Prospects of Using m-Technologies for Disaster Information Management in Bangladesh and other LDCs

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Abstract: *This paper explores the prospects of using wireless mobile technologies for disaster information management in Bangladesh. The basic objective of the paper is to give specific recommendations to relevant stakeholders, such as the government and the mobile phone service providers, as to how mobile technologies may be used effectively before, during and after a disaster. The first section of the paper gives an overview of the nature of the natural disasters that affect Bangladesh almost every year in varying degrees of intensity. The second section identifies some of the information and communication gaps before and after a disaster that make disaster management more challenging and somewhat ineffective. The third section introduces some of the relevant mobile technologies that may be used in Bangladesh and other similar LDCs. The fourth section establishes how these mobile technologies may be effectively used to address the information and communication gaps. The concluding section gives some specific recommendations and suggestions for the relevant stakeholders.*

Keywords: mobile, wireless, m-Government, LDC, Bangladesh, disaster, flood, cyclone, SMS, mobile Internet, 2G

1. Introduction

With over 1300 rivers, including three major rivers of South Asia, flowing through Bangladesh and into the Bay of Bengal in the south, the country is one of the most disaster-prone countries of the world. Its devastating calamities, particularly floods and cyclones, are continuing to claim the lives of hundreds to thousands and to damage billions of dollars worth of property almost every other year. Although the disaster management systems have improved in the past decades, the government still faces significant problem in disseminating early warnings and post-disaster instructions to the populace of a country, where only 20 percent of its geographical region have electricity. The cyclone that hit the coast of Bangladesh in April of 1991 claimed the lives of about 138,000 people, whereas a cyclone of similar intensity in the US only killed 18 people the next year.

Besides major disasters, there are other more preventable accidents, such as sinking of boats and ferries caught in storm, which occur due to misinformation or lack of access to information about most recent weather warnings. Since the country is laden with rivers, travel by boat is a regular phenomenon for many people. There is currently no system by which passengers can check the current weather condition in a particular location, and have to rely on the boat owners, who are often indifferent towards bad weather conditions and subsequently overload boats. These lead to innumerable accidents almost every other month in Bangladesh killing hundreds at a time.

2. Disaster and Management of Information System in Bangladesh

The location and climate together makes Bangladesh a disaster-prone country. Although Bangladesh is experiencing almost all kinds of disaster, cyclone and flood are considered as the most devastating and regular occurrence.

2.1 Cyclone

Cyclone is a disaster calamity which is a low pressure and depression originated in the Bay of Bengal. Basic source of cyclone is the action and reaction of hot and cold water and the motion of air and water (Khan, 2003). During cyclone whirling storm and tidal bore hits the coastal areas at a speed of 80 to 120 miles per hour and it pushes saline water in the approaching larger plain areas. Natural disaster of similar intensity is known as typhoon in the Pacific ocean and Hurricane in the Atlantic ocean.

Need for information for safety measures

- Coastal inhabitants are needed to be aware about the damaging nature of cyclone well in advance to be prepared.
- Concurrent update of danger signals.
- Fishermen should be warned about the cyclone well in advance so that they can be back in the safe area from fishing.
- Preservation of food is necessary as there will be immediate unavailability of food in the disaster affected area in the post cyclone period.
- Electrical infrastructures fetch additional hazards during cyclone causing fire. Early warning can result in disconnection of electricity during cyclone.

Possible use of instant information

- Concerned organizations should ensure their readiness to follow standing orders and directives of the state authorities.
- Local shelters need to arrange for probable population.
- Area and village wise voluntary team can be formed beforehand for necessary preparedness, awareness and rescue and relief moves.
- Location of relief food can be notified.

2.2 Floods

Excessive rain fall during the rainy season and on rush of upstream flow pressurizes the rivers to overflow their banks and disastrous flood occurs. During the flood of 1998 in Bangladesh, for instance, 25.5 percent of the population were affected and the area submerged was about 100,000 sq. km.(67.76 percent of Bangladesh's total land area) (CPD, 2004). The duration of the 2004 flood was 65 days. The cost of total damage in the flood 2004 was estimated to US$ 7 billion by the World Food Program as of August 2004, 2004 or 12.81 percent of current GDP, while in 1998 the total damage was estimated to be US$ 1.7 billion or 4.66 percent of current GDP (CPD, 2004).

Need for information for safety measures:

- To make aware about the possible time and intensity of upcoming flood.
- To take last moment possible steps to reduce damages in agriculture.
- To Warn about possible outbreak of diseases in the specific area.

Possible use of instant information

- To circular standing orders and emergency messages among the disaster management related agencies.
- To keep provision for shelter and food ready in the probable flood affected areas.
- To circulate information about the availability of relief, food, drinking water and medical assistance.

3. Current Disaster Information Management System

The responsibility for managing disasters in Bangladesh is entrusted with the Disaster Management Bureau (DMB), a government agency, under the ministry of Disaster Management and Relief. The functions of disaster management bureau are as follows (DMB, 2002):

- To coordinate disaster management activities;
- To organize training and public awareness activities;
- To collect, preserve and analyses data on various disasters;
- To operate an Emergency Operation Center (EOC);
- To promote prevention and preparedness at all levels on various disasters;
- To help line ministries, departments and agencies to develop contingency disaster management plan and arrange effective dissemination of disaster warning and
- To organize logistics arrangement in connection with disaster management.

Current information flow system

Local disaster shelters play a central role during disaster. The local centers are basically two storied buildings located in the disaster-prone areas. The number of cyclone centers that provide shelter during cyclone in Bangladesh as of 1999 is 1841 and this number for flood shelters that provide shelter during flood in Bangladesh as of 1998 is 200 (DBM, 2002). Use of radio is only effective medium to communicate directly with disaster prone area and this device has got widest reach even to the people living below poverty line. Uses of television for disaster information are increasing but yet get effective as the number of television is not significant due to un-affordability and lack of electricity in rural areas. Use of flag in cyclone centers and local focus points is another old medium for communication of disaster information. Information flow through human chain, that is word of mouth, is still the only duplex medium of communication. Private wireless communication is in use in some district level areas.

Selected quotes about disaster management situation in Bangladesh

"While much of the inefficiency was due to the scale of logistics involved, planning with better informed guesses about the aerial distribution of damage and relief requirements could have produced a better response." (Maniruzzaman et al, 2001)

One journalist aboard a helicopter distributing relief reported, `. . . relief work was not systematic in any way. We simply flew around, and dropped bags wherever we thought necessary. . . . Those getting relief were simply lucky'" (Haider et al, 1991)

"One cannot wait for an accurate response from the field, which will take a long time." (BIDS, 1991)

This led to the realization that a duplex real-time communication medium can mitigate the intensity of disaster to a great extent.

4. Relevant Mobile Technology (Context Aware & Location Identification)

The driving force for focusing on Mobile technology for disaster management arises from its inheriting features of Global System for Mobile Communications (GSM) wireless network technology. For the purpose of disaster management works, it is important to identify geographic location of the disaster prone area. Location of the mobile user can be identified by two basic approaches (Heikki, 2001). One is through the mobile network signal system where signals send by the mobile phone system to its base and another is through using integrated Global Positioning System (GPS) with the mobile phone receiver, an additional hardware that takes care of location functions. In this paper we will focus on the techniques that locate the geographical position using mobile network signal system which does not require any additional hardware. Although accuracy of location based on signal system over integrated GPS is still an issue of debate but in the context of less developed country like Bangladesh adding hardware at the user's end will involves additional cost at user's end which is not possible to effort for a lot of user.

The purpose of presenting these technical concepts is to give a general idea how location is identified in the cellular networks to non-technical readers and to avoid any technical details. Some basic GSM based location identification techniques are discussed below (Marko and Pentti, 2003):

- Cell Coverage
- Received Signal Levels
- Angle of Arrival
- Timing Advance
- Enhanced Observed Time Difference

4.1 Cell coverage

Cell is the geographical area periphery for one base station. When a mobile phone generates any call, it contains its Cell location information. Cell coverage or cell ID or cell of origin (COO) is the simplest methood of calculating location of the mobile user based on the cell information. Since it is an inherent feature of any cellular system there is no need to change mobile handsets or network infrastructure and can be implemented in an existing infrastructure through minor software updates. The major drawback of this method is its dependency on the cell radious which is variable depending on the context. The cell size of a base station can be 50 meters in a city to 35 km to an rural area. However, for the purpose of managing natural disaster, which is generally covers a wide area, this drawback can be over looked. But this method requires user intiative to generate call to identify her/ his position which poses contraint.

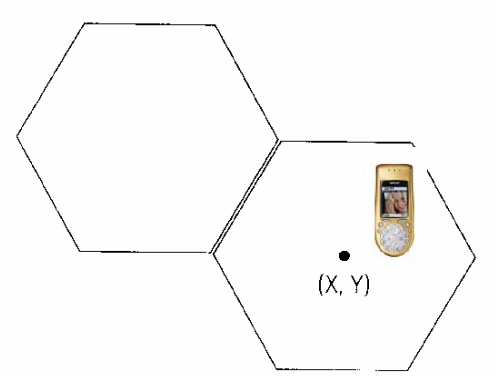


Figure 1: Position based on call identification (Marko and Pentti, 2003)

4.2 Received signal levels

Received signal level method or Signal strength method is an easy and low-cost method to enhance the accuracy of pure cell ID based location. This method identifies the location by analyzing the mobile signals between mobile unit and three surrounding base stations. Mobile signal level is used to estimate a range from three base stations where the location is determined as the unique intersection point of these three circles.

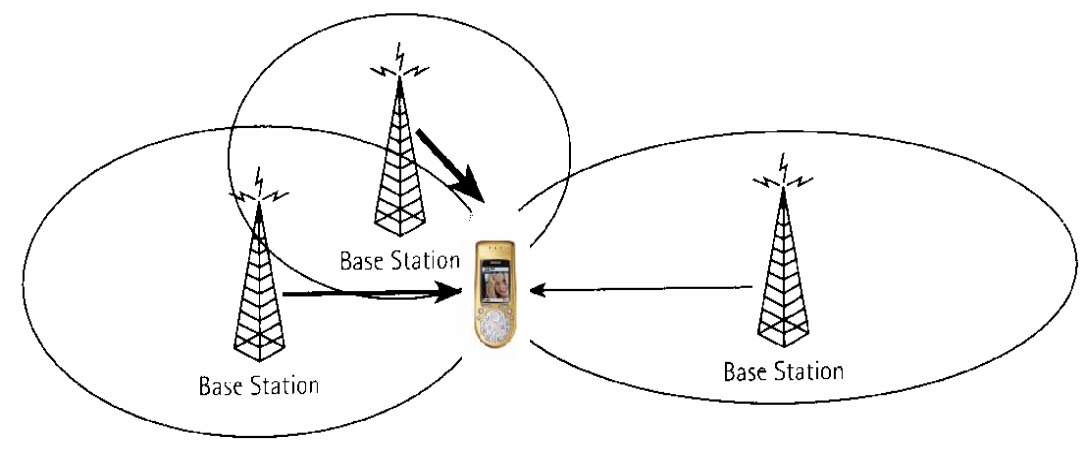


Figure 2: Received signal levels (Marko and Pentti, 2003)

4.3 Angle of arrival

In Angle of arrival, directional antennas are used in the base station to estimate the angle from which the signal arrives. Assuming two-dimensional geometry, angle of arrival measurement at two base stations is sufficient for unique location. But this method has two shortcomings in disaster management context. The first is it requires line of sight between mobile station and base station which may be available at rural place but impossible to get at urban place. And the second is high cost of antennas for base station. This method can be applied to sensitive areas like sea port.

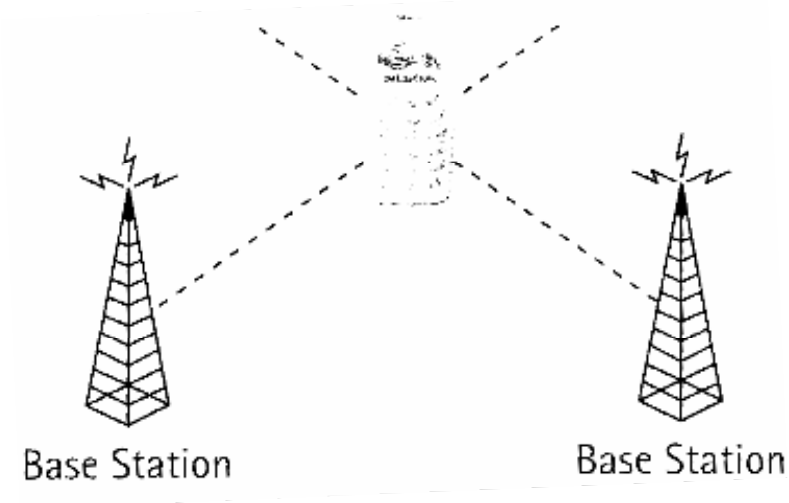


Figure 3: Positioning with angle of arrival measurements (Marko and Pentti, 2003).

4.4 Timing advance

Timing advance is available at the network which is the time delay between mobile and serving based station. The formula for calculating Timing advance is d= (TA * c) /2, where distance of mobile from base station is d and c is the signal speed.

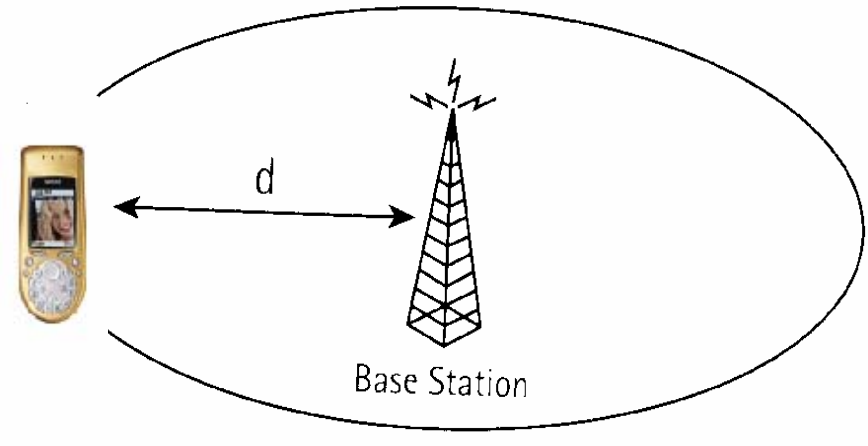


Figure 4: Timing Advance (Marko and Pentti, 2003)

4.5 Enhanced observed time difference

E-OTD is included in GSM location standards where mobile device measures the time differences of signals received from a pair of base stations in known locations. This method is particularly useful for the user to identify his/her location in an unknown place. This method has higher accuracy and no capacity limitation as mobile device calculates its position. This technique needs for software modifications to the handsets and the need for additional receivers (Heikki et al, 2001).

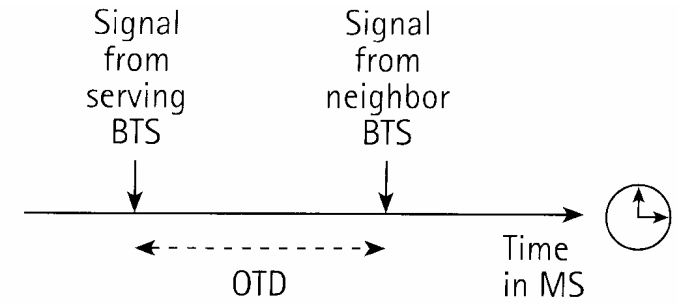


Figure 5: E-OTD (Marko and Pentti, 2003)

5. Mobile Technology and Its Spreads in Disaster Prone Areas in Bangladesh

5.1 Mobile penetration in Bangladesh

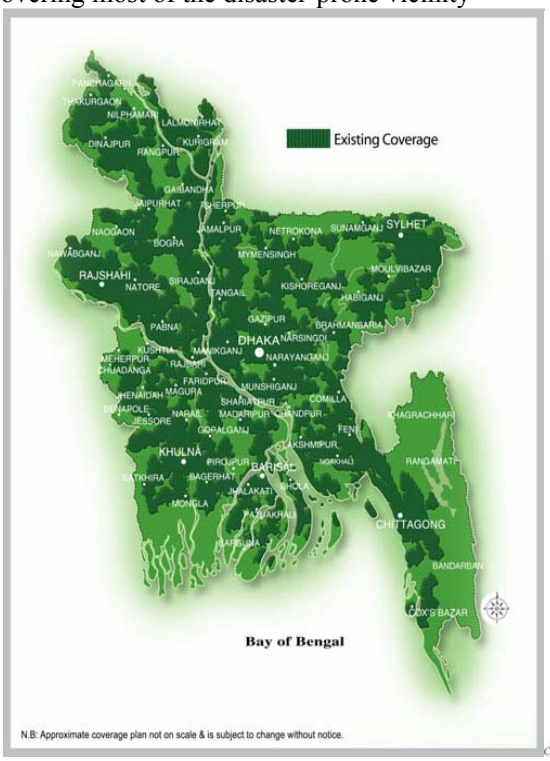
On a brighter note, Bangladesh is one of the first countries in the world to have exemplified a model for rural access to mobile phones through widely acclaimed initiatives of Grameen Phone followed by other mobile service providers. The growth rate for mobile phone market has been 200 percent over the last two years. Currently, there are approximately 3.5 million mobile phone subscribers, compare to only seven thousands fixed phone subscribers. Almost every single village in Bangladesh has been brought under the coverage of mobile network system. And due to the wide prevalence of low cost pre-paid cards, there are now many who can afford to keep a mobile phone since the minimum bill payable per month is about US$ 5.

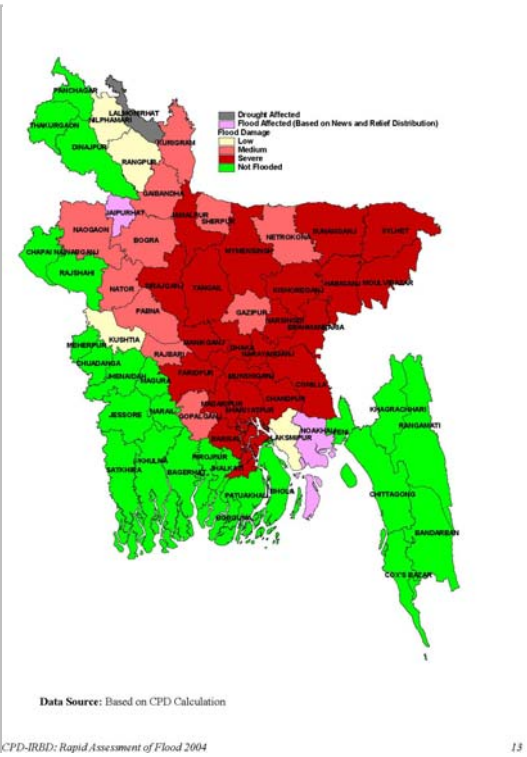
Company	Subscribers	2002	2003	2004	2005
Grameen Phone	Number (Appox)	1000000	1500000	2000000	2700000
	Growth Rate (Appox)		150%	133%	135%
Aktel	Number	500000	750000	1300000	
	Growth Rate		150%	173%	

Table 1: Number of subscribers of two major mobile phone operators Source: Authors compilation from various sources

5.1 M-Tech availability in disaster- prone areas

In this section we will examine the availability of mobile technology in disaster-prone areas. For the simplicity of understanding two maps of Bangladesh are presented below. Map 1shows cumulative network coverage of all mobile service providers in Bangladesh in 2004. Map 2 shows the areas that were affected during the flood of 2004 in Bangladesh. By comparing following two maps, we can see that the Network coverage of cellular phones has reached a fairly distributed geographical area covering most of the disaster-prone vicinity





Map 1: Existing Coverage of Grameen Phone (Grameen Phone, 2005) Map 2: Damage Intensity of Flood 2004(CPD, 2004).

6. Model for Disaster Information Management Using M-Tech

6.1 Assumptions

The basic assumption is that 2nd Generation level technology for mobile communication is available in Bangladesh and that mobile phones have reached a critical mass. Moreover, the Network coverage of cellular phones has reached a fairly distributed geographical region covering most of the disaster prone areas.

6.2 The proposed model

In the proposed model, the Disaster Management Bureau (DMB) will play the central role of coordination for implementing mobile technology for disaster management. This DMB has a line of communication with other weather forecasting agencies. The weather forecasting agencies will forecast the disaster, cyclone for example, and pitch this information to the DMB. Dissemination of disaster warning, rescue and recovery information will be disseminated through two separate but complementary approaches. One is through the formal channel of communication like local authority and local disaster shelters. To implement this channel, the prerequisite is that all local centers will have at least one mobile phone. It is also possible to select a local representative who owns a mobile phone to keep communication with the centers that don't have mobile phone. The central coordinator (DMB) will send updated information to the local centers which in turn will be distributed using both online and offline media. This weather information will be highly specific depending upon the cell of the mobile phone. The prevailing system of communication is through radio which is not much targeted.

Another approach, which is the focus of proposed model, is disseminating disaster warning, rescue and recovery information directly to the affected people using mobile phones. The central coordinator (DMB) will collect weather information from the weather information department. There will be line of communication between the DMB and the mobile phone operators. After receiving location based weather report, the central coordinator will write a Short Message Service (SMS) describing the weather report and necessary steps to be taken and then send it to the mobile phone operators. Mobile operators then disseminate this short message to all mobile phones in a specific geographic cell. This service will be push service which will not require users' active participation.

6.3 Pull services and reverse information

The key motivators of using mobile technology are the opportunities to use pull service and reverse information. One of the limitations of disaster management systems developed so far is that it has been considered the user/ beneficiary as a dormant payer in information receiving. By using mobile technology, a person can query and be informed by sending request to a specific number at any time. This request can be in the form of SMS and/or call. Also depending on his/her current position, she/he can get specific weather forecast, including disaster warning. Moreover, disaster recovery activities like providing relief can also be informed to the people of specific location using mobile based context aware feature.

Most of the relief work did achieve its level of success due to lack of response from the field where the affected people were stayed. There is yet to have any medium of effective real-time communication between the relief team and the field. As a result, relief is not properly distributed among suffered people. Using mobile technology concurrent information can be gathered from the field which in turn ensures proper distribution and minimizes losses.

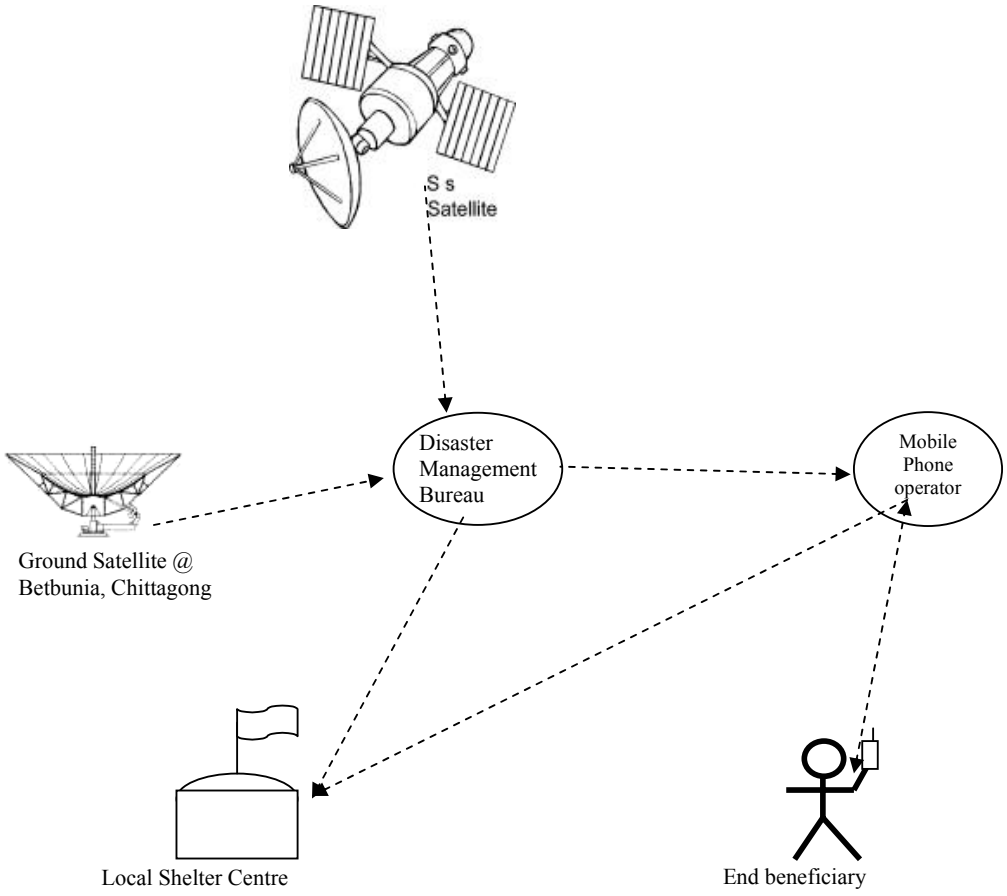


Figure 6: Proposed Model for Disaster Information Management

In figure 6, proposed model has exposed. Disaster Management Bureau is playing the central role and coordinating the information flow from prediction to dissemination. DBM will collect Weather information from several forecasting agency through collected through ground satellite. DMB then interpret the information and create a SMS message based on pre determine template. This SMS warning will then send to the mobile operator for broadcasting in the specific area. Another SMS will also be sent to the local disaster shelter center for showing flags and relay through other existing media. Two way line between the mobile user and the operator implies that user can call or SMS to a specific number for weather forecasting information.

7. Lessons Learnt, Policy Implications and Recommendations

7.1 Infrastructure and cost

- Government should provide at least one mobile phone to all disaster management agencies like local center for communication. Partnership with the mobile operators could be an effective way to reduce the operating cost.

- Mobile operators should reduce/ subsidize the call charge in disaster affected areas which can be identify using location identification techniques.

7.2 Awareness programs

- Awareness programs need to be organized at grass-roots level in order to promote and make easy to understand mobile messages containing disaster information all available media.
- Awareness programs should also be targeted towards local government, NGOs and other civil society organizations.

7.3 Coordination

- Disaster Management Bureau (DMB) may play the central role of coordination with private public partnership model basis that is maintaining partnership with private companies like mobile operators for disaster information management.
- Role of the private sector, particularly the mobile telephony providers, should be encouraged as part of promotion of corporate social responsibility.
- Grass-roots NGOs should prepare themselves to make effective use of mobile technologies during pre-disaster and post-disaster.

7.4 Technology

- Technology needs to be developed for messaging in local language like Bengli. Example could be Nokia's recent innovation in India that is messaging in Hindi language.

8. Concluding remarks

In conclusion, mobile technology, in disaster management, may be used in the following ways

To disseminate pre-disaster warnings

Mobile phones may be used to disseminate information about impending disasters. Since only 30 percent of the population of Bangladesh has access to electricity, they do not always have access to other media such as TV or radio, and if they have, they may not have it turned on during emergency. But mobile phones are widely prevalent and are 'always on'.

To disseminate post-disaster announcements

The government and NGOs can send relevant announcements such as transferring to specific shelters or information about relief distribution after a disaster. Immediately after a disaster, it is found that many are left homeless and always on the move. During these situations, sending out announcements through mobile phones can be an effective means to keep people organized and run post-disaster operations smoothly.

To receive information about relief needs

The mobile phone can also be an effective means for the affected people to send out information about relief needs, and notify relevant bodies about unequal or undesired relief distribution strategies. This can empower the affected people and enable them to find a voice during a helpless time.

To exchange information about health hazard

The mobile technologies can also be used to send emergency information about health hazards, both from the side of the government and also from the side of the disaster-affected people. The government can send warnings about possible hazards and preventive measures, and likewise the affected people can send information about the situation on the ground and notify relevant bodies about medication needs.

References

BIDS (1991) The April Cyclone and Economic Loss: An Informed Guess from Secondary Data. Dhaka: Bangladesh Institute of Development Studies.

Disaster Management Bureau (DMB), (2002) Disaster management Training Handbook, the ministry of Disaster Management and Relief.

Grammen Phone corporate website. http://www.grameenphone.com/ dated March 11, 2005

Haider, R., Rahman, A.A. & Huq, S., Eds (1991) Cyclone '91: An Environmental and Perceptional Study. Dhaka: Bangladesh Centre for Advanced Studies.

Heikki Laitinen and at el, (2001) "Cellular network optimisation based on mobile location", 2001 CELLO Consortium.

Khan Alauddin, (2003) "Safety Measures for Disasters", Jelly Khan.

Maniruzzaman K. M., Okabe Atsuyuki & Asami Yasushi, (2001) "GIS for Cyclone Disaster Management in Bangladesh", Geographical & Environmental Modelling., Vol. 5, No. 2, 123-131.

Palola Marko & Tarvainen Pentti, (2003) "Location Technologies in the Mobile Domain", VTT Electronics, Oulu.

Centre for Policy Dialogue (CPD), (2004), *Rapid assessment of flood 2004,* Dhaka: University press limited.

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