Ground Based Search and Rescue Operation during Cyclone Hazard in the Coastal Area of Bangladesh: A Disaster Management Perspective

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Abstract: *Bangladesh is frequently hit by many natural disasters, which cause tremendous damages to lives and properties. During severe cyclone in the coastal areas, timely and effective emergency response i.e., relief works and search and rescue (S&R) operations conducted by ground workers are greatly hindered due to the inaccessibility to the hit area. Sometimes it takes several days to gain access to some of the hardest-hit areas. On the other hand, aerial surveillance for S&R operations is also unsatisfactory due to lack of resources as well as of modern technologies. This paper discusses the existing approaches and associated problems of S&R operations during emergency response phase in the context of Bangladesh. Particular attention is given to the limitations of the spatial information acquired through conventional aircraft or satellite system. The limitations of such spatial information are evaluated in terms of temporal and spatial resolutions that are required for S&R operation. Finally, this research proposes a new tool for acquiring and processing geospatial information. Such tool is intended for strengthening ground-based emergency response which could be effectively utilized for timely and planned response.*

Keywords: Natural Hazard, Disaster Management, Emergency Response, Search & Rescue

1. DISASTERS IN BANGLADESH

Bangladesh is frequently hit by disasters, particularly cyclones, floods, landslides, and drought. The country's tropical monsoon climate is influenced by the Himalayan, the Assam, and the Burmese mountain ranges in the north and the northeast and the Bay of Bengal in the south. The strong monsoon rains, coupled with Bangladesh's location in the delta of the world's second largest river basin, make it extremely vulnerable to recurring floods. In addition, the country's approximately 710 kilometers of coastline leave huge tracts of land open to the destructive effects of cyclones and storm surges [1]. Figure 1 and Figure 2 shows the flood and cyclone prone areas in Bangladesh respectively.

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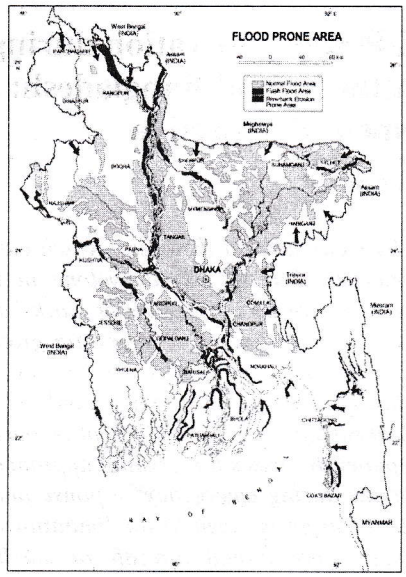

Fig. 1: Flood Prone Area of Bangladesh

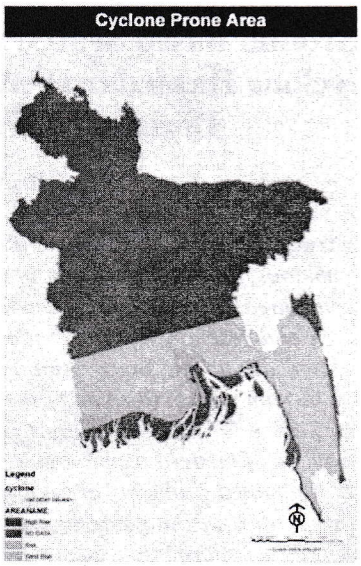

Fig. 2: Cyclone Prone Area of Bangladesh

Source: Disaster Management Bureau, Bangladesh

Bangladesh is one of the worst sufferers of all cyclonic casualties in the world. The high number of casualties during tropical cyclone is due to the fact that the cyclones are always associated with storm surges. It damages lives, properties including crops and infrastructure etc. Table 1 provides a list of devastating cyclones; their characteristics and casualties:

Table 1: Bangladesh Cyclone in Chronological Order

Date and Year	Maximum Wind Speed (km/hr)	Storm Surge Height (m)	Death Toll
May 11, 1965	161	3.7-7.6	19,279
November 12, 1970	224	6.0-10.0	300,000
May 25, 1985	154	3.0-4.6	11,069
April 29, 1991	225	6.0-7.6	138,882
November 15, 2007	223	6.1-9.1	3363

Source: Bangladesh Meteorological Department, 2007

Satellite data are used to monitor formation, intensity, and movement of cyclones in the Bay of Bengal. The accompanying storm surges can also be predicted from this data. Based on such information, an early warning system has been developed, which effectively reduces damage to lives and property [2].

2. PHASES IN DISASTER MANAGEMENT

Disaster Management is a set of actions and processes designed to lessen disastrous effects either before, during or after a disaster. The phases of disaster response are illustrated in figure 3 and are discussed below [3]:

Preparatory Phase: This phase includes all of the activities that help a society and the disaster agencies to prepare for a disaster event. Activities that are carried out include organization, legislation, and development of procedures, inventories of resources and establishment of response plans. These activities are broadly classified as disaster prevention, mitigation and preparedness. The objective of prevention is to prevent the disaster from occurring. Disaster mitigation accepts the fact that some natural events may occur, but it tries to lessen the impact by improving the community's ability to absorb the impact with minimum damage or disruptive effect. Disaster preparedness assumes that a disaster will occur; it focuses on structuring the emergency response and on providing a framework for recovery.

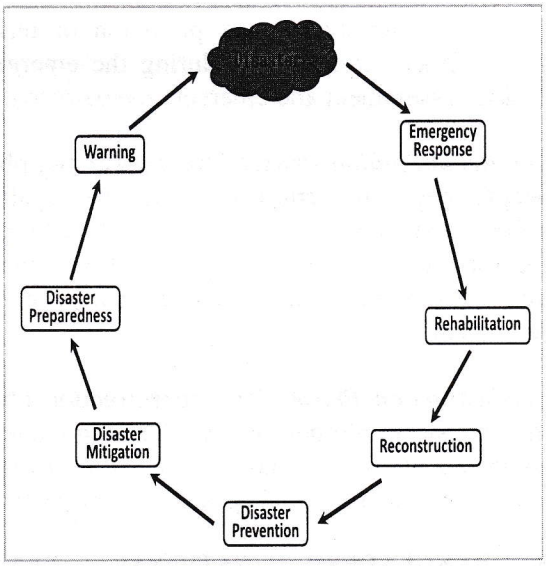

Fig 3: Disaster Management Cycle

The Warning Phase: Most disasters are preceded by a period of time during which it becomes obvious that something hazardous is going to

happen. By monitoring events, the specialist look for indicators that tell when, where and what magnitude the event may be. This is known as prediction or forecasting. The objective is to provide disaster managers with enough information so they can give the people at risk adequate notice or warning to prepare for the disaster and if necessary to evacuate. At the present time, warning is possible for droughts and famines, cyclones and most severe weather phenomena, volcanoes, large scale fires, and in some cases earthquakes [4].

The Emergency Phase: This phase of disaster response involves actions that are necessary to save lives and reduce suffering. These include search-and-rescue, first aid, emergency medical assistance and restoration of emergency communication and transportation networks. Some disasters also necessitate evacuation from areas still vulnerable to further disaster events and provision of temporary shelter, food and water. Other actions taken during the emergency phase include initial disaster assessment and emergency repairs to critical facilities.

The Rehabilitation Phase: This transitional phase is a time period when people begin to return to work, to repair infrastructure, damaged buildings and critical facilities and to take other actions necessary to help the community to return to normal. Emergency relief measures must be discontinued during this phase so that people can begin to regain their self-reliance.

Reconstruction Phase: The reconstruction phase of a disaster involves the physical reordering of the community and of the physical environment. During this period people reconstruct housing and other community facilities and agriculture returns to normal.

3. BANGLADESH NATIONAL PLAN FOR DISASTER MANAGEMENT

The objectives of Bangladesh Government (GoB) for proper handling of disasters, is to coordinate the efforts taken at different stages in disaster management cycle, space technology in disaster management, space technology in disaster prediction, warning and mitigation, and use of internet facilities for disaster monitoring, predictions and information dissemination, etc. [5]

3.1 DISASTER MANAGEMENT MODEL

GoB has created a simplistic model to guide disaster risk reduction and emergency response management efforts. The model (Figure 4) has three key elements and ensures that the move to a more comprehensive risk reduction culture remains central to all efforts.

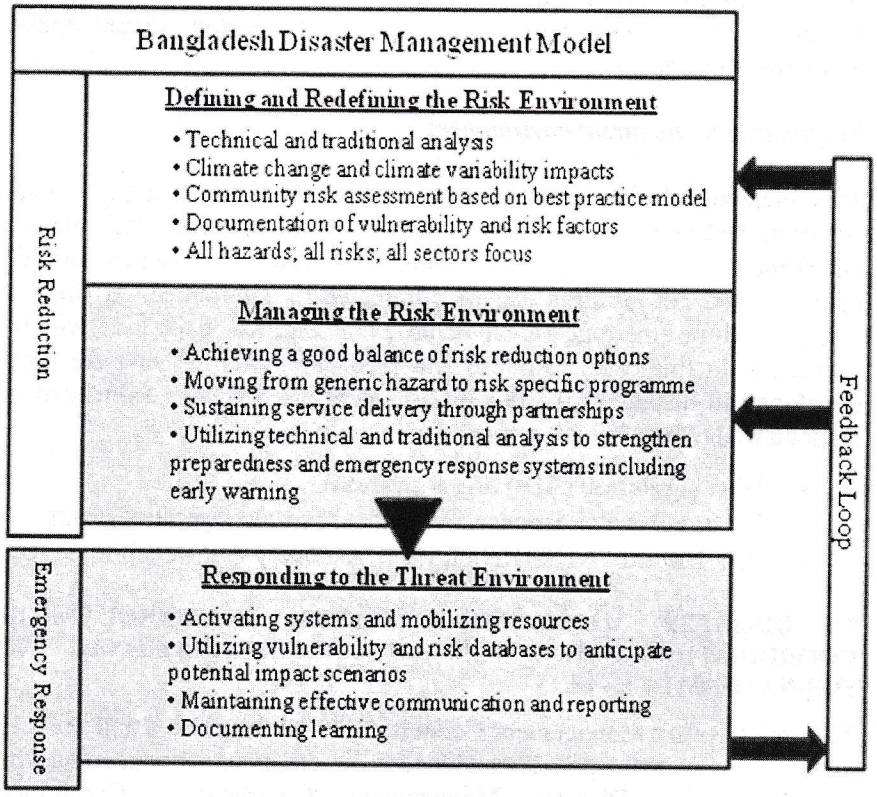

Figure 4: Bangladesh Disaster Management Model

Defining and redefining the risk environment

To develop actions for managing risk, the risk environment must first be defined, which provides the knowledge of the interaction of hazard and the elements at risk (community). In order to understand the interaction of hazards on communities, it is important to conduct a vulnerability assessment for the community.

Managing the risk environment

This element of the model promotes the design of risk reduction strategies (Community Based Adaptation Programmes) as an outcome of the risk assessment process. Managing the risk environment involves developing programs and strategies that eliminate, or reduce the level of risk. All activities undertaken to eliminate or reduce risk are "mitigation" strategies which includes activities such as Prevention, Preparedness, Response and Recovery.

Responding to the threat environment

This element of the model involves responding to an actual threat situation. Defining risk environments properly can influence and enhance emergency response systems and decisions. Not all hazards can be managed and not all risks can be eliminated or minimized. At times a response to an emerging threat or an event that has happened will be necessary. In this case, response and recovery systems that have been developed in managing the risk environment are activated as needed to respond to the threat. Such response may include:

- Warning Period (Alert and activation).
- Hazard Onset (Response, Search and Rescue Operation), and.
- Post Hazard Period (Relief, Early Recovery and Rehabilitation).

3.2 DISASTER MANAGEMENT SYSTEM IN BANGLADESH: COORDINATION AMONG VARIOUS AGENCIES (NATIONAL AND SUB-NATIONAL LEVEL)

National Disaster Management Council (NDMC) formulates and reviews disaster management policies and issues directives to all concerned, the Inter-Ministerial Disaster Management Coordination Committee (IMDMCC) plays key role in implementing the directives maintaining inter-ministerial coordination, supervising the services of the Armed Forces as well as NGOs working in the field of disaster management in the country. Under the mechanism there exists a well established organization named Directorate of Relief and Rehabilitation (DRR) within the administrative control of the Ministry of Disaster Management and Relief (MDMR) wherein Emergency Operations Center (EOC) is located. The DRR acts during post-disaster emergency situation and operates relief activities for distribution to remote field levels under the

supervision and guidance of MDMR and IMDMCC. The MDMR has a small dynamic professional unit, Disaster Management Bureau (DMB) which performs specialist functions and ensure coordination with line departments/agencies and. The DMB also helps EOC by extending technical support services through MIS/GIS for information exchange. In addition, the Cyclone Preparedness Programme (CPP) also plays very important role during and immediately before cyclone disaster by maintaining coordination with EOC, Bangladesh Meteorological Department (BMD), DMB, NGOs and others and extending direct help to the community people. Figure 5 shows the national and sub-national level governmental bodies engaged in disaster management and their coordination/interaction.

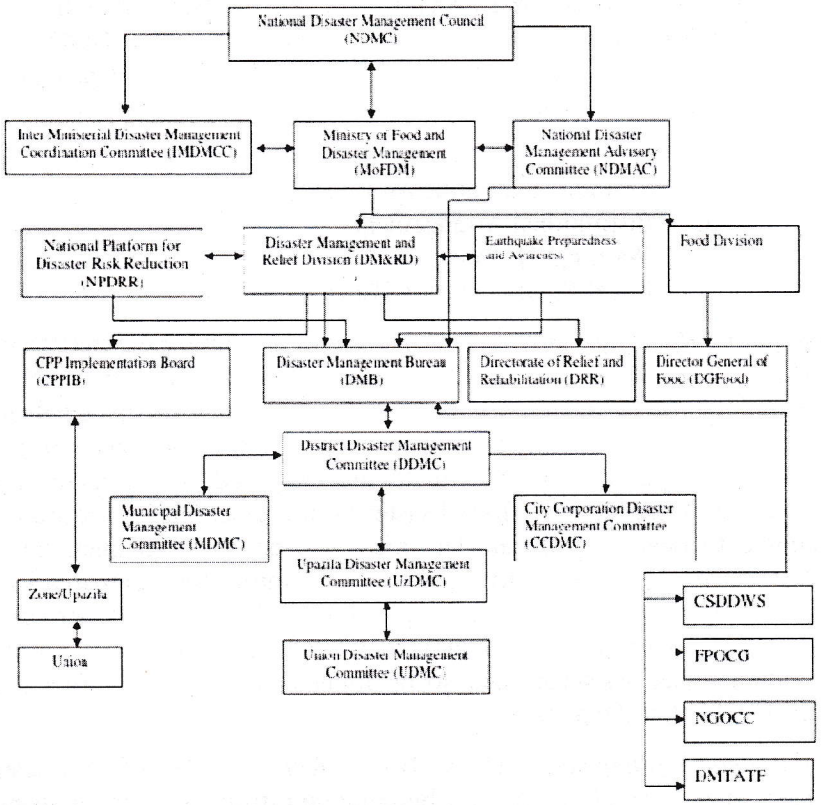

Figure 5: Coordination among various Disaster Management Institutions in Bangladesh

Source: National Plan for Disaster Management 2010~2015, MoFDM

3.3 DISASTER MITIGATION: ONGOING PRACTICE

GoB has given equal importance to both structural as well as non-structural mitigation measures keeping in view the aspect of better coordination within overall disaster management system. [4]

a) *Structural Mitigation*: As part of structural measures, the GoB with its own and external resources has so far constructed 1,841 cyclone shelters. Sluice gates and regulators on different rivers and canals as safety measures against inundation by tidal waves, storm-surges and flooding have been constructed.

b) *Non-structural Mitigation*: Non-structural mitigation practices pursued by the GoB focus on **i.** preparedness and possibilities for action to reduce risks and losses, and **ii.** better coordination mechanisms between all actors involved (GO, NGO and community people at the grass-root level) during all phases of disaster. Such practicing measures involve :

   i. Legislation, Policy and Plan
   ii. Training and Public Awareness
   iii. Institutional Arrangements
   iv. Warning Systems
   v. Local Disaster Action Plans

Legislation, Policy and Plan: The Act is aimed at establishing machinery working through the State and Local Governments and public corporations and providing for the formulation of disaster management plan and policy. The policy involves accurate definition of disaster threat, organizational arrangements which are required to prepare for, responding to and recovers from disaster events, assessment of resources available to deal with threat. The plan also covers both planning at normal times for aspects like prevention / mitigation, preparedness, response and recovery, and also planning for operational activities concerning mobilization and deployment of national resources, requests for international assistance and so on immediately before, during and immediately after the disaster.

Institutional Arrangements: The GoB has taken a number of significant steps during the last few years for building up institutional arrangements from national to the union levels for effective and systematic disaster management. Some of these steps are:

- Establishment of Council and Committees at the national, district, sub-district and union levels.
- Establishment of Emergency Operations Centre for information exchange during emergency period related to impending disaster.

The national level councils and committees are headed by different ministries and government bodies. The field level committees are established at district, sub-district and union level. These committees coordinate and review the disaster management activities at their respective levels.

Local Disaster Action Plan: An elaborated procedure is strictly followed for the preparation of Local Disaster Action Plans (LDAP). Disaster management Bureau of Bangladesh has prepared LDAP for most disaster prone 29 districts, 84 sub-districts, and 776 unions. The LDAP basically contains three parts. First part deals with union profile both narrative and simple sketch along with hazard and vulnerability. Second part contains formation of Disaster Management Committee (DMC) and its responsibilities. Final part has all the details of action plan including various volunteer groups (VG) and sub-committees for undertaking responsibilities like:

- warning dissemination and precautionary response;
- arrangements for evacuation;
- arrangements for rescue and casualty care;
- damage and needs assessment;

The LDAP has full participation of the local people and the communities. The main purpose is to mobilize local communities in the most disaster-prone areas to prepare and protect themselves and to increase their own capacities to cope with and recover from disaster without waiting for outside assistance.

3.4 STRATEGIC GOAL OF DISASTER MANAGEMENT FOCUSING ON EMERGENCY RESPONSE (2010-2015)

The strategic goals of the National Disaster Management Plan (NDMP) are drawn from the SAARC Disaster Management Framework. These goals are well linked to the international and national drivers, so that the plan can articulate the long-term strategic focus of disaster management

in Bangladesh. The plan is expected to contribute towards the formulation of a road map for the development of strategic and operational plan by various entities. Some of the strategic goals, which focus on and are related to emergency response, are mentioned below:

a) *Strategic Goal # 5:* Expanding Risk Reduction Programming across hazards and sectors

Key Target: Update hazard maps such as flood, cyclone, drought, earthquake and tsunami.

Expected Outcome: Local and national development plans are developed on the basis of the updated hazard maps.

Action Agenda for 2010~2015: Conduct Hazard Risk Analysis and produce updated hazard maps.

b) *Strategic Goal #6:* Strengthening Emergency Response Systems

Key Targets:

- Establish and improve Search and Rescue mechanism by preparing a potential search and rescue scenario
- Strengthening S&R capability of first responding institutions by providing training and equipments support
- Establish an all hazard volunteer groups for S&R operations
- Establish an effective command and control system.

Expected Outcome

- An effective search and rescue mechanism to provide timely operations
- First Responding Institutions are fully equipped to efficiently handle the S&R operations
- A well-trained standby volunteer workforce to assist in S&R operations

Action Agenda for 2010~2015

- Identify potential rescue scenarios and determine appropriate search and rescue equipment needs

- Strengthen first responding institutions with required training and equipment support
- Establish and strengthen the community based institutional mechanism for disaster volunteering, such as CPP, Bangladesh Scouts etc.
- Develop and implement a training programme to establish the all hazard volunteer workforce at city corporations level
- Prepare Standing Orders (SODs) for specific hazard based disasters incorporating command, control and coordination mechanism for emergency response.

c) *Strategic Goal # 7:* Developing and Strengthening Regional and Global Networks

Key Targets:

- Establish public and private partnerships for disaster risk reduction.

Expected Outcome

- To create a working interface with and between the technical and scientific community

Action Agenda for 2010~2015

- Identify national disaster management players
- Establish formal and informal partnerships through signing of Memorandum of Understandings and Letter of Agreements

The above strategic goals, along with other goals are headed mainly by Disaster Management and Relief Division (DM&RD) and Disaster Management Bureau under Ministry of Food and Disaster Management (MoFDM) and various other ministries. The supporting agencies are various academic and research institutes, NGOs, CBOs etc. The NGOs work in close collaboration with government agencies in order to implement various strategic goals. In order to ensure efficient implementation of the goals and other common objectives, the NGOs work together in an integrated manner and as a result a strong network has been formed among the national and international NGOs in Bangladesh, which is mentioned in section 4.4.

3.5 COMPREHENSIVE DISASTER MANAGEMENT PROGRAMME (CDMP)

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

Community Empowerment program under the CDMP provides improved coordination between development oriented and disaster management aspects of Bangladesh government and NGO programmes. It activates the LDAPs as an essential organ of both Emergency Response and Community Mitigation. Failure to effectively implement the community empowerment program work would mean that the opportunity to enhance decentralized management will be lost.

The objective of the **Response Management** program under the CDMP is to establish and strengthen the capacity of the Disaster Management Information Center (DMIC), which will be achieved through the implementation of the following major activities:

- Development of an Information Strategy, identification of user(s), their information needs and DMIC information products.
- Mapping out main sources of information relevant to vulnerability and disaster management.
- Designing and dissemination of information products.
- Equipping DMIC with information-communication technology (ICT) capability to facilitate effective information management during normal and emergency periods.

3.6 CYCLONE PREPAREDNESS PROGRAMME (CPP)

Ministry of Food and Disaster Management (MoFDM), in association with the Bangladesh Red Crescent Society (BDRCS), is implementing Cyclone Preparedness Programmes (CPP) in the 12 coastal districts of the country to minimize loss of lives and properties in cyclone disaster by strengthening the disaster management capacity of coastal people of Bangladesh. Various aspects of CPP are discussed below: [6]

Goal: The goal of CPP is to minimize loss of lives and properties in cyclonic disaster by strengthening the capacity in disaster management of the coastal people of Bangladesh.

Objectives:

1. To develop and strengthen the disaster preparedness and response capacity of coastal communities who are vulnerable to cyclones.
2. To increase the efficiency of volunteers and officers. To maintain and strengthen the CPP warning system and ensure effective response in the event of a cyclone.

Activities: Following are some of the main activities of CPP

1. disseminate cyclone-warning signal to local residents;
2. Assist people in taking shelter.
3. Rescue victim affected by a cyclone, and provide first aid to people injured by cyclone.

Early Warning Mechanism of CPP

The CPP Dhaka office, located in the BDRCS National HQ Compound, receives, special weather bulletins containing cyclone warning signals from the Bangladesh Meteorological Department as soon as a depression is formed in the Bay of Bengal. The information is transmitted to the 6 Zonal Officers and the 30 Thana level Officers over HF Radio. The Assistant Directors, in turn, pass it to Unions through VHF Radio. Where VHF Radio has not yet been installed the message is passed on by a messenger. The Union Team Leaders contact the Unit Team Leaders immediately. The Unit Team Leaders with his Volunteers spread out in the villages and disseminates the Cyclone warnings, almost door to door, using megaphones, hand sirens and public address system. The Team Leaders at the same time keep track of the approaching Cyclone by listening to national radio broadcasts over the transistor radio. The Team Leaders are thus alerted and start work without losing time. The Volunteers keep on announcing the special weather bulletins on patterns of the approaching cyclone. When situation turns serious, the GOB passes order for evacuation. The Volunteers implement the order and advice and help people in taking shelter in cyclone shelters or other available safe places.

4.0 DISASTER RESPONSE BY DIFFERENT ORGANIZATIONS

Bangladesh Government (GoB) has adopted several tools for disaster response at different stage of disaster cycle. Satellite remote sensing helps to predict the path of the cyclone and based on such information an early warning can be disseminated to the concerned area. In case of severe cyclone as predicted by the satellite data, people can stay at the cyclone shelters constructed by GoB. Following the hit of the cyclone, Bangladesh Air Force (BAF) conducts aerial surveillance for quick damage assessment as well for search and rescue operation and relief distribution. Bangladesh Army and NGOs conduct search and rescue operation from ground with the aid of community involvement. International Organizations such as Sentinel Asia provides satellite images in case of major disaster for a specific region or member country. Disaster responses by different organization are described in brief in the following sub topics.

4.1 BANGLADESH REMOTE SENSING ORGANIZATION IN DISASTER

Since late 1960s, Bangladesh Space Research and Remote Sensing Organization (SPARRSO) have been implementing remote sensing technology for monitoring cyclones in Bangladesh. GMS (Geostationary Meteorological Satellites) and NOAA-AVHRR (National Oceanic and Atmospheric Administration-The Advanced Very High Resolution Radiometer) data are being used to monitor formation, intensity and movement of the cyclones in the Bay of Bengal. The accompanying storm surges are also predicted. Such information provides support in the preparatory phase or warning phase of the disaster management. Based on this information an Early Warning System has been established in the country. This system effectively reduces the damage to life and property [7]. Figure 6 shows the NOAA satellite images of super cyclone SIDR approaching to the coastal areas of Bangladesh.

Satellite images are also used for post-disaster assessment in Bangladesh especially for estimating the extent of damage in infrastructure or food crops. It is very helpful in the planning of rehabilitation process for the disaster victims. Figure 7 shows the extent of the area inundated by the storm surge accompanied by super cyclone SIDR in 2007.

4.2 EMERGENCY RESPONSE BY CPP

The smallest unit of CPP is individual village-based team and is called unit team. A union team leader is responsible for all the villages under that union and supervises all the respective unit team leaders. The size of

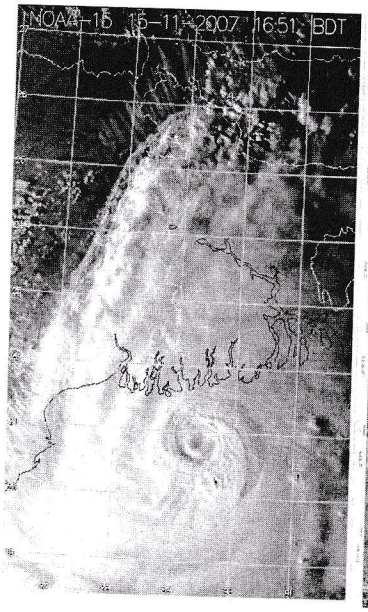

Figure 6: Path of Super Cyclone SIDR taken by NOAA, November 15, 2007
Source: SPARRSO, Bangladesh

Figure 7: SPOT4 NIR and SWIR Image of the Area Affected by Storm Surge of Super Cyclone SIDR, November 19, 2007
Source: Center For Satellite Based Crisis Information, DLR, Germany

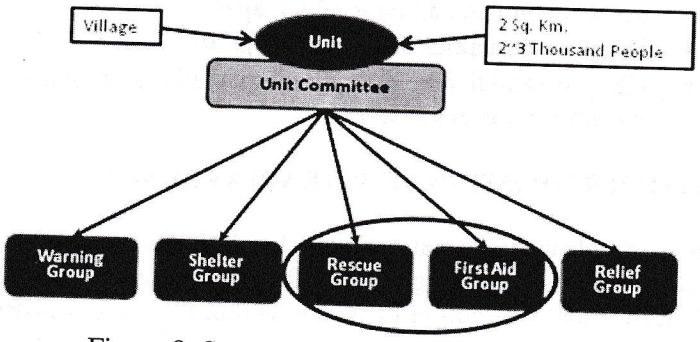

Figure 8: Structure of a Unit Team in CPP

the target area that each unit team has to cover is around $2km^2$ and number of vulnerable people in this area is around 2,000~3,000. The unit team incorporates the local community and each unit team has twelve members. This team has been assigned with specific duties such warning, shelter, rescue, first aid, and relief distribution. Figure 8 shows the structure of a unit team.

4.3 BANGLADESH AIR FORCE IN DISASTER MANAGEMENT

Bangladesh Air Force (BAF) plays a vital role in the disaster management. BAF for its command structure, trained manpower, capabilities is always in a better footing to make the fastest response in the hour of need [10]. The major roles in disaster management are as follows:

a) Pre Disaster Stage:
   - Preserve all up-dated charts of coastal areas, offshore coastal islands and disaster prone areas.
   - Keep all transport aircraft and helicopters in readiness for emergency flights.

b) During Disaster or Emergency Stage:
   - Keep a constant watch over disaster situation.
   - Undertake the rescue operation and to assess the damages due to cyclonic storm.

c) Post Disaster Stage:
   - Carryout aerial survey of the cyclone/flood affected areas, assess nature and amount of damages
   - Evacuate casualties to nearest hospitals.
   - Carry essential relief supplies especially food and drinking water to the affected areas

4.4 DISASTER RESPONSE IN REMOTE AREAS BY NGOS

There are a number of international and local NGOs working in close collaboration for disaster management in the remote areas of Bangladesh. Figure 9 shows the distribution of NGOs within the coastal districts of Bangladesh.

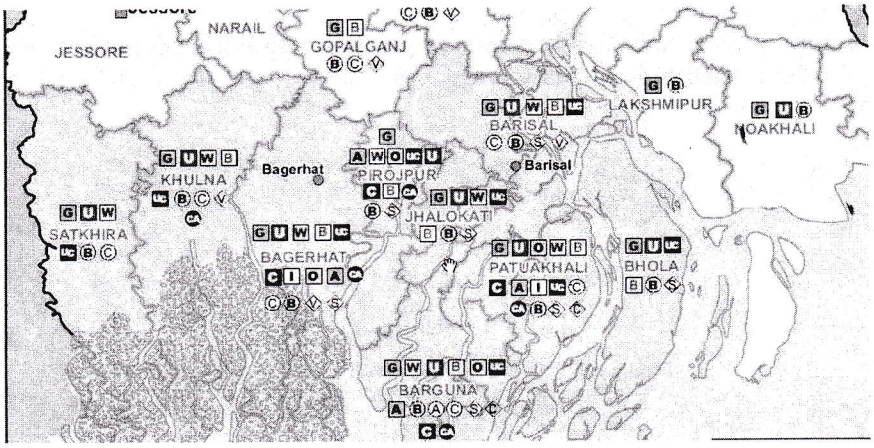

Figure 9: Distribution of NGOs in different Coastal District of Bangladesh
Source: VAM Unit, World Food Programme, Bangladesh

They involve the local community of the disaster prone area in order to accomplish the following tasks:

- Conduct public awareness and preparedness program.
- Convey the early warning signals to the locality.
- Search and rescue operation, and relief distribution during disaster.
- Rehabilitation and reconstruction of the community during post-disaster stage.

There is an open coalition among some of the NGOs who are working together as disaster management partners in the high risk areas of Bangladesh in order to reduce the risk of disaster on livelihood security of vulnerable household. In 1997, a network has been formed and called as NIRAPAD (Network for Information, Response, and Preparedness Activities on Disasters) [11]. Figure 10 shows the network of NIRAPAD with the partner NGOs.

The mission of this organization is to evolve as an effective, efficient network and resource centre in disaster risk management information, technology and training to build capable organizations and professionals in disaster risk reduction in Bangladesh. NIRAPAD, working closely with government organizations, shares the information on disaster situation, technologies, technical and resource persons, preparedness of

public, private and NGO sectors in disaster response and mitigations, disaster related support and services available.

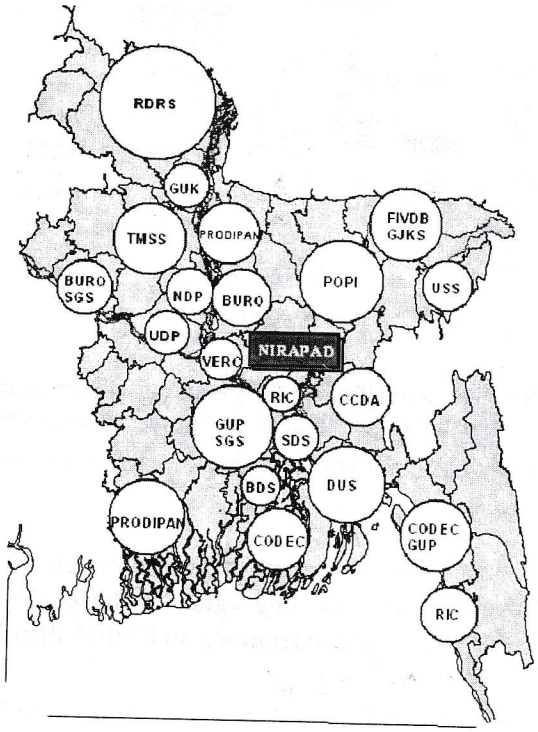

Figure 10: Network of NIRAPAD
Source: NIRAPAD, Bangladesh

4.5 INTERNATIONAL ORGANIZATION: SENTINEL ASIA

The Sentinel Asia is a voluntary and best-efforts-basis initiative led by the Asia-Pacific Regional Space Agency Forum (APRSAF), to use Remote Sensing information and Web-GIS data-delivery technologies to support of disaster management in the Asia-Pacific region. It also shares disaster information in the region using the Digital Asia (Web-GIS) platform to make the best use of earth observation satellites data for disaster management in this region [12]. APRSAF is originally designed to provide opportunities for regional space agencies and associated governmental bodies to exchange technical views, opinions and information on national space programs and space resources. Data Provider Nodes operate their own satellite reception facilities, and in some cases their own spacecraft, and therefore are tasked to process the

imagery they can collect in near real-time and make it available through the network. The respective users can access these using Web-GIS service with their country's more detailed GIS information. Such data are often used for early-warning or for post-disaster maps during recovery operations. Several satellites have been under operation, namely ALOS (Advanced Land Observation Satellite) of Japan, KOMPSAT (Korean Multi-Purpose Satellite 2) of Korea, THEOS (Thailand Earth Observation Satellite) of Thailand, and IRS (Indian Remote Sensing Satellite) of India.

5.0 PROBLEMS WITH EXISTING SEARCH AND RESCUE (S&R) OPERATION

Disaster response in Bangladesh is stronger and organized than ever before and it is improving day by day. Several modern technological approaches have been undertaken by the government in order to develop early warning system. The local and international NGOs are working in close collaboration with the governmental agencies for effective disaster responses. Figure 11 shows the cyclone prone areas in the coastal zones of Bangladesh. The marine and estuarine islands are severely affected, which are sparse and scattered throughout the coastal area, which is approximately 710km.

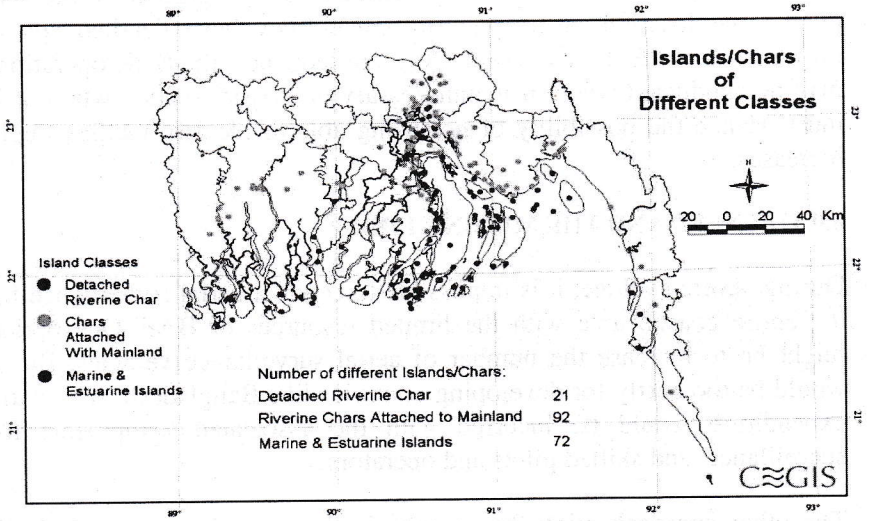

Figure 11: Marine and Estuarine Islands, Vulnerable to Severe Cyclone
Source: CEGIS, Bangladesh

One of the major tasks during the emergency response stage is to conduct search and rescue (S&R) operation for disaster victims. It is often crucial, in terms of saving lives, that the victims be identified and rescued as soon as possible. Only the Bangladesh Air Force (BAF) conducts aerial surveillance for S&R operations. The usual approach for this purpose is to use manned aircraft equipped for covering wide area with special sensors and to assign the actual recognition task (surveillance) to the crew. However, in the usage of manned aircraft, it is difficult to operate from low altitude. A binocular telescope is usually employed in the manned aircraft for the magnification to detect small targets from high altitude. In that case, the range of vision for searching becomes narrow and the possibility of oversight must increase [12]. Besides, BAF does not have sufficient number of helicopters for conducting S&R for the entire coastal area.

On the other hand, S&R operation from ground is conducted by NGOs and Bangladesh Military with the aid of community involvement. Different organization with their own accessories, works as different group in order to carry out their own disaster response activities. But these operations are often hindered and delayed significantly due to inaccessibility to the area caused by damaged infrastructure or due to the lack of resources. Also it is very difficult for the ground workers to predict the location of the victims unless they have detailed spatial information of the disaster scene. As a consequence, the S&R operations may be conducted where it is unnecessary or maybe omitted where it is must. Hence the possibility of not being able to identify victims might increases.

6.0 THE NEED AND THE MISSING LINK

During severe cyclone, it is impossible to conduct aerial surveillance for the entire coastal area with the limited resources of BAF. One option might be to increase the number of aerial surveillance vehicles. But it would be too costly for developing countries like Bangladesh. Also extra expenditure would be incurred with the associated equipments for surveillance, and skilled pilots and operators.

The other approach might be to provide the ground teams with detail spatial information about the disaster scene so that the search area can be narrowed down and if possible pinpointed. In that case, the rescue

commander would be able to allocate resources with more efficiency. And the success rate of search and rescue operations might increase. There has to be a means of acquiring spatial information before the rescue team can be dispatched. Aerial images can play a vital role in this case. The usual methods for acquiring aerial images are conventional aircraft or the satellite systems. But both of these systems have limited capability to acquire timely, detail and accurate imagery i.e., spatial information.

Mehrotra et al. (2004) mention that the objective of an imaging system for emergency response should aim to enhance the mitigation capabilities of the first responders in the event of a crisis by dramatically transforming their ability to collect, store, analyze, interpret, share and disseminate data [14]. The author discusses here the benefit of high resolution optical imagery acquired before and after the disaster, which can provide a 'quick look' for damage assessment, distinguishing areas of catastrophic damages and is extremely useful information in emergency response situations. The values of this "quick-look" imagery are largely dependent on the capability of the system to acquire imagery quickly enough to be useful to first responders in emergency situations [15]. The ability to obtain real-time imagery can be complicated by numerous factors. Green et al. (2003) pointed out that acquiring aerial imagery using conventional aircraft during a disaster can be difficult when there is a lack of suitable runways. Such situation might occur if the runway is damaged by the disaster or the disaster area is far away from a suitable runway [16]. Satellite systems can also provide imagery and have proven valuable in widespread disasters such as hurricane, flood, forest fire etc. In this regard Sentinel Asia responds very fast and provides satellite images of specific area upon request by the member countries during major disaster. Such images can be effectively used for post-disaster assessment, but unfortunately the spatial resolutions of these satellite images make them relatively ineffective for detecting disaster victims and therefore Search and Rescue operations as well. Since the highest spatial resolution that can be achieved with the available satellite (KOMPSAT, Korea) is 1m.

7.0 CONCLUSION AND RECOMMENDATIONS

On the basis of the above discussion, in order to strengthen the present ground-based S&R operation in the coastal areas of Bangladesh, the following needs are highlighted:

- A data acquisition tool which should be:
  - able to capture detail spatial information of the disaster area
  - affordable to individual group who conducts S&R operation
  - simple in handling and operable from within the disaster scene
  - fast and can be operated as on need basis
- A data processing and handling tool which should :
  - be able to create geocoded spatial information from the acquired data
  - be able to automate narrowing down the search area
  - provide visual inspection capability for disaster monitoring
- Effective coordination among the rescue team and the proposed tool in order to overcome the time constraint for effective S&R operations

The proposed system is intended to be developed in accordance with and to support the strategic goals (#5 and #6) set by the National Disaster Management Plan of Bangladesh. The future research work is therefore open for collaborative approach of multidisciplinary personnel. Teamwork among academicians, disaster manager, armed force personnel and technical personnel might provide best outcome of the future research.

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