least 30 minutes ahead of time, evacuation of maximum community peoples is possible.

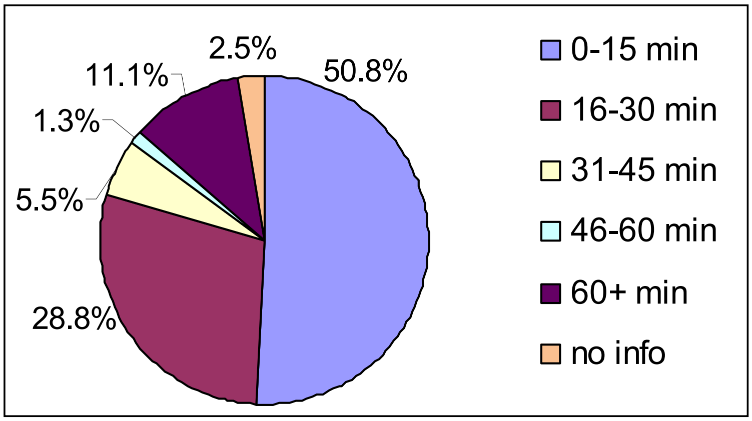


Figure 10: Time to reach nearest cyclone shelters

Figure 11 depicts how people react after getting warning. About 33% appears to move immediately after the warning is issued, about 42% move after a while. Remaining 25% appears to be reluctant to respond to a warning.

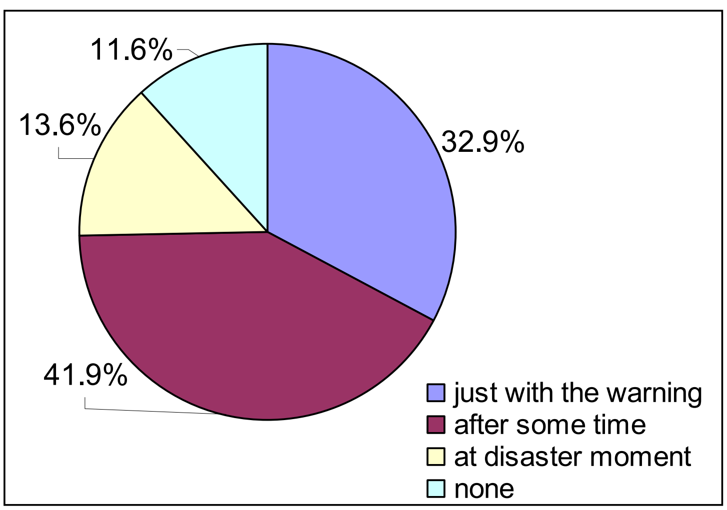


Figure 11: Response of people after getting warning

7.2.4 Emergency Facilities

Government owned shelters have no provision of emergency food, volunteer and first aid facilities. The NGOs such as World Vision, Gono Shastho Kendro and Red Crescent has volunteer and first aid facilities. Local people also bring food to the shelter as much as they can. Nevertheless, government owned cyclone shelters have no practice of preparing volunteer for emergency period and there is no ongoing programme of that kind of volunteer preparing activities. Only Red Crescent Society has this kind of activities in each Union level.

In response to the question about the problems of Cyclone Shelter, almost all the surveyed people stated their sufferings due to lack of sufficient food, water, proper sanitation systems, emergency medicines and huge congestion along with absence of necessary volunteer service.

7.2.5 Live Stock Facilities

Most of the cyclone shelters have no livestock facilities. Geographically Cox's Bazar is a hilly area, that's why there is no practice of Killa (high land, above 15 to 20 feet high from the ground level surrounded by big trees to protect livestock from cyclone and storm surge). During cyclone people cut off the rope of their cattle and make them free to rescue their lives. High lands and hills also act as support to protect the livestock.

7.2.6 Early Warning Signals

Most of the cyclone shelters particularly government owned ones have no provision of early warning and signaling system. In Cox's Bazar, Red Crescent offers all the responsibility of early warning and signaling system through hoisting flags. World Vision has the early warning facilities for their own beneficiary. World Vision in Cox's Bazar distributed 150 radios to their beneficiaries to disperse immediate information on the possible occurrence of cyclone.

7.2.7 Warning Dissemination System

Communication and accurate forecasting will be without benefit unless the information can be conveyed to the people at risk in a timely manner. Warnings are usually disseminated about 24 hours before the cyclone according to most responded surveyed. The warning in

Cox's Bazar area is broadcasted in formal Bangla language, which is not always understandable by the coastal people who use local dialect, and most of them are not educated. The warning system can not distinguish between the possibility of a cyclone striking Bangladesh and the probability (beyond a reasonable doubt) of and fall, plus the intensity, likely target, timing and also when to start evacuation. Another challenge of the warning system is the awareness of the people about the disaster based on which people respond to a warning. The survey showed that 42.9% people will respond immediately after receiving of warning while 38.5% move after the disaster take place. However, an immediate response would be required for earthquake and tsunami disasters.

During the survey a comparative study was made among the cyclones of 1970, 1991 and 1997 to know about the medium and effectiveness of warning dissemination systems. Very few people could remember about any warning dissemination in 1970. Again, in case of 1991, people stated mainly radio and television where they heard the warning; some people also mentioned the use of loud speakers and few people could not remember anything about getting any warning. On the other hand, almost all the people could mention at least one medium of warning dissemination, in most of the cases even more than one media, regarding the cyclone of 1997. Along with radio, television, loud speaker, people also mentioned about the activities of the volunteers and Red Crescent Society and few other NGOs. Another important matter is that most of the people informed that there is hardly anybody to help them to reach the cyclone shelter at crisis moments; few volunteers sometimes come forward but they are not sufficient at all.

7.2.8 People's participation in 'Shelter Management'

The government owned shelters are mainly used as educational institutions, particularly primary schools. School committee has some role in the management of shelters. The NGOs use their shelters as multipurpose buildings. They also actively manage the shelters. But the finding of the survey is that the general people are totally unaware of the management of Shelters. Nobody involve them or they do not participate in the maintenance of the shelters. Most of the people said that they know nothing about the Shelter Management bodies; nobody cares about their opinion in this regard even there is no one to tell them about their responsibilities to maintain and take care of the shelters.

7.2.9 Usefulness of Cyclone Shelters and Effectiveness of Warning Dissemination

People showed positive attitude towards the effectiveness of Shelters and Warning Systems. Almost all the people replied that sheltering and warning could ensure more safety and awareness than previous times and thus contributed significantly in loss reduction. In addition some people opined that after 1991, no major cyclone has occurred in coastal region; existing systems might helping in low intensity disaster, but in case of any devastating occurrence it may not perform at all. That's why new options and more effectiveness are certainly expected to be well prepared to fight against inevitable natural disasters.

7.2.10 Applicability to Earthquake and Tsunami Disasters

The survey showed that existing sheltering and warning dissemination system is not sufficient to fight against cyclone in term of warning dissemination system. Moreover they are not planned on the basis of community requirements. On the other hand, earthquake occurs without any warning. Thus sheltering system is very important for post disaster rescue works. If the shelters are not designed considering seismic activities, the shelters themselves can be vulnerable to earthquake disaster.

Tsunami creates high tidal surges and thus causes devastating inundation. Warning system can play very important role against tsunami disaster since it takes time for water wave to reach the shore from the source of earthquake. The existing dissemination media can be used for tsunami but they need to be more effective and quick as the time span of disaster occurrence is very short.

7.3 Rural Rapid Appraisal

Rural Rapid Appraisal (RRA) is suitable for group level evaluation interview. It has been performed on focus-groups to collect more detailed information on the issues that are of greatest importance. This technique required the researchers to talk extensively and informally with rural people and to observe local conditions, while also making use of secondary information such as administrative records or information from institutions.

RRA is a process of learning about rural conditions in an intensive, iterative, and expeditious manner or any systematic activity designed to draw inferences, conclusions, hypotheses, or assessments, including the acquisition of new information, during a limited period of time. It characteristically relies on small multidisciplinary teams that employ a range of methodological tools and techniques specifically selected to enhance understanding of rural conditions in their natural context, with particular emphasis on tapping the knowledge of local inhabitants and combining the knowledge with modern scientific expertise but minimizing prior assumptions.

7.3.1 Development of Questionnaire

Objective of this research is to evaluate the effectiveness of the warning system from the view point of local community and hence to examine the potentiality of using those for earthquake and tsunami disasters. Two sets of questionnaire were developed for that purpose according to KII and RRA. By these questionnaires, the existing warning and sheltering system is evaluated based on the response to the local vulnerable groups. For earthquake and tsunami disasters, major concern is the time for receiving the warning and the time to reach the shelter after receiving of the warning, since the time lag between tsunami appearance and recognition of tsunamigenic earthquake is expected to be less. Thus, the issues of warning mechanism, time for warning and evacuation, medium used and effectiveness etc. were focused during development of questionnaires.

The questionnaires were developed in such a manner so that they become useful tools to judge the involvement of the community in the earthquake and tsunami preparedness program of the study area. Sample RRA in questionnaire form is shown in Table 8. The Questions of the survey was developed on the basis of the following considerations,

For warning system

- Coverage
- Acceptability
- Warning authority
- Media
- Easily understandable

For shelters

- Connectivity
- Security condition of the shelters
- Sustainability
- Capacity
- Comfortability

Table 8: RRA in questionnaire form

1. NwYSo Avkq‡K›` msjM GjvKvi Z_¨		
K. †gvU RbmsL¨v		
L. cwiev‡ii msL¨v		
M. eq¯‹ †jv‡Ki msL¨v		
N. cwZeÜxi msL¨v		
O. Aw`ewmi msL¨v		
P. agxq msL¨vjN		
mvgwRK		
K. GjvKvq wewfbœ †¯”Qv‡mex msMVb †hgb - Gb wR I, Kve, BZ¨w` wK ai‡bi KvR K‡i _v‡K?		
L. NwbSo-‡gvKwejvq GjvKvi m¤cwZ I cvi¯úwiK mn‡hvwMZv †Kgb?		
A_%bwZK		
K. GjvKvi gvbl †Kvb †Kvb †ckvi mv‡_ RwoZ (µgvbmv‡i)		
L. Av‡qi mn‡hvMx/weKí Av‡qi Drm wK wK?		
M. gwmK Av‡qi Dci wfwË K‡i gvb‡li †kYxfvM		
1000-2000	2000-4000	4000+
N. GjvKvi `wi` Rb‡Mvôxi mÂ‡qi Af¨vm Av‡Q wK? NwbSo †gŠm‡g Zvi v GB mÂq w`‡q wK KvR K‡i?		
O. GjvKvq wK e¨vsK/evRvi Av‡Q? NwYSo †gvKwejvq GB cwZôvb¸‡jv wK ai‡bi mn‡hwMZv K‡i _v‡K?		
AeKvVv‡gvMZ		
K. GjvKvi iv¯v-NvU †Kgb?		
L. ewo †_‡K Avkq‡K‡›` hvIqvi iv¯v KqwU?		
M. ewo †_‡K Avkq‡K‡›` †h‡Z RUjv nq wK?		
N. Avkq‡K‡›`i Ae¯v †Kgb?		
O. mvgwRK cwZôvb †hgb-¯‹j-K‡jR, gmwR`-gw›`i, Kve, evRvi weKí Avkq‡K›` wnmv‡e e¨envi Kiv nq wK?		
cwZôwbK		
K. ¯vbxq miKvi (BDwbqb cwil`/†cŠimfv) NwYS‡oi ms‡KZ cPvi, Zv cvj‡b wK K‡i _v‡K?		
L. e¨emvqx gnj, ivR%bwZK `j, mvs¯wZK msMVb, mgvR wn%ZIx e¨w³eM, NwYS‡oi ms‡KZ cPvi, Zv cvj‡b wK K‡i _v‡K?		
M. miKv‡ii †mev`vbKvix cwZôvb †hgb-Av¯v, wk¶v, cïm¤ú`, Kwl, BZ¨w` NwYS‡oi ms‡KZ cPvi, Zv cvj‡b wK K‡i _v‡K?		
2. Avcbvi v wKfv‡e NwYS‡oi ms‡KZ †c‡q _v‡Kb?		
3. †K ev Kviv Avcbv‡`i NwYS‡oi ms‡KZ †`q?		
4. Avcbvi v NwYSo AvNvZ nvbvi KZ¶b Av‡M ms‡KZ †c‡q _v‡Kb?		
5. ms‡KZ cvIqvi ci Avcbvi v wK K‡ib?		
6. Avcbvi v wK NwYS‡oi ms‡K‡Zi A_ †ev‡Sb?		
7. NwYSo mZK ms‡KZ cZvKv †Kv_vq Dov‡bv nq? cZvKvi A_ wK Avcbvi v †ev‡Sb?		
8. NwYS‡oi AvMvg ms‡KZ wKfv‡e cPvi Kiv nq?		
9. Mv‡gi mevB wK Avkq‡K‡›` hvq? hviv hvbbv Zviv †Kb hvb bv?		
10. NwYS‡oi ms‡KZ wK iKg n‡j ¶q-¶wZ Av‡iv Kg n‡e?		
11. fwgK¤ú/mbwg wK Avcbvi v Zv wK Rv‡bb? G m¤ú‡K wK Rv‡bb?		

7.3.2 RRA Data Analysis

The survey was conducted in different areas of the Cox's Bazar District such as Cox's bazar, Moheskhali-Hoyanak, Chokoria-Dulhazra, Teknaf, Ukhia, Kolatoli. Generally the authority of primary school which are used as cyclone shelter at the disaster moment was chosen in a random manner from the survey and whether they had proper knowledge about the community was ensured. But the authority of madrasa and other center were also surveyed. To fulfill the purpose of the survey aged persons were selected. Information about the area near the cyclone shelter was collected in this manner. Figure 12 shows volunteer conducting RRA and Figure 13 shows people's participation. A filled out RRA in paper format is shown in Figure 14. Sample database prepared based on RRA survey are given in Appendix B.

Figure 12: Volunteer conducting RRA

Figure 13: People's participation

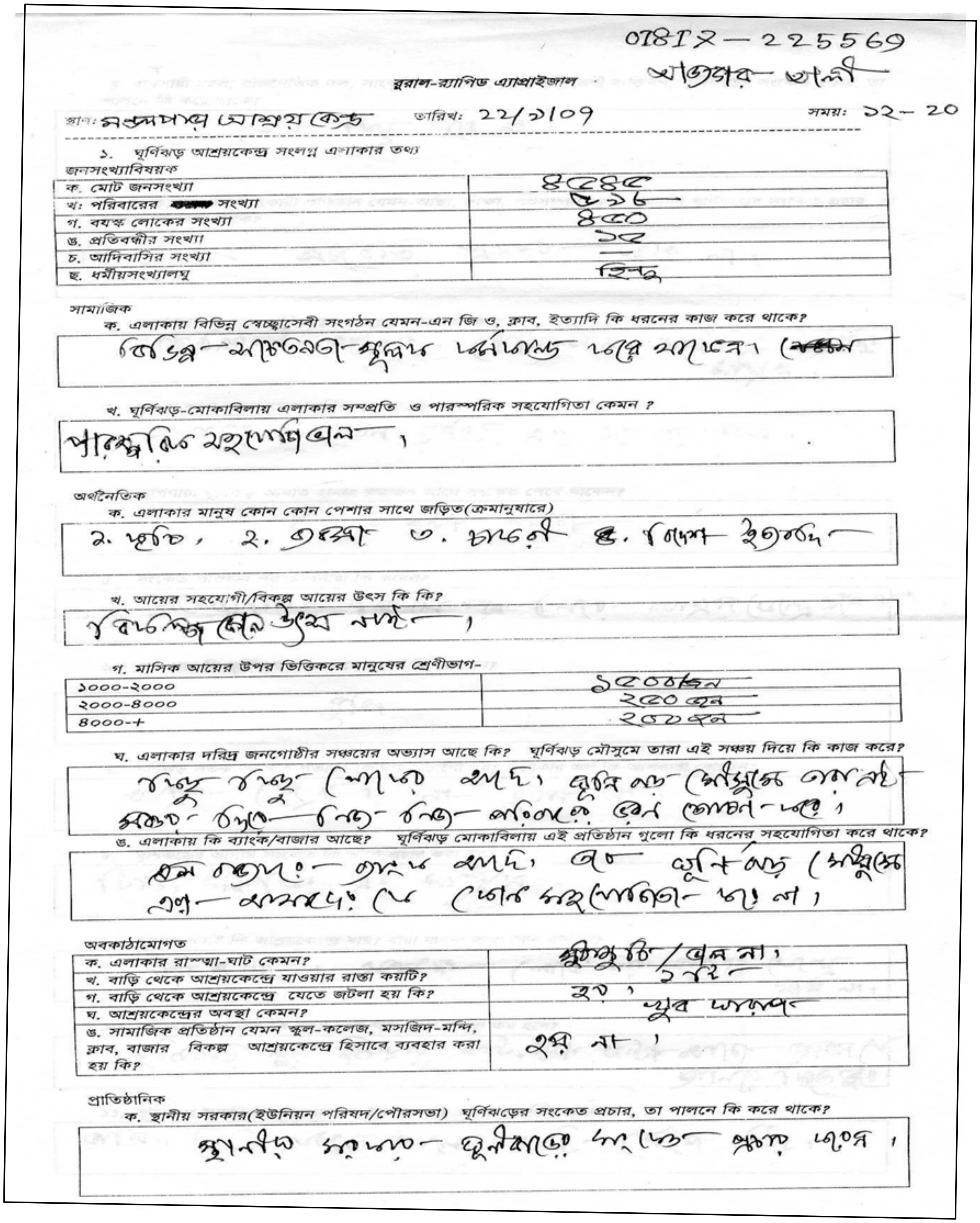


Figure 14: RRA in paper format

7.3.3 Local inhabitants near to the cyclone shelter

Total 241 filled out questionnaire from six locations in the district were considered for analysis and producing graphs. Table 9 shows the distribution of population near to the cyclone shelters in different areas. Figure 15 shows about 63.1% surveyed groups or community live in the total population range of 0-5000. Few communities were found particularly in Ukhia, Chokoria-Dulhazra and Moheskhali-Hoyanak having population above 10000.

Table 9: Population Distribution

Area	0-5000	%	5000-10000	%	10000+	%	Total	%
Cox's Bazar Sadar	45	76.3%	13	22.0%	1	1.7%	59	24.5%
Moheskhali Hoyanak	26	55.3%	16	34.0%	5	10.6%	47	19.5%
ChokoriaDulahazra	30	63.8%	12	25.5%	5	10.6%	47	19.5%
Teknaf	15	51.7%	13	44.8%	1	3.4%	29	12.0%
Ukhia	19	61.3%	8	25.8%	4	12.9%	31	12.9%
Kolatoli	17	60.7%	10	35.7%	1	3.6%	28	11.6%
Total	**152**	63.1%	**72**	29.88%	**17**	7.1%	**241**	100.0%

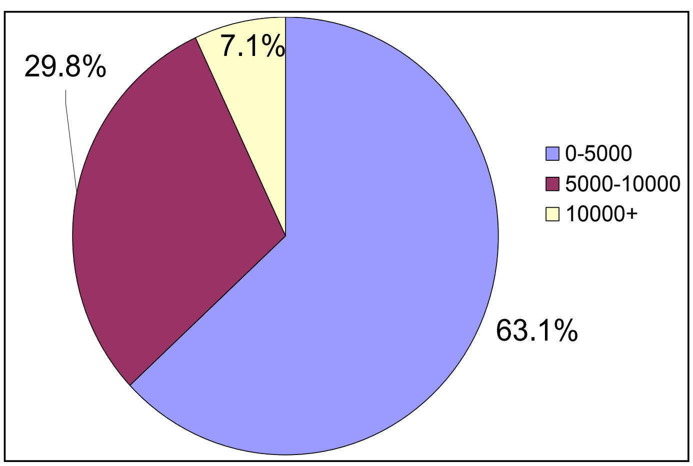


Figure 15: Population near to the cyclone shelter

From the survey it is found that most of the people get the warning sometimes before the occurrence. According to the data analysis 79.3% community get warning 0-8 hours before cyclone (Figure 16).

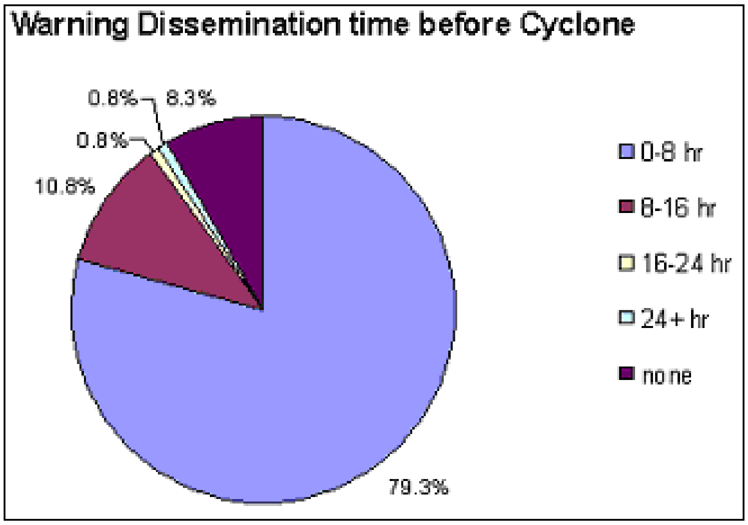


Figure 16: Warning Dissemination time before cyclone

The survey showed that warning is disseminated mainly by Hand-mic. Radio and TV are also used in this purpose where available. In some places flags are also shown to indicate the oncoming disaster. So an important thing arises here whether the people can understand the meaning of that dissemination of warning. Survey showed that people are acquainted with this type of dissemination. Most of the communities, about 81.3% (Figure 17) of the surveyed ones, have such an understanding that the higher the warning number the situation is more critical, though they are not clear about exact meaning of a particular warning number.

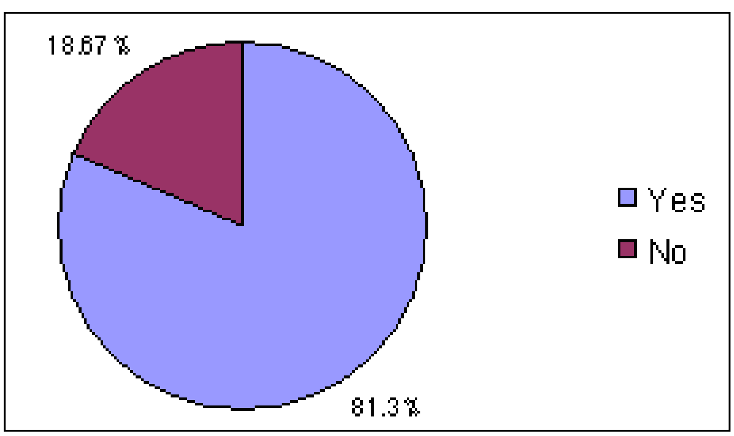


Figure 17: Understanding the meaning of warning surveyed

For the quick evacuation at disaster moment number of roadways connecting to the shelter and houses are very much important. If road transport system is not much more improved or not sufficient in number then it will take more time to get evacuated. Road side hazard would be caused if so and transfer of cattle and domestic animals to safer place would be difficult. Figure 18 shows that according to the responder's answer almost half of the surveyed community have only 0-2 connecting roads to the safer places, which is really an alarming fact for the disaster period.

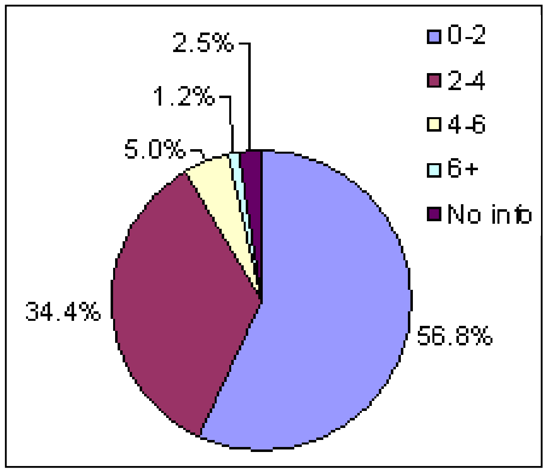


Figure 18: Number of roads connecting houses and shelters

There are a large number of shelters in Cox's Bazar area as mentioned earlier but people cannot use those when needed. Figure 19 shows that about 89% surveyed community do not go to the shelter. Their comments were also taken about the reason of not going there. Most of the people said that there was not sufficient space and other utilities like toilet, water, light and food. So it can be said that existing sheltering system is neither sufficient nor reliable to meet the present need. Figure 19 depicts the situation.

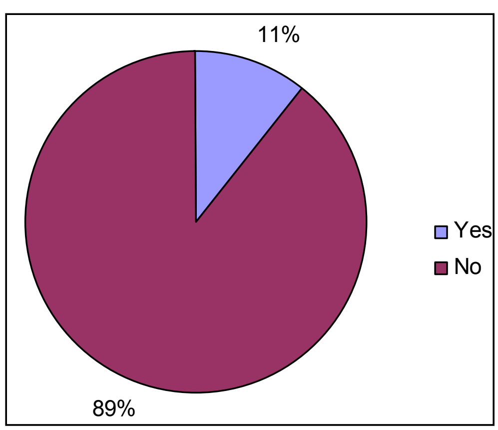


Figure 19: Utility of cyclone shelter at the disaster moment

7.3.4. Initiatives of Local Administration and Other Organization

In the coastal area local administration such as Pourosova, Union parishad take some necessary steps to warn the people. Usually they warn by Mic or using megaphone. Survey shows that they cannot cover all the area properly. About 19% (Table 10) of the surveyed groups are out of the coverage of the warning dissemination of the Local Administration.

Table 10: Role of Local Administration

	Yes	%	**No**	%	**Total**	%
Cox's Bazar Area	51	86.4%	8	13.6%	59	24.5%
Moheskhali Hoyanak	42	89.4%	5	10.6%	47	19.5%
ChokoriaDulahazra	36	76.6%	11	23.4%	47	19.5%
Teknaf	18	62.1%	11	37.9%	29	12.0%
Ukhia	25	80.6%	6	19.4%	31	12.9%
Kolatoli	24	85.7%	4	14.3%	28	11.6%
Total	**196**	81.3%	**45**	18.67%	**241**	100.0%

The contribution of other organizations such as cultural or political parties in warning dissemination is very poor. Table 11 below shows that 72.61% of the surveyed communities do not get any help from those organizations.

Table 11: Role of other Organization

	Yes	%	**No**	%	**Total**	%
Cox's Bazar Area	17	28.8%	42	71.2%	59	24.5%
Moheskhali Hoyanak	4	8.5%	43	91.5%	47	19.5%
ChokoriaDulahazra	15	31.9%	32	68.1%	47	19.5%
Teknaf	6	20.7%	23	79.3%	29	12.0%
Ukhia	3	9.7%	28	90.3%	31	12.9%
Kolatoli	21	75.0%	7	25.0%	28	11.6%
Total	**66**	27.4%	**175**	72.61%	**241**	100.0%

This situation is almost same in case of the different Govt. organizations such as health, education, agriculture existed there. Table 12 shows that 68.88% of the community surveyed do not get any help from them in disaster preparedness.

Table 12: Role of Govt. organization

	Yes	%	No	%	Total	%
Cox's Bazar Area	12	20.3%	47	79.7%	59	24.5%
Moheskhali Hoyanak	7	14.9%	40	85.1%	47	19.5%
ChokoriaDulahazra	16	34.0%	31	66.0%	47	19.5%
Teknaf	20	69.0%	9	31.0%	29	12.0%
Ukhia	6	19.4%	25	80.6%	31	12.9%
Kolatoli	14	50.0%	14	50.0%	28	11.6%
Total	**75**	31.1%	**166**	68.88%	**241**	100.0%

7.3.5 Role of NGOs

Survey showed that only NGOs work more actively at the time of disaster. Almost all of the communities surveyed get disaster warning by NGOs such as World Vision, Red Crescent etc. Effective steps like miking are taken by the NGOs. Flag is also shown at the vehicles which are used for the purpose of miking and at the office also.

8. Review of Tsunami Warning Systems

Issue of developing warning for tsunami has drawn attention after the 2004 tsunami at Sumatra that killed many peoples around the coast. Tsunami propagates at a speed of over 1000 km/hr, which may reach to the coast within few minutes to several hours. Tsunami warning involve following steps.

1. *Detection of Tsunami:* A network of sensors to detect earthquake and tsunami. For an earthquake generated tsunami, a tsunami forecast can be made based on the source of earthquake and the magnitude. An earthquake of sufficiently large magnitude on a tsunamigenic fault can only cause tsunami. While tsunamis travel at speeds of 500 to 1,000 km/h (around 0.14 and 0.28 km/s) in open water, earthquakes can be detected almost at once as seismic waves travel with a typical speed of 4 km/s. Thus there is a possible time for tsunami forecast to be made based on earthquake record and warnings to be issued to threatened areas. However, generation of the tsunami need to be confirmed

from measurment of sea surface elevation. Detection of earthquake and tsunami is a global phenomena and an International system would be involved with the detection.

2. *Dissemination of Warning:* A communication infrastructure to issue timely alarms to permit evacuation of vulnerable area. An International System involving earthquake and tsunami detection first disseminate warning to the vulnerable region. The Regional System then disseminates it to the vulnerable community. Thus International and a Regional system would be involved in the warning dissemination.
3. *Community Preparedness:* The vulnerable community needs to be prepared for the disaster in order to safeguard lives and properties and then minimize the loss. The preparedness may include sheltering system and community awareness and understanding. Thus the community preparedness is a Regional system where sheltering infrastructure to be developed in the region and awareness to be built among the local community.

8.1 Existing Tsunami Warning Systems

As discussed above the tsunami detection is initially based on earthquake wave measurement which is concurrently confirmed with measurements from tidal heights. The warning is then disseminated through the communication infrastructures. Thus, tsunami early warning systems are based on earthquake and tidal sensors, speedy communications, alarm networks and disaster preparedness training in vulnerable regions. Therefore, two distinct types of warning systems namely International Tsunami Warning System, responsible for detecting and monitoring tsunami and providing early warning and regional warning system, responsible for dissemination of warning and development of a preparedness program. International co-ordination of international tsunami warning system is achieved through the International Coordination Group for the Tsunami Warning System established by the Intergovernmental Oceanographic Commission (IOC) of UNESCO. International warning system covers those operated in Pacific Ocean, Indian Ocean and North Eastern Atlantic, the Mediterranean and connected seas.

8.2 Tsunami Warning in Pacific Ocean

Tsunami warnings for most of the Pacific Ocean are issued by the Pacific Tsunami Warning Centre (PTWC) and West Coast/Alaska Tsunami Warning Center (WC/ATWC), operated by the United States's National Oceanic and Atmospheric Administration (NOAA). PTWC, located in Ewa Beach, Hawaii was established in 1949, following the 1946 Aleutian Island earthquake and a tsunami that resulted in 165 casualties on Hawaii and Alaska. WC/ATWC located is in Palmer, Alaska and issues warnings particularly for the west coast of North America, including Alaska, Canada, and the western coterminous. It was founded in 1967 after the great Alaskan earthquake occurred in Prince William Sound on March 27, 1964. Both centers use seismic data as its starting point, but then take into account oceanographic data when calculating possible threats of tsunami. Tide gauges and tsunami detection buoys in the area of the earthquake are checked to establish if a tsunami wave has formed. The only early warning system to detect oncoming tsunamis existed in the Pacific region. There is also a Tsunami Warning Service, established in 1952, and run by the Japan Meteorological Agency (JMA). In case tsunamis are originated by seismic events far from Japan, JMA takes a coordinated action with the Pacific Tsunami Warning Center (PTWC) in Hawaii and issues forecasts for the long-propagating tsunamis.

8.2.1 Pacific Tsunami Warning Centre

The Pacific Tsunami Warning Center (PTWC), operated by NOAA in Ewa Beach, Hawaii, USA, is a tsunami warning system, overseeing international tsunami prediction and issuing warnings for the Pacific Ocean area. Area-of-responsibility of the Pacific Tsunami Warning Center consists of Hawaii, other U.S. interests in the Pacific Basin, countries participating in the Tsunami Warning System in the Pacific, and on an interim basin Indian Ocean and Caribbean Sea countries. It serves as the International Tsunami Warning Center for 25 member countries in the Pacific Ocean Basin.

Activities of the earthquake and tsunami warning scheme of the center include locating and sizing the earthquake; earthquake analysis and review; sea level data analysis to verify the existence of a tsunami and to calibrate models; and disseminating information to the appropriate emergency management officials. Seismic data is thus the starting point for generating the warning. NOAA developed the Deep-ocean Assessment and Reporting of Tsunamis (DART) system to monitor existence or nonexistence of a tsunami (Figure 20). Six of these buoys were deployed in the north Pacific by 2001. Thirty two more DART buoys are operational in the Pacific Ocean after the heightened awareness due to the tsunamis caused by the 2004 Indian Ocean earthquake. DART consists of a sea-bed bottom pressure recorder (at a depth of about 6000 m) which detects the passage of a tsunami and transmits the data to a surface buoy via acoustic modem. The surface buoy then radios the information to the PTWC via the GOES satellite system. The bottom pressure recorder lasts for two years while the surface buoy is replaced every year. The system has considerably improved the forecasting and warning of tsunamis in the Pacific.

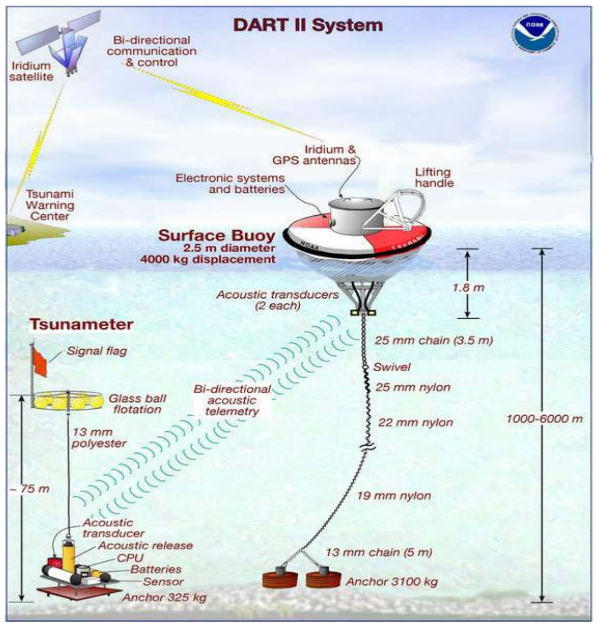


Figure 20: DART Buoy System (http://nctr.pmel.noaa.gov)

Tsunami bulletins are initially issued based solely on seismic data. Approximately 225 channels of seismic data are recorded at the center. Seismic networks which provide the data are operated and funded by many different agencies, including the United States Geological Survey (USGS), the Global Seismic Network, the National Tsunami Hazard Mitigation Program, various universities throughout the country, other national networks, and by the tsunami warning centers. Access to this data is provided through dedicated circuits, private satellite networks, and the internet.

Once a significant event has occurred, the nearest tide gages and deep ocean tsunami detectors, DART, are monitored to confirm the tsunami, and its degree of severity. The center has access to more than 200 tide sites and 15 DARTs throughout the Pacific and Atlantic Basins. Figure 21 shows the locations of DART in the Pacific Ocean. Figure 22 shows the other DART station owned by different countries. In addition, the Canadian Hydrographic Survey, and the Japanese Meteorological Agency provide sea level information to the center.

According to the seismic data, Pacific Tsunami Warning Centre will issue the following type of bulletins:

Tsunami Information Bulletin: When it is broadcasted it means though a threat exists, there is no evidence that a tsunami is making its way across the Pacific.

Tsunami Watch: PTWC has determined the earthquake may very likely have created a tsunami and is advising parties to be alert as PTWC awaits tide data to support tsunami generation.

Tsunami Warning: PTWC observed serious conditions to issue immediate concern to parts of the Pacific.The message will include approximate arrival times for various parts of the Pacific.

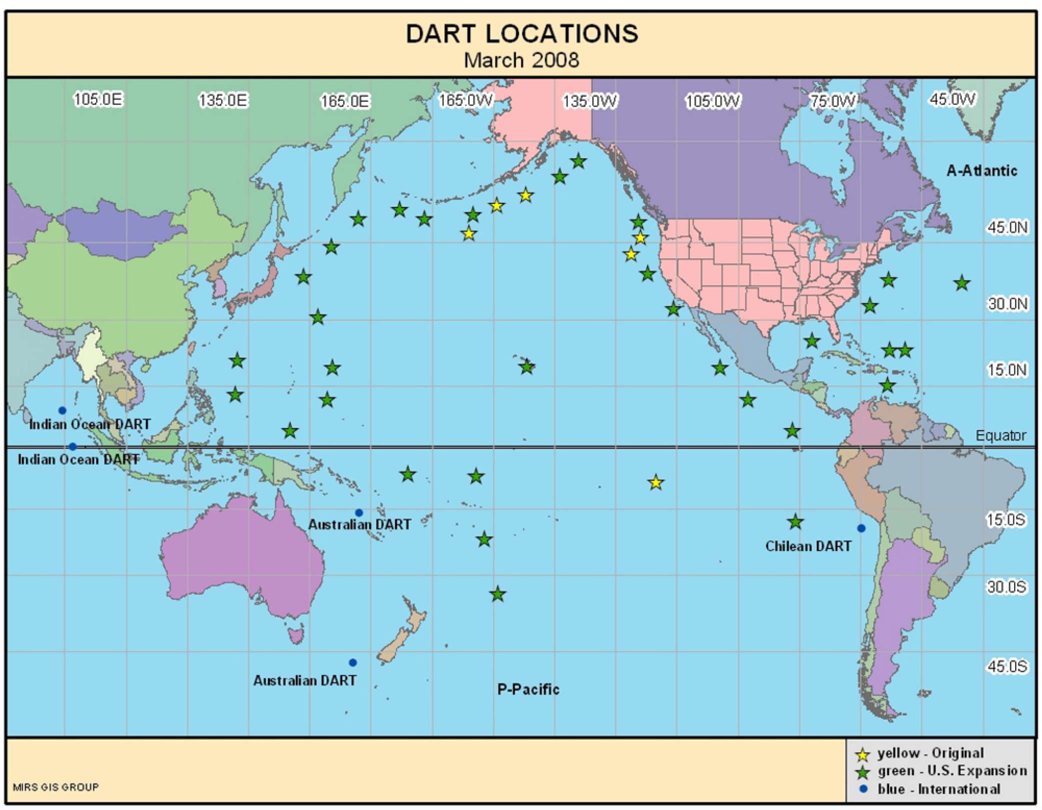


Figure 21: Location of DART in the Pacific Ocean (http://nctr.pmel.noaa.gov/Dart/)

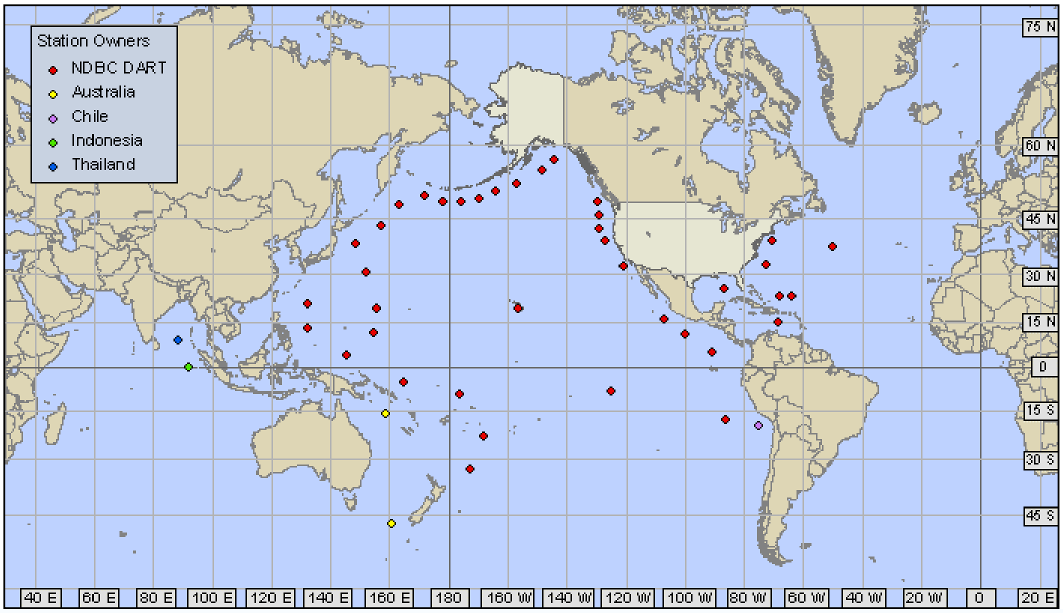


Figure 22: DART Station owners (http://www.ndbc.noaa.gov/dart.shtml)

8.2.2 West Coast & Alaska Tsunami Warning Center

The West Coast/Alaska Tsunami Warning Center in Palmer, Alaska monitors for earthquakes and subsequent tsunami events. If a tsunami is generated, they issue tsunami watches and warnings, as well as tsunami information bulletins. The West Coast/Alaska Tsunami Warning Center area-of-responsibility (AOR) consists of Canadian coastal regions and the ocean coasts of all U.S. States except Hawaii. There are four basic types of messages issued by the WC/ATWC. These are defined below:

Tsunami Warning: The highest level of tsunami alert. Warnings are issued by the TWCs due to the imminent threat of a tsunami from a large undersea earthquake, or following confirmation that a potentially destructive tsunami is underway. They may initially be based only on seismic information as a means of providing the earliest possible alert. Warnings advise that appropriate actions be taken in response to the tsunami threat. Such actions could include the evacuation of low-lying coastal areas and the movement of boats and ships out of harbors to deep waters. Warnings are updated at least hourly or as conditions warrant continuing, expand, restrict, or end the Warning.

Tsunami Watch: The second highest level of tsunami alert. Watches are issued by the TWCs based on seismic information without confirmation that a destructive tsunami is underway. It is issued as a means of providing advance alert to areas that could be impacted by a destructive tsunami. Watches are updated at least hourly to continue them, expand their coverage, upgrade them to a Warning, or end the alert. A watch for a particular area may be included in the text of the message that disseminates a Warning for another area.

Tsunami Advisory: The third highest level of tsunami alert. Advisories are issued by the TWCs to coastal populations within areas not currently in either warning or watch status when a tsunami warning has been issued for another region of the same ocean. An Advisory indicates that an area is either outside the current warning and watch regions, or that the tsunami poses no danger to that area. The Center issuing the Advisory will continue to monitor the event, issuing updates at least hourly. As conditions warrant, the Advisory will either be continued, upgraded to a watch or warning, or ended.

Information Statement: A text product issued to inform that an earthquake has occurred and to advise regarding its potential to generate a tsunami. In most cases, an Information Statement indicates there is no threat of a destructive tsunami affecting the issuing TWC's AOR, and are used to prevent unnecessary evacuations as the earthquake may have been felt in coastal areas. An Information Statement may, in appropriate situations, caution about the possibility of a destructive local tsunami. A supplemental Information Statement may be issued if important additional information is received such as a sea level reading showing a tsunami signal. An Information Statement may also be upgraded to a watch or warning if appropriate. Further, the Information Statement may be used to recommend a warning when protocols agreed to by emergency management authorities within an AOR so specify.

8.2.3 Japan Meteorological Agency

Six regional centres connected up to 300 sensors located across Japan's islands, including around 80 water-borne sensors, monitor seismic activity round the clock. If an earthquake looks as if it has the potential to trigger a tsunami, the JMA issues an alert within three minutes of it being identified. The alerts are broadcast on all radio and TV channels, and if necessary an evacuation warning is also given. Using data from its seismographs and buoys in the Indian Ocean, Japan's Meteorological Agency also fax to Sri Lanka and Singapore information on quakes bigger than magnitude-7 and possible tsunami within 30 minutes of the initial tremors.The JMA aims to give people in the path of the wave at least 10 minutes' warning to evacuate the area. Local authorities, central government and disaster relief organisations also get warnings via special channels so they can respond to a disaster swiftly.

JMA's network can predict the height, speed, and destination and arrival time of any tsunami destined for Japanese shores. JMA's seismological network consists of about 180 seismic stations. The seismic data are transmitted on a real time basis by the dedicated telephone lines to the JMA headquarters and centers in each District Observatory. Transmission lines are connected between neighboring centers to share the earthquake data. This network allows for continued monitoring and analyzing of earthquakes, even if part of the network would be damaged by a large earthquake. By using the seismic network and processing computers, earthquake location and magnitude are determined quickly after detection of the earthquake.
A database of the relationship between earthquake occurrence and tsunami arrival based on about 100,000 cases of computer simulation is prepared for tsunami forecast around Japan (the quantitative tsunami forecast system).

When a large earthquake occurs, the database is searched using the location and magnitude of the earthquake as indices, and the stored heights and arrival times of tsunami along the coasts are read out, for the issuance of tsunami warning for individual 66 tsunami forecast blocks in the Japanese coastal area.

In case of an earthquake occurrence, JMA analyzes the earthquake observational data and quickly issues tsunami warning, if necessary. The warning is automatically transmitted to disaster management authorities and broadcasting media. The earthquake and tsunami information including tsunami warning is used as a trigger of evacuation and urgent operation for rescue and mitigation of disasters. Figure 23 shows observational network in Japan.

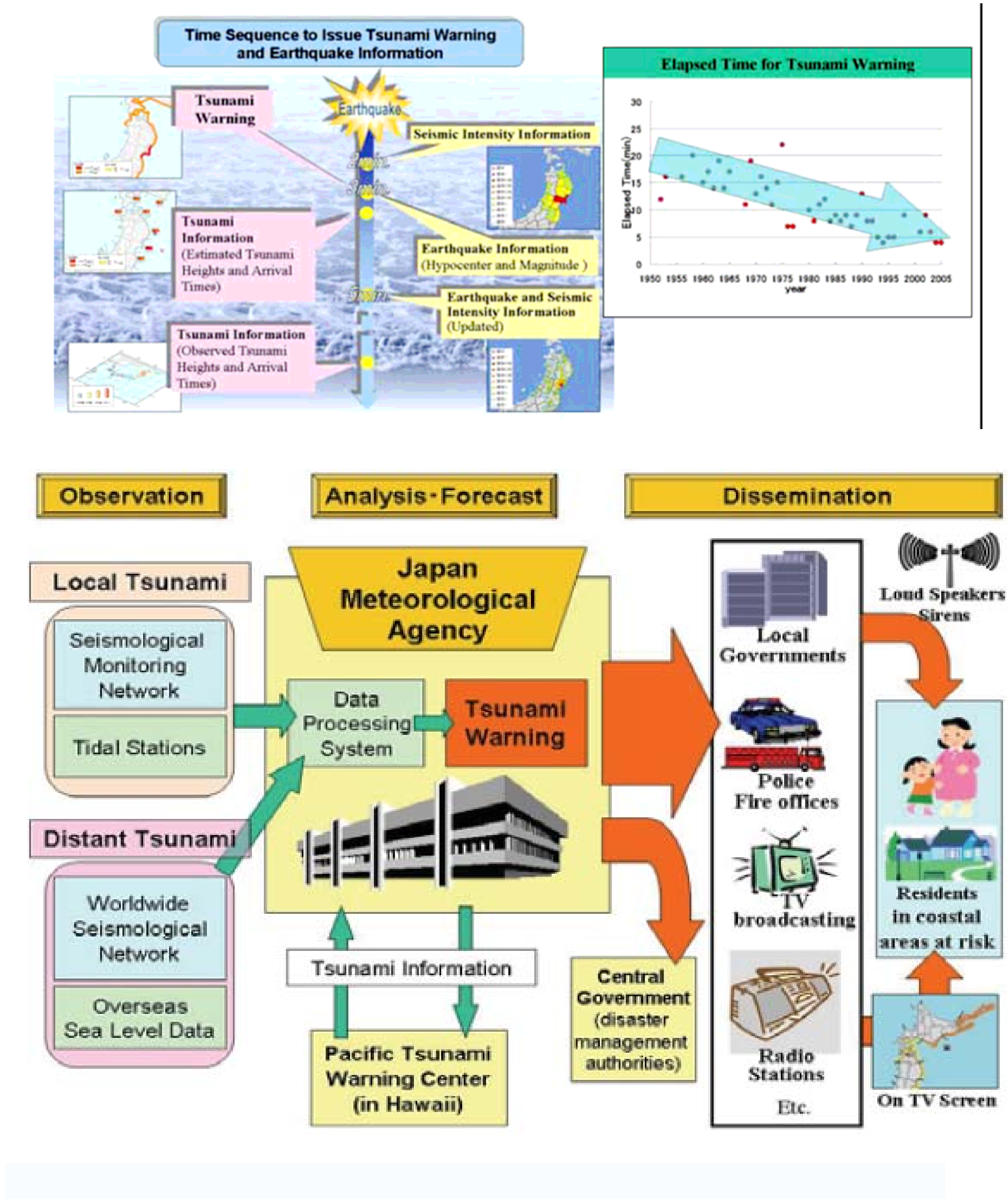


Figure 23: Observation Network and Transmission of Tsunami Warning in Japan

(http://www.jma.go.jp)

In case of an earthquake occurrence, JMA analyzes the earthquake observational data and quickly issues tsunami warning, if necessary. The warning is automatically transmitted to disaster management authorities and broadcasting media. The earthquake and tsunami

8.3 Indian Ocean Tsunami Warning System (ICG/IOTWS)

The Indian Ocean Tsunami Warning System is a tsunami warning system set up to provide warning to inhabitants of nations bordering the Indian Ocean of approaching tsunamis. It was agreed in a United Nations conference held in January 2005 in Kobe, Japan as an initial step towards an International Early Warning Programme.
The system became active in late June 2006 following the leadership of UNESCO. It consists of 25 seismographic stations relaying information to 26 national tsunami information centers, as well as three deep-ocean sensors. However, UNESCO warned that further coordination between governments and methods of relaying information from the centers to the civilians at risk are required to make the system effective.

Eighteen months after the tragic tsunami of December 2004, the entire Indian Ocean region has a warning system capable of receiving and distributing tsunami advisories around the clock by the end of July 2006. This initial system will be capable of improved and faster detection of strong, tsunamogenic earthquakes; increased precision in the location of the epi- and hypocentres of earthquakes; confirmation of the presence of a tsunami wave in the ocean after a strong earthquake; issuing a ‘tsunami watch’, ‘regional watch’ or a ‘global tsunami ocean warning’; and calling off ‘tsunami watches’ and ‘regional ‘tsunami watches.”
Twenty-six out of a possible 28 national tsunami information centres, capable of receiving and distributing tsunami advisories around the clock have been set up in Indian Ocean countries. The seismographic network has been improved, with 25 new stations being deployed and linked in real-time to analysis centres. There are also three Deep-ocean Assessment and Reporting of Tsunamis (DART) sensors. The Commission for the Nuclear-Test Ban Treaty Organization (CTBTO) is also contributing data from seismographic stations.

At present, information bulletins are issued from Japan and Hawaii, pending a final decision on the location of regional centres in the Indian Ocean. This will be facilitated when important additional contribution including instruments such as deep-sea pressure sensors and satellites become available in late 2007 and 2008.

8.4 Tsunami Warning in North Eastern Atlantic, the Mediterranean and connected Seas (ICG/NEAMTWS)

Warning systems are also being established in the North East Atlantic, Mediterranean and Adjoining Seas, and the Caribbean. Protection is also being reinforced in the South West Pacific and the South China Sea.

Tsunami Warning System (TWS) in Russia was organized in 1958, six years after destructive tsunami of November 4, 1952. Two departments are responsible for the TWS functioning: 1) Federal Service for Hydrometeorology and Environment Monitoring and 2) Geophysics Service of Russia Academy of Science (RAS). Russia Far East TWS consists of three Regional Services: Sakhalin, Kamchatka and Primorye Services. At the present stage of development of a science is not obviously possible to predict an earthquake but after one's occurring to some probability a tsunami generation is predictable.

In Sakhalin Region the TWS consists of Tsunami Warning Center (TWC) and Seismic Station of RAS Geophysical Service, both located in Yuzno-Sakhalinsk. The TWC's primary objective is to provide timely tsunami warnings, all clears and information to the people and organizations and also studying of tsunami phenomenon. The seismic station is responsible for Tsunami Warning issuance in case of near source quakes when epicentral distance is up to 3000 km from Yuzno-Sakhalinsk while TWC issues warnings based on tsunami information after occurring of major quakes in the Pacific with distance of more than 3000 km.
Issued Tsunami Warning transmits to Civil Defence and Emergency Regional Headquarters and to Central Telegraph Station of Yuzno-Sakhalinsk. TWC personnel after an occurred earthquake computes tsunami arrival times for Sakhalin and Kuril Isls coastal places, then determines danger ending, issues all clear in all cases.

In accordance with international agreements in case of emergency Sakhalin TWC cooperates with TWC abroad. Sakhalin TWC prepares for Regional Emergency Commission information about expected and real conditions after occurred underwater earthquake and information about intensity and consequences of major quakes occurred on land.
For the period of 1958 - 1998 in Sakhalin and Kuril Isls there were registered 42 tsunami, 34 of them were generated in near-source zone (Kuril-Kamchatka Trench, Japan and Okhotsk seas) and 8 - in distant regions of the Pacific.

Tsunami waves are generated not in all cases of occurring of major earthquakes near coast but considering that generation probability is high, Tsunami Warning are issued always when magnitude is greater or equal threshold (for the Kuril-Kamchatka Trenh, Japan and Okhotsk seas threshold is 7.0).

9. Development of Regional Warning System

It is revealed with reference to the tsunami warning system in Indian Ocean that Information bulletin on potential hazards are issued to the Indian Ocean countries including Bangladesh from Japan and Hawaii. However, final decision about the warning and preparation is pending on the regional countries. Thus development of a regional system for each country would be required for a disaster preparedness program.

9. 1 Concept of Operations

Anderson (2006) reviewed different aspects of a regional system required to make the disaster preparedness as effective. Three steps have been identified for an effective disaster preparedness program of a regional system as follows:

1. Reception and authentication of external hazard event and warning information by monitors located at the Disaster Risk Management Center and dissemination to targeted communities specially equipped with Hazard Information technologies. The activities of Disaster Risk Management Centre are:
    - Receiving an Event of Interest (EOI);
    - authenticating/Confirming the EOIs with a Center Executive
    - constructing a Message for the communities
    - Relaying the message to Hazard Information devices in designated communities
2. Reception and authentication of messages by the Guardians in communities equipped with hazard information devices and dissemination.
3. Community response according to the message after receiving of the warning message

9.2 Community preparedness

Community preparedness is a very important part of a disaster preparedness programme where community should understand the message disseminated to them and should be able to respond according to the message. Following training activities is recommended for a community for disaster preparedness:

- hazard mapping
- resource mapping
- risk assessment and
- identification of vulnerable households and groups of people in the community

- Creating awareness of the early warning mechanism in place and the response activities that need to be undertaken;
- Enabling the identification of appropriate dissemination mechanism to vulnerable households;
- Enable formulation of a response plan, which includes an evacuation plan with clear actions, roles and responsibilities and identify resources needed;
- Instill the competency to conduct an evacuation drill which is comprehensive;
- Provide the ability to measure the effectiveness of response plans carried out as simulations.

9.3 Hazard Information Devices in Srilanka

Five different Information and Communication Technologies (ICTs) were reviewed to evaluate their suitability in varied settings for "last mile of a national disaster warning system" for Sri Lanka (Anderson, 2006). The ICTs are shortly discussed below.

CDMA Fixed Wireless Phones:

The CDMA fixed wireless phones provide standard dial-tone voice phone services and are very useful, especially in rural areas that have limited or no wire-line services. They are relatively fast and dependable, portable and can be easily re-located. Further, usage requires little or no training. But they are vulnerable to congestion during periods of high intensity of traffic that may be generated by people's responses to the disaster.

Mobile Telephones-Cell Broadcasting:

Cell broadcasting uses an existing function of cellular networks which allows a text message to be broadcast to all cellular phones of a particular operator in a given geographical area. It places a very low load on the network and also impervious to network congestion. It can support multiple channels for different message types and can be activated remotely by the network operator.

Addressable Satellite Radio (ASR):

ASR supports a variety of functions including text alerts, both short and extended, audio broadcasts of unlimited length, geographical, individual and group based message targeting. Further, because the receivers' signals are fed from a geostationary satellite, and receivers can be DC battery operated, ASR can operate independently of local or national infrastructure. However, programming and loading message content into the system is still dependent upon having a reliable Internet connection.

VSAT-Internet delivered web/e-mail bulletins:

Internet access delivered to users in remote areas is possible with Very Small Aperture Terminal (VSAT) technology that uses a satellite connection as a high-speed digital link between the user and the Internet backbone. VSAT is a relatively robust and reliable communication link which is available at a reasonable cost.

Amateur Ham Radio:

During the Indian Ocean tsunami that destroyed electricity and communication infrastructure in the Andamans & the Nicobar islands, amateur ham radio amateurs were the critical link between the islands and the Indian mainland and helped in the coordination of rescue and relief operations.

Although CDMA and GSM technologies are available in Bangladesh but they are liable to challenges, especially due to network jam in emergency situation. Considering the challenges faced in Srilanka and the suitability for Bangladesh, the system with Addressable Satellite Radio appeared the most efficient one for deploying in Cox's Bazar Bangladesh.

9.4 Addressable Radio for Emergency Alert (AREA)

Addressable radio for emergency alert is a technology, where, Digital satellite delivers signals into small and low cost receiving equipment that is very handy. The devices are deployed in public remote areas for awareness and preparedness. Worldspace Corporation has developed a new radio which is called Addressable Radio for Emergency Alert (AREA). There is a siren connected through a relay, which is activated when an alert is received. The AREA can be also be used for infotainment of the community during non-hazard times the system gets integrated to the daily lives of the community.

The receiver which is called DAMB-R2 is a low-memory radio with a small display and limited processing power. DAMB-R2 features dual channel reception, one of the channels always being a data channel called OAAC (Over Air Activation Channel). Through the OAAC channel the alert provider can send an alert message. DAMB-R2 has the capacity to monitor the alert, validate the message and perform the action. The action is generally to activate a relay for a siren, turning on/switch to WorldSpace channel for audio messages, displaying text regarding the alert and delivering a file to a computer connected to the unit. DAMB-A2 which is a variant of DAMB-R2 incorporates all the functionalities of DAMB-R2 and is usually connected to the USB port of a computer. Figure 24 shows the overall schematic.

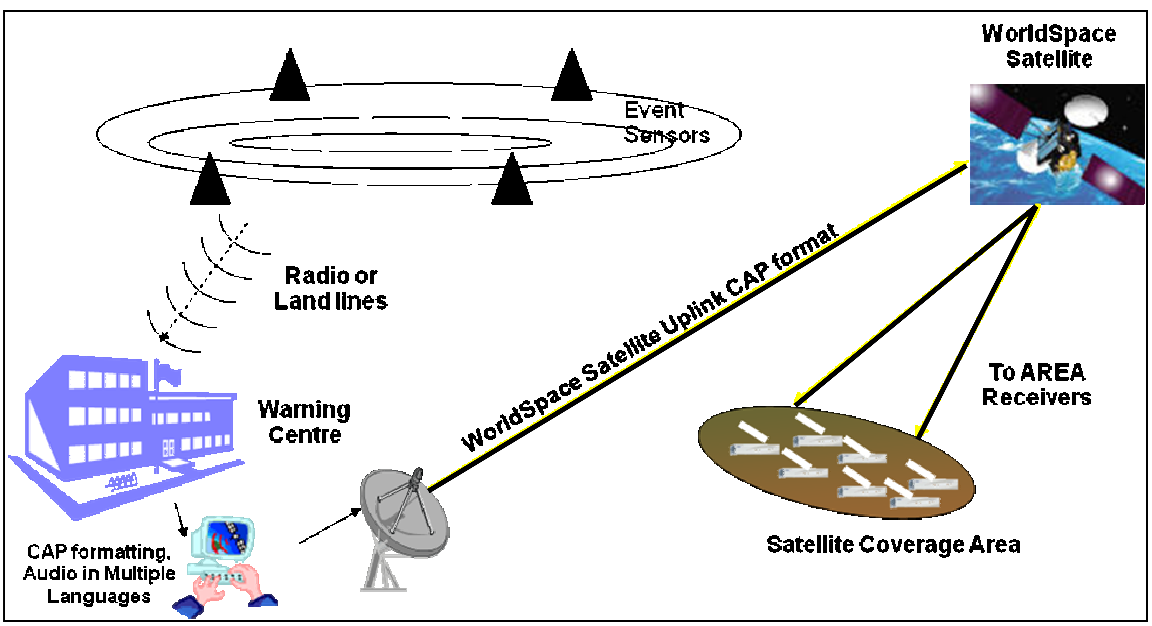


Figure 24: Schematic of WorldSpace Satellite System (Rangarajan et el., 2006)

An unobstructed path from the satellite to the receiver antenna is required in order to receive a clear signal from the satellite. The receiver antenna is positioned directly under the satellite. Radio Line of Sight (RLOS) is then assumed to exist between the satellite and the receiver antenna. The receive configurations in AREA is adaptable to the needs and conditions of the location where the service is intended. There are three different types of configurations. These are described as follows:

AREA-A

In AREA-A configurations a special satellite modem which is called DAMB-A2 is connected to an USB port of the computer. At normal non hazard times, AREA-A delivers various channels of audio to play out on the computer, and can provide the pipe for downloading multi-media digital contents of relevance, such as agricultural information, health information, and education, to the communities. A computer system with Pentium II processor and Windows operating system is required. The onset of alert is decoded by AREA-A which, in turn, activates a series of alarms and announcements on the computer. The alert generating software has the provision to automatically tune to any desired channel; this feature is available for switching to the datacast channel of WorldSpace to enable downloads.

AREA-M

Another configuration of the system is AREA-M that has a GPS receiver connected to DAMB-R2 with an external box. AREA-M can also be placed on any vehicle, including fishing boats. These units receive power from the vehicle and play the audio in its speaker system. When an alert signal is initiated by the proper agency the same receiver will sound an alarm, display the alert parameters and switch the audio to a different channel where more specific information can be provided. By using the GPS signal fed to AREA-M, the alert deliver can be restricted to those receivers that are located within the risk zone identified by the agency responsible for generating the alert.

AREA-C

AREA-C configurations are suitable for a fixed location, with public address for the community. Figure 24 shows the system. In this configuration, the rechargeable battery provides immunity to the loss of AC power at the alert-instant. The automatic remote activation of the siren provides the capability to alert the community over long distances, typically one km. Besides the textual display and their updates, the radio plays the special alert audio channel to provide authentic information to the community.

The different configurations of the AREA solution are shown in Figure 26.

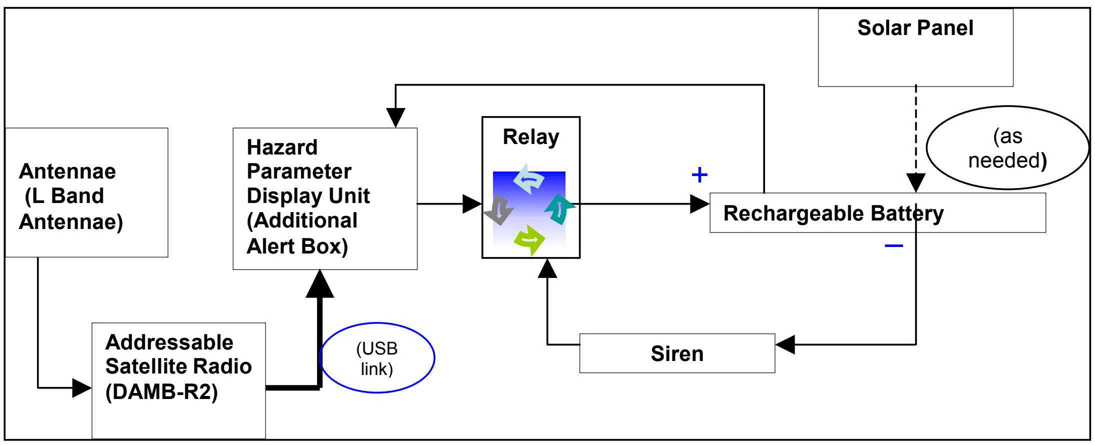


Figure 25: AREA –C Configuration (Rangarajan et al., 2006)

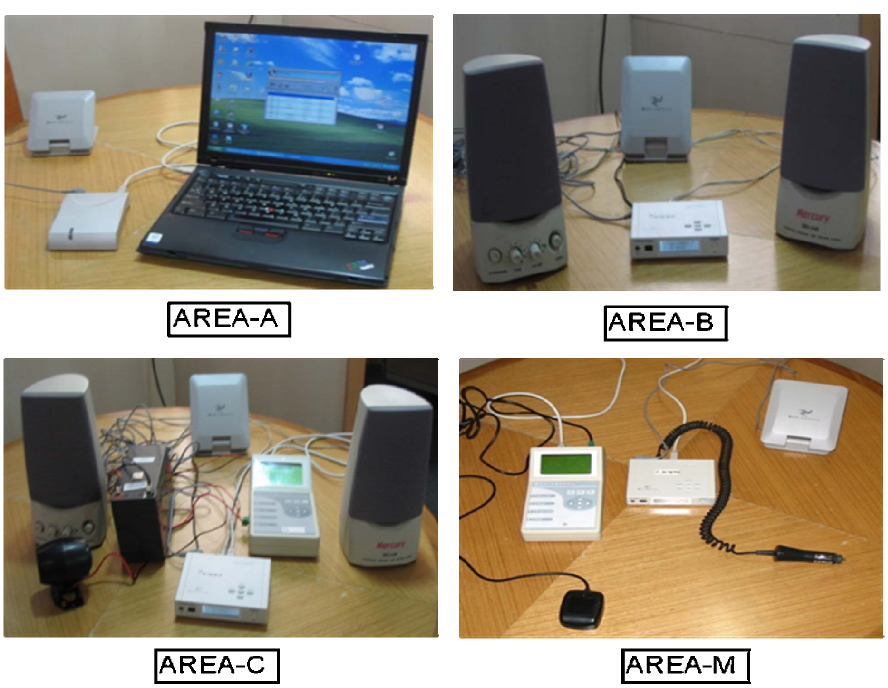


Figure 26: Different Configuration of the AREA solution

9.5 Operation

When an emergency message is to be communicated the authority after due process of validation start broadcasting messages and feed contents to the AREA C and AREA M receivers. The radio will automatically switch its channel to a special channel and start relaying the broadcast message and also display the alert parameters.

Once the alert is recognized by the receiver, an audio alarm is generated. In AREA-C configurations, it closes a relay which activates the siren which can be heard over a radius of typically 1 km. In contrast, AREA-A provides a computer generated warning signal, while AREA-M uses a buzz for drawing the attention to the alert. After the cancellation of the message all AREA receivers will switch back to its original mode. The AREA receiver has a provision to automatically switch on itself on the special broadcast, even if it is in an off mode (i.e. music not playing for any reason), and sound the alarm. A User's Manual for the receiving and broadcasting of messages has been provided in Appendix C.

9.6 Installation of AREA in Bangladesh

For installation of AREA C receivers it was found appropriate and secured place in Government Administration offices i.e. Upazila administration offices. Eight AREA C receivers were handed over to the Project Implementation Officer at eight Upazilas of Cox's Bazar district, one to the District Relief and Rehabilitation officer and another one to the Chairman of the Saint Martin's Island.

10. Earthquake Warning

Although Seismologists all over the world have agreed that earthquake prediction will not be available very soon, efforts have been made for developing earthquake warning after occurrence of earthquake but before reaching the effects to the vulnerable area. In case of an earthquake energy radiates outward in all direction.

This energy travels through and around the earth as three types of seismic waves defined as follows:

1. Primary Wave
2. Secondary Wave
3. Surface Wave

Figure 26 shows the waves formed after an earthquake.

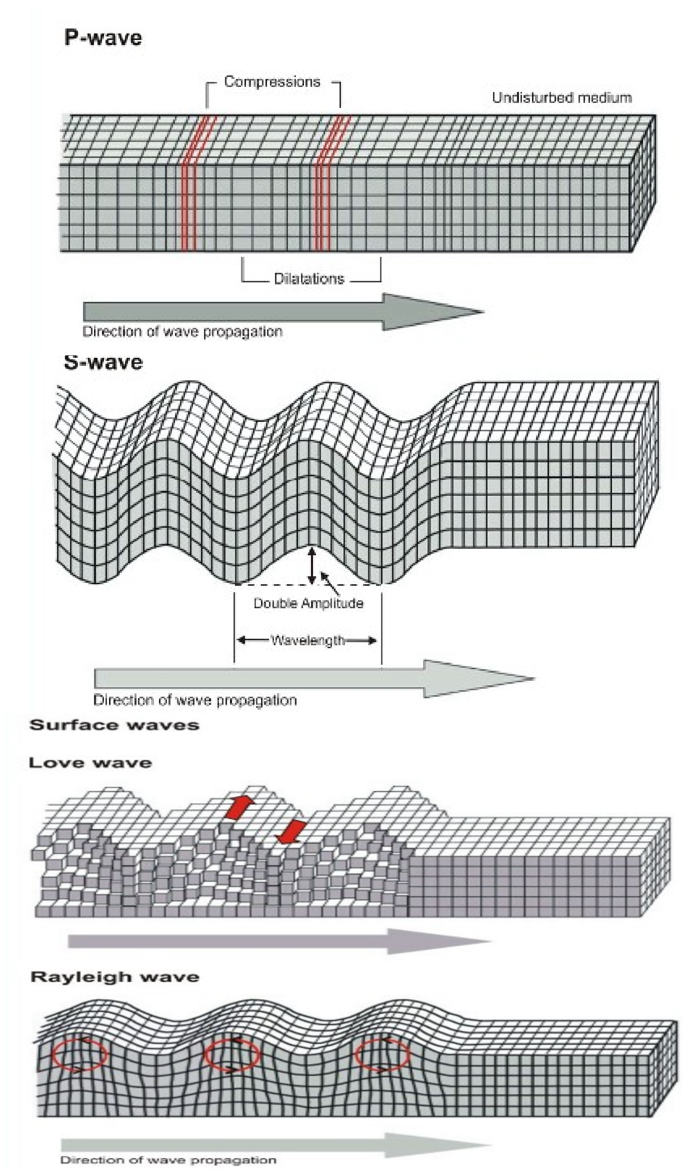


Figure 27: Different Types of waves (Kramer S.L., 1996)

P Waves

This is the fastest kind of seismic wave. The typical travelling time is 1.68 times faster than S-waves and 2 to 3 times faster than the Surface-waves, which typically travel at about 3.7 km/s. Thus for every 8 km travelled there is a one second separation between the P and S waves. S waves travel about 4 km/s faster than surface waves.

The P-wave can move through solid rock and fluids, just like the water or the liquid layers of the earth. It travels by pushing and pulling the rock just like sound waves. In a earthquake prone area there is a comment of the people that before an earthquake animals behave unusually. Actually animals can sense the P wave and express the coming danger with unusual behavior.

S Waves

Secondary waves (this is also called shear waves) can travel through solids, but they cannot travel through liquids. The energy of an S-wave travels through the earth as a sequence of up-and-down vibrations perpendicular to the surface of the earth. The particles vibrate in all directions, North-South and East-West. Its velocity is between that of P-waves and that of Surface waves.

Surface Waves

This is the slowest and by far the most destructive of the three types of seismic waves. Surface waves travel along the surface of the earth as two types of waves such as Love waves and Rayleigh waves. These waves roll along the ground just like a wave rolls across a lake or an ocean.

Thus if we can detect the P wave, earthquake warning will be possible. Devices shown in Figure 27 are developed based on this principle. The devices can detect the P-wave and gives alarm, allowing evacuation time before the S-wave hit. However, earthquake alarms have not proven safety against large earthquakes.

Figure 28: Earthquake Warning System (http://www.lamit.ro

11. Summary

The objective existing Warning Dissemination System and Cyclone Shelters of Cox's Bazar, Bangladesh have been evaluated in this project with a goal to develop an effective Regional Warning Dissemination System for Cox's Bazar District. The study revealed that even though the existing cyclone shelters in the country are insufficient to accommodate the huge population at risk, the shelteres can be used for cyclone and tsunami hazards. Time to reach to the most of the shelters is 15 to 30 minutes. However attention is required on connectivity, accessibility and security during disaster period.

The existing early warning dissemination system has been successful in reducing loss of lives and properties. However, there is a scope for improvement of the system from the view point of the community. The Flag-based warning is not always understandable to local community. Education among the communities through training program and revision of warning messages to include more specific information about the intensity, target area, evacuation time etc. would be helpful in this regard. A supplementary warning system is expected to improve the effectiveness and reliability of the system.

Considering the facts, an emergency early warning system, the WorldSpace Satellite System has been proposed and deployed in the study area on a pilot basis. This system appeared to be reliable and usable for multi-disaster approach. It is able to disseminate warning in different forms and the information delivered can be chosen on the basis of the requirement of the different risk zones. It can disseminate warning to remote areas where other networks of information transfer often fail.

The findings of the research thus expected to be a milestone on the way to ensure the success of community preparedness program for disastrous regions of the country and contribute significantly in reducing losses.

LIST OF REFERENCES

Anderson, P. (2006). Last of the Mile Hazard Warning System (LM-HWS) ICT Assessment and Community Simulation Observation report. LirneAsia, Colombo, Srilanka.

Asia tsunami warning system ready, BBC News, 28 June 2006

B.B.S. (2001). Bangladesh Bureau of Statistics, (Udin and Yasmin, 2005)

CPP and BDRCS, (2002). Cyclone Preparedness Program, Bangladesh Red Crescent Society, 2002

http:// www.crisscross.com

http://www.enviortech.org

http://www.jma.go.jp

http://www.noaa.gov

http://nctr.pmel.noaa.gov/Dart/

http://www.ndbc.noaa.gov/dart.shtml

http://www.lamit.ro

Indian Ocean Tsunami Warning System up and running, UNESCOPRESS, 28 June 2006

Kramer, S. L. (1996), Geotechnical Earthquake Engineering, Prentice Hall, Inc., Upper Saddle River, New Jersey, Chapter-2, Page 19-20

L.G.E.D. (2003). Local Government Engineering Department, (Udin and Yasmin, 2005)

S. Rangarajan, Jerome Soumagne and Jean-Luc Vignaud, 2006. Addressable Radios for Emergency Alert (AREA): A WorldSpace Solution for Effective Delivery of Alerts

Uddin, A. M. K. and Yasmin, A. (2005), "District Information-Cox's Bazar", Water Resource Ministry, Water Resource Planning Organization, People's Republic of Bangladesh Government

UN plans interim tsunami warning system that could be running almost at once, UN News, 31 January 2005