THE POTENTIAL ROLE OF MOBILE NETWORK IN DISSEMINATING FLOOD WARNING: A STUDY ON A PILOT PROJECT IN TWO UPAZILAS UNDER MANIKGANJ AND TANGAIL

A Dissertation for the Degree of Master in Disaster Management

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Abstract

The Ganges, Brahmaputra, and Meghna (GBM) river systems in India and Bangladesh are some of the most flood-prone river systems in the world. Excessive floods present serious risks to the millions of people living in the floodplain areas. In a normal year an estimated 25 percent of Bangladesh is flooded, whereas, in an excessive flood year an estimated 65 percent of the country is flooded. Despite constant and pervasive flooding, Bangladesh does not have an effective system for providing useful flood forecasts or other flood warning information at the community level. The present system of government-issued flood warnings is presented in both a context and a format that are neither understood nor usable by the floodplain inhabitants.

Riverside Technology Inc. America (RTi), Center for Geographical Information Services (CEGIS) and Bangladesh Disaster Preparedness Centre (BDPC) jointly initiated useful, timely, and understandable flood information dissemination at the community level to reduce vulnerability to damage due to flooding in the floodplains of Bangladesh. The pilot initiative was taken at Baro Bonna village of Jiyonpur union in Daulotpur upazila under Manikganj district and at Dhunail village of Doptior union in Nagorpur upazila under Tangail district. Both the villages are in the flood plain of Brahmaputra river system and very much prone to flood frequent flood. The name of this pilot initiative is Community-based Flood Information System (CFIS) where CEGIS with the support of RTi performed technical responsibility to produce flood information and BDPC played the role of social partner to reach the information to the inhabitants of the villages in an understandable manner.

For communities and inhabitants to benefit from flood forecasts, the information must be context based, timely and in a format that is understandable and useful. CFIS project fully recognized the technical challenges of creating reliable local level forecasts, and the equal, if not greater, challenge of communicating the information to local communities. This project, for the first time in the history of Bangladesh, used mobile network as a means for connecting root level people with flood forecast through Short Messaging System (SMS) and commenced a new era for warning community people of flood disaster.

This **dissertation is the outcome of a study on** the *efficiency* **of using cell phone network for connecting root level people of flood plains of Bangladesh with flood forecasts produced at national** level. The **definition** of *efficiency* **is to reach flood forecasts to the people of flood plains** timely with **understandabily**. A number of **KIIs and FGDs were conducted to investigate the level of said** efficiency **and the potentiality of using SMS as a means for warning communities at risk to flood disasters without digging much into the technical issues.**

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Acronyms

ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Center
BARC	Bangladesh Agriculture Research Center
BBS	Bangladesh Bureau of Statistics
BDPC	Bangladesh Disaster Preparedness Centre
BIWTA	Bangladesh Inland Water Transport Authority
BMD	Bangladesh Meteorological Department
BWDB	Bangladesh Water Development Board
CDMP	Comprehensive Disaster Management Programme
CEGIS	Center for Environmental and Geographic Information Services
CFAN	Climate Forecast Applications Network
CFIS	Community-based Flood Information System
CIDA	Canadian International Development Agency
CSFFWS	Consolidation and Strengthening of Flood Forecasting and Warning Services
DAE	Department of Agriculture Extension
DANIDA	Danish International Development Agency
DEM	Digital Elevation Model
DGPS	Differential Global Positioning System
DHI	Danish Hydraulic Institute
DMB	Disaster Management Bureau
DMCs	Disaster Management Committees
DMIC	Disaster Management Information Centre
EGIS	Environment and Geographic Information System Support Project for Water Sector Planning
EMIN	Environmental Monitoring Information Network
FAP	Flood Action Plan
FFWC	Flood Forecasting and Warning Centre
FGD	Focus Group Discussion
GBM	Ganges, Brahmaputra, and Meghna (Rivers)
GeoSFM	Geospatial Stream Flow Model
GIS	Geographic Information System
GMS	Geostationary Meteorological Satellite
GPS	Global Positioning System
GTS	Global Telecommunication System
ICT	Information and Communications Technology
ICTDG	Information and Communications Technology Development Group
IMDMCC	Inter-Ministerial Disaster Management Coordination Committee
IRS	India Remote Sensing
ISESCO	Islamic Education Scientific and Cultural Organization

ISPAN	Irrigation Support Project for Asia and the Near East
IWM	Institute of Water Modeling
JICA	Japan International Cooperation Agency
JRC	Joint River Commission
KII	Key Informant Interview
MoDMR	Ministry of Disaster Management and Relief
MPO	Master Plan Organization
NASA	National Aeronautics and Space Administration
NDMAC	National Disaster Management Advisory Committee
NDMC	National Disaster Management Council
NGO	Non-Government Organization
NOAA	National Oceanic and Atmospheric Administration
NWRD	National Water Resources Database
OFDA	Office of US Foreign Disaster Assistance
PWD	Public Works Department
RTi	Riverside Technology, inc.
SAR	Synthetic Aperture Radar
SMS	Short Message Service
SPARRSO	Space Research and Remote Sensing Organization, Bangladesh
SRDI	Soil Research and Development Institute
SWC	Storm Warning Centre
TDC	Thana Disaster Committee
UDC	Union Disaster Committee
UDMCs	Union Disaster Management Committees
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
USGS	United States Geological Survey
UzDMC	Upazila Disaster Management Committee
VFMC	Village Flood Management Committee
WARPO	Water Resources Planning Organization
WB	World Bank
WFP	World Food Programme
WMO	World Meteorological Organization
WV	World Vision

1.1 General Statement

Bangladesh is a multi hazard prone country. Flood, cyclone, drought, riverbank erosion, water logging, tidal surge, nor'wester, etc. assault the country every year. For mitigating all the natural phenomena, a poor and developing country like Bangladesh has very limited capacity to take required huge structural measures. So, the country's disaster management plan must emphasize the non-structural measures and disaster forecasting and warning system, of course, should come first. Rapid dissemination of disaster warning is the first requisite for the effectiveness of warning dissemination system. Mobile network which is now available even in remotest char areas may play a significant role in this regard. This study is for an exploratory type of research which is perhaps first of its kind in Bangladesh. Disaster forecasting and warning is found available at national level. But the community people who are living in the risk environment and who are the subject for the first hit by riverine floods remain unwarned. The reasons are- warning scarcely reach to the communities at risk, root level people do not understand the warning messages and the warnings are not area specific. If warning dissemination mechanism adopts mobile network as its basis for message dissemination, warnings may reach to the root level people very rapidly and a drastic change may come in disaster warning dissemination system of the country. Some pilot initiatives have already been taken to test the effectiveness and feasibility of developing community-based disaster warning dissemination system basing in mobile network. The objective of this study is to explore the potentiality of adopting mobile network for effective flood warning dissemination at community level. For this study, firstly, the organizations that have piloted and have been piloting projects on community-based early warning dissemination based on mobile network have been explored. Then data was collected from national level to community level stakeholders of those pilot projects. Both technical and social data are collected on feasibility of warning the root level people of the country through utilizing mobile network and the promising role of mobile phone communication in disaster warning dissemination throughout the country. It is a qualitative study and the collected data are processed and analyzed manually. All the data are collected through a number of interviews and FGDs.

This dissertation concludes the findings and experience for the project "Vulnerability and Risk Reduction Through a Community-Based System for Flood Monitoring and Forecasting," or the Community Flood Information System (CFIS) in short. The project was prepared in response to the April 24, 2002, annual program statement *"Enhanced Disaster Preparedness in South Asia: Through Community-Based and Regional Approaches"* of the U.S. Agency for International Development (USAID), Bureau for Humanitarian Response, Office of U.S. Foreign Disaster Assistance (OFDA). Riverside Technology, inc. (RTi), the Center for Environmental and Geographic Information Services (CEGIS), and the Bangladesh Disaster Preparedness Centre (BDPC) conducted the project that was initiated in October 2002 and completed in March 2008.

1.2 Rational of the Study

Bangladesh is at the downstream end of two of the World's largest rivers, the Ganges and the Brahmaputra, both originating from the Himalayan mountain range. More than 93% of the catchment area of these rivers lies outside Bangladesh, mainly in India. The topography of Bangladesh is formed by the rivers, and is primarily a delta with extensive flood plains, which are fertile and densely populated.

Bangladesh experiences an intensive monsoon from May to September, and flooding is an annual occurrence. After the independence of Bangladesh, within the last thirty years the country experienced more than ten devastating floods. In 1998 68% of the land was inundated. Considering the geophysical condition of the country and the national capacity, it is quite impossible to control flooding through structural measures. Non-structural measures can be particularly effective in mitigating the damaging effects of flooding in Bangladesh, and flood forecasting and warning are primary means to achieve this in a highly cost effective manner.

Figure 1: GBM river Basin

The Flood Forecasting and Warning Centre (FFWC) **under Bangladesh Water Development Board** (**BWDB**) **under the Water Resource Ministry was established in 1972** for dissemination of flood forecasting and warning nationally and till now it is playing a vital role in the field of

Table 1: Last 30 years **history of severe floods**

Year	Flooded area (Sq.Km)	%
1Gi<"	52,600	36.00
1987	57,300	39.0"
1988	89,970	61.0
1998	100,250	68.OC

who live in vulnerable areas do not get the forecasting and warning messages. Since FFWC **disseminates forecasting through electronic media and people of Bangladesh are mostly poorest of the poor**, **do not have access to electronic media. Even in this twenty** first **century, in the decade of developed communication**, **the farmers of this country still develop their cultivation and plan their harvesting**, **observing the climate and using their indigenous knowledge. Besides**, **the common people cannot properly interpret the forecasting and warning messages properly**. Last, **but not the least**, **the warning messages are not area specific**. **Under such**, **this study seeks the potentiality of using cell phone** network for **connecting root level people of flood plains** of the country with **national flood forecasting system.**

1.3 Objective of the Study

1.3.1 Broad objective:

To assess the potentiality of using mobile network in Bangladesh for effective flood warning dissemination at community level.

*1.3.2 Specific **Objectives:***

(I) To evaluate the effectiveness of using mobile phone in CFIS (Community-based Flood Information System) pilot initiative of BDPC and CEGIS from the context of rapid dissemination and understandability of the flood warning message.

(II) To find out the scope of community-based flood warning dissemination throughout the country depending on mobile network

(III) To present the feasibility of using mobile' network for warning the at risk communities regarding flood disaster

1.4 Profiles of CFIS Implementing Organizations

Riverside Technology, **inc. (RTi**) is a water resources engineering and consulting firm based in the United States and specializes in analysis and decision support systems for integrated water resources management. RTi's capabilities include real-time flood forecast system development and implementation; reservoir simulation and optimization; hydrologic and hydraulic modeling; automated hydro-meteorological data collection, and monitoring network design and implementation; data communications; and database management systems. RTi has worked on a wide spectrum of surface and ground water projects and has extensive experience in strengthening and developing water institutions at multiple levels, building linkages between water institutions and water users. RTi has assisted communities in developing flood forecasting and warning systems and has extensive international experience, including projects throughout the United States; in South, Southeast, and Central Asia; Latin America; Africa; and the Middle East.

Center for **Environmental and Geographic Information Services** (CEGIS) is a public trust established by the government of Bangladesh with the secretary of the Ministry of Water Resources as the chairperson of the Board of Trustees. As one of Bangladesh's premier scientifically independent centers of excellence, CEGIS' mission is to support the management of natural resources for sustainable socio-economic development using integrated environmental analysis, integrated water resources management, GIS, remote sensing, and information technology. The major strength of CEGIS is its multidisciplinary group of highly qualified scientists and technical professionals (e.g., fisheries, economics, agriculture, sociology, GIS, remote sensing, hydrology, database, programming, ecology, biology, river morphology, engineering, ground water, soil science, etc.) who bring a wide range of skills to the organization and are able to study and manage both technical and institutional water related issues in an integrated manner. CEGIS has extensive experience understanding and providing management tools for the complex river systems and floodplains of Bangladesh.

The Bangladesh Disaster Preparedness Centre (BDPC) is a non-governmental organization solely engaged in disaster management programs, including research, strategy formulation and project implementation, training; development of media materials and publications, post-disaster response planning and intervention, monitoring and evaluation, and advocacy. Most of BDPC's programs are involved with disaster preparedness that enhances the capacity of people at family and community levels, and with post-disaster relief and rehabilitation operations. A few of the many related projects of BDPC include: a USAID-supported disaster management handbook for Bangladesh; UNDP-funded strengthened flood warning and preparedness systems at national and local levels; a public awareness strategy for a flood-proofing pilot project formulated for CARE-Bangladesh; over 100 training courses conducted on disaster management for more than 250 NGOs working in cyclone and flood prone areas, with emphasis on public awareness and response; and a DANIDA-funded pilot project for people-oriented flood warning dissemination procedures for the FFWC.

2.1 Introduction of the areas

The study area is situated in a flood prone zone on the left bank of the Jamuna River and includes parts of Daulatpur *Upazila* of Manikganj District and Nagarpur *Upazila* of Tangail District. The area is designated by CARE Bangladesh as "medium vulnerable to flood" (CARE, 1999). Moreover, both Daulatpur and Nagarpur *upazilas* are seriously affected by flood and erosion. In Daulatpur, the five major bridges damaged during the 1998 flood have not been repaired or reconstructed. An additional problem affecting the flood hazard is siltation of riverbeds in the area. However, for this study Bara Boinna mouza under Daulatpur upazila and Dhunail Mouza under Nagorpur upazila are selected as these mouzas received in-depth piloting under CFIS project.

2.2 CFIS **Location**

The total study area of the CFIS project covered part of Daulatpur *Upazila* under Manikganj District and part of Nagarpur *Upazila* under Tangail District, an area of about 400 km2 *(Figure. 2.1).* Four unions of Daulatpur *Upazila* and 10 unions of Nagarpur *Upazila* fall within the study area *(Table 2.1).* The west side of the area is the left bank of the Jamuna River, and the east side is the Dhaleswari River. The northern boundary is the road going from Mokhna Union to Salimabad Union, while the southern boundary follows the Ghior *Khal* in the east and the Daulatpur *Upazila* boundary in the west. This floodplain was selected based on the following criteria:

1. Floodplain without major flood protection.
2. A range of land uses that are vulnerable to flood.
3. People expressed interest in receiving flood information (based on reconnaissance). Source: *CFIS Reconnaissance visit report 2003*

It was decided to work at two levels. Hydrological analysis, and flood forecasting and information would cover the entire area, but community-based flood information and warnings provided through CFIS would cover two unions and focused more intensively on two *mauzas:* Boro Bonna *Mauza* of Geyonpur Union under Daulatpur *Upazila* and Dhunail *Mauza* of Duptiair Union under Nagarpur *Upazila* which are the study area under present research:

d by CFIS Project

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Study area

Figure 2.1: Study Area

2.3 Agriculture Land Use

The agriculture land use map prepared by the Soil Research and Development Institute (SRDI) and shown in *Figure 2.2,* gives an overall picture of the area. Based on field information, union wise land use practices are described below.

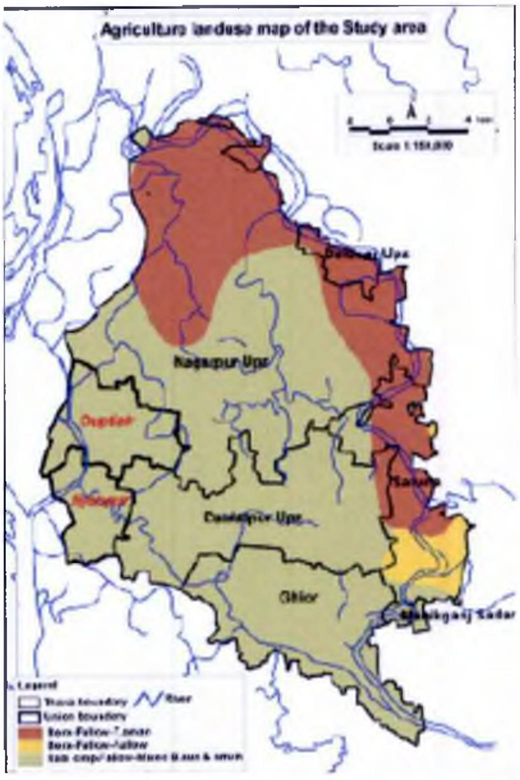

Figure 2.2: Land use based on SRDI

In *char* Kataria, Bachamara, and Baghutia unions, the major cropping pattern is similar to that of Dhamsar Union where no crops are grown in the Unions, approximately 90 percent of the area consists of river channels and sand bars or sand deposits. *Boro* paddy is grown in the cultivable areas during the *rabi* season (between January/February and May/June). In February/March, groundnuts are sown along with B. *Aman* paddy. In July, groundnuts are harvested and the B. *Aman* **remains** until it is ready for harvesting in October/November. Some sugarcane is also grown.

In Jiyanpur and Chak Mirpur unions the major area falls within the active off-take of the Dhaleswari River, and hence, sand deposits cover large areas in Geyanpur and western Chak Mirpur. *Boro* paddy is grown in areas where there has not been any continuous sediment deposit for two or three years.

In Dhamsar Union, the general is mustard in November to mid-January, followed by *Boro* paddy in the remainder of the winter (rabi) season. Very little *Aman* paddy is grown here because of deep flooding. The depressed areas are used for fisheries.

In Kalia Union, the situation depressed areas, but these form fishing grounds. In higher lands, the cropping pattern is generally mustard followed by a late *Boro* paddy crop in March to June. Relatively more land is cultivated with *Aman* paddy in Kalia Union than in Dhamsar Union.

Source: ***Uazila agricultur*** *offices*

2.4 Cropping Pattern

Boro paddy is the major crop grown in the winter *(rabi)* season from January to May. In **some** areas during November to mid-January, mustard is also grown. In the monsoon, most of the areas are left fallow with *B.Aman* and *T.Aman* cultivated in some places.

Cropping intensity in the area overall is 158 percent, but is considerably higher in Nagarpur (173 percent) than Daulatpur (136 percent); this is a result of more double cropping in Nagarpur in the *rabi* season (oilseeds followed by *Boro* paddy), and higher cultivation of *Boro* paddy and jute *(Table 2.2)*. Of the other *rabi* crops, pulses include lentil, *mugbeen, khesari,* and *maskali.* Oil seeds include *til, tesee,* mustard, and sunflower. Almost all the cultivable land is utilized during the *rabi* season, but due to flooding, especially in Daulatpur, the area cultivated in the monsoon is limited.

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* *red spinach, green spinach, snake gourd, sweet potato, bitter gourd, okra, watermelon.*

Kharif-1 = **early monsoon season**; *Kharif-2* = **late monsoon season**; ***Rabi*** = **dry season**

Aus **= early monsoon rice,** ***B Aman*** = **broadcast local varieties of monsoon rice, often varieties that elongate with flooding**; ***T Aman*** = **late monsoon transplanted rice verities (local and high yelding) that do not elongate**; ***Boro*** **= dry season irrigating rice mostly comprising of high yielding varieties.**

Source: ***Uazila agricultur*** *offices*

The production of *Boro* paddy in the study area in 2002 was reported to be 63,920 metric tons, followed by *Aman* paddy (19,450 metric tons), wheat (18,882 metric tons) and *Aus* paddy (3,229 metric tons), according to the *upazila* agriculture offices in March 2003.

2.5 Population and Poverty

The population density is high in the study area, especially in Nagarpur. According to *national census data,* the population density of Nagarpur Upazila (263 km2) was 754 per km2 in 1981, 905 per km21991, and 970 per km in 2001 (BBS 2004). The 641 per km2 in the 1991 census, rising to 727 per km2 in 2001 (BBS 2004). The average household size in the study area was approximately 5.2 persons. In 1996 in Manikganj District, 41 percent of rural households had no land to cultivate, and in Tangail District 30 percent of rural households had no land to cultivate (BBS 1999). Overall, more than 70 percent of people in the Daulatpur and Nagarpur study area depend on agriculture, with the main source of household income coming from cultivation, including sharecropping.

The poor in the project area hardly eat two meals a day, while the rich and the middle class people eat three meals a day. The poor eat adequate quantities of rice, vegetables, and pulses at dinner, their main meal, while they eat rice (sometimes stale), mashed potato, and green chili in the morning. Most of the time, the poor cannot afford a full meal. The rich and the middle class families eat rice, vegetable, pulses, and fish/meat almost every day at both lunch and dinner. Nor sometimes eggs at breakfast. They drink milk at least once or twice a week.

Source: *FGD with Union Disaster Management Committees*

2.6 Communications

Nagarpur *Upazila* is connected with the district headquarters by road and waterways. The basic means of transport available are bus, boat, and rickshaw. The *Upazila* headquarters is connected with most of the union *parishads* by *kutcha* roads. Country boats play a vital role in the rainy season. There are 10 post offices and one telegraph office in Nagarpur *Upazila*. Surface and mobile phone communication exists in Nagarpur *Upazila* as well as eight post offices and one telegraph office. There was no mobile phone network in Daulatpur *Upazila* in 2003, but by late 2007, both *upazilas* had network coverage.

Source: *Upazila Parishads*

2.7 Approach of CFIS Project

The CFIS project was designed as a pilot operational system, producing accurate and timely information on current and forecasted flood conditions for a floodplain study area. The project had three main components.

- ***Pilot Operational System***: An operational pilot system was developed to produce daily flood monitoring and forecast maps for use at the community level. The pilot system was designed to operate during the 2004-2007 flood seasons, providing the project with a range of hydrological conditions (wet and dry years) for analysis and evaluation. The overall concept and information flows in this, the most important of the components, is shown in *Figure 2.3.*

- *Flood Mitigation:* Flood information was provided to the local government and communities in the study area to mitigate potential impacts of flooding. Cooperation and partnerships with other organizations were sought to leverage resources and broaden dissemination and flood mitigation activities. The project coordinated with a number of projects/organizations, particularly the CIDA-funded Environmental Monitoring Information Network (EMIN) project.

- ***Replication***: In addition to the operating system and flood mitigation, the final two years of the project sought methods and sources for extension and replication of the CFIS distributed flood forecasting and monitoring system in other flood-prone areas of the country.

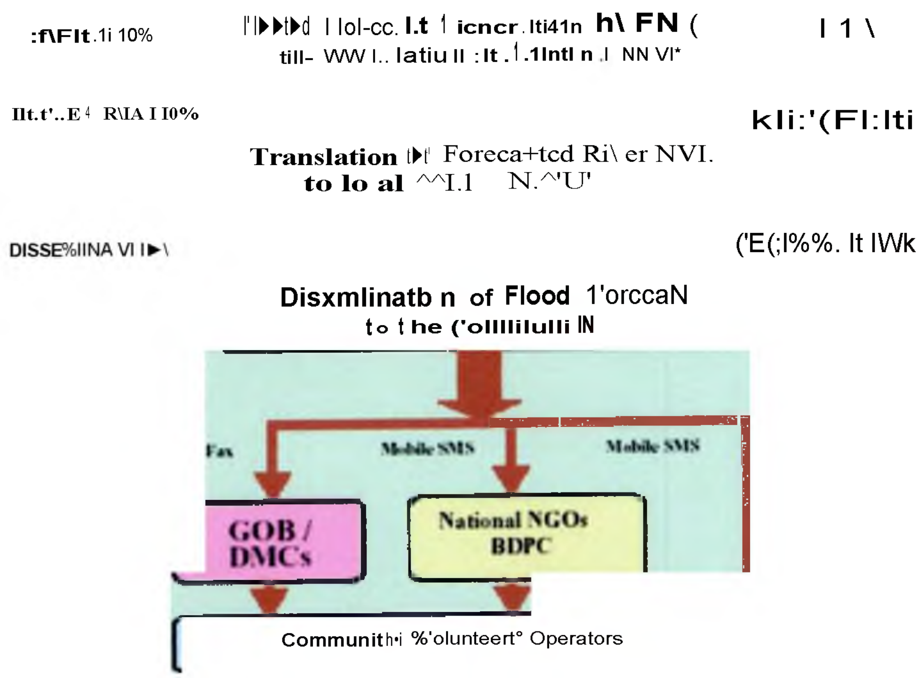

Figure 2.3: Overview of Flood Forecast Dissemination under CFIS Project

Source: *CFIS Final* ***Report 2008***

Critical to the CFIS project design were tasks to increase the sustainability and effectiveness of the CFIS project. The needs of the communities and the local government institutions for flood monitoring, forecasting, and warning dissemination were assessed under the CFIS project using a number of different participatory tools and methods with active participation of the communities. Special efforts were made to coordinate with local government programs and institutions to increase exposure and ownership.

This is a qualitative study. The areas that were covered under piloting of Community-based Flood Information Systems (CFIS) were brought under this study. Because, CFIS disseminated flood information based on mobile network. The focus of this study is to see whether mobile network can successfully reach flood early warnings to the remote communities of the country and can make the warnings understandable through disseminating flood information based on cell phonic SMS. The methodology for attaining the objective of the study was as follows:

3.1 Exploring the relevant organizations and focal persons

The organizations (both GO and NGO) that were involved in CFIS initiative were explored. Necessary documents and papers were collected as secondary source of information to understand CFIS' warning dissemination mechanism. The focal persons of the technical and social organizations who were involved in CFIS were discovered for interview.

3.2 Selection of pilot areas

CFIS pilot areas that were covered for in-depth study under the project were brought under the location for this study.

3.3 Exploring the field level stakeholders under CFIS

We dug into CFIS mechanism to understand how the warnings were reached to the communities and how people could interpret those. The field level important stakeholders were explored also who made the warning dissemination functioning at field level.

3.4 Sampling

It was a purposive sampling. Data was collected from the key persons who were related to the functioning of community-based warning dissemination mechanisms initiated under CFIS. The key persons were like president and secretaries of local disaster management committees. Data was collected from national level stakeholders like

technical persons of CEGIS, **engineers** of FFWC, **planners for household level warning dissemination under CFIS, etc.**

3.5 Data Collection

Both primary and secondary data was collected. Secondary data was collected from basically CFIS documents and FFWC. Primary data was collected through interviews at different level and through FGDs at field level. In-depth interviews were conducted with the technical and national level stakeholders. Data was collected on technical, social and administrative **issues.**

3.6 Data processing and analyzing

Since it was a qualitative study and different types of qualitative data came (social, administrative, technical, etc.), data was processed manually. While analyzing the data, feasibility issue and effectiveness of adopting mobile network was mainly focused.

4.1 Flood Disaster Concepts

Floods have severe impacts on the Bangladesh population, particularly on rural people. For example, the "flood of the century" in 1998 covered more than two-thirds of Bangladesh, causing a loss of 2.04 million tons of rice, an amount equal to 10.5 percent of the target total production in 1998/99. The flood also threatened the health and lives of millions through food shortages caused by crop failure, loss of purchasing power, and the spread of water-borne diseases. The rural poor lost their cattle, poultry, and vegetable fields due to the disaster. The daily laborers were hard hit as well, with little or no opportunity for work left in the wake of the disaster. Recent severe floods in Bangladesh were in the years 1987, 1988, 1998, 2004, and 2007. The substantial damages caused by these floods are presented in *Table 3.1.*

Table 3.1: **Flood Damages in Bangladesh**

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Note: NA indicates that data could not be made available.

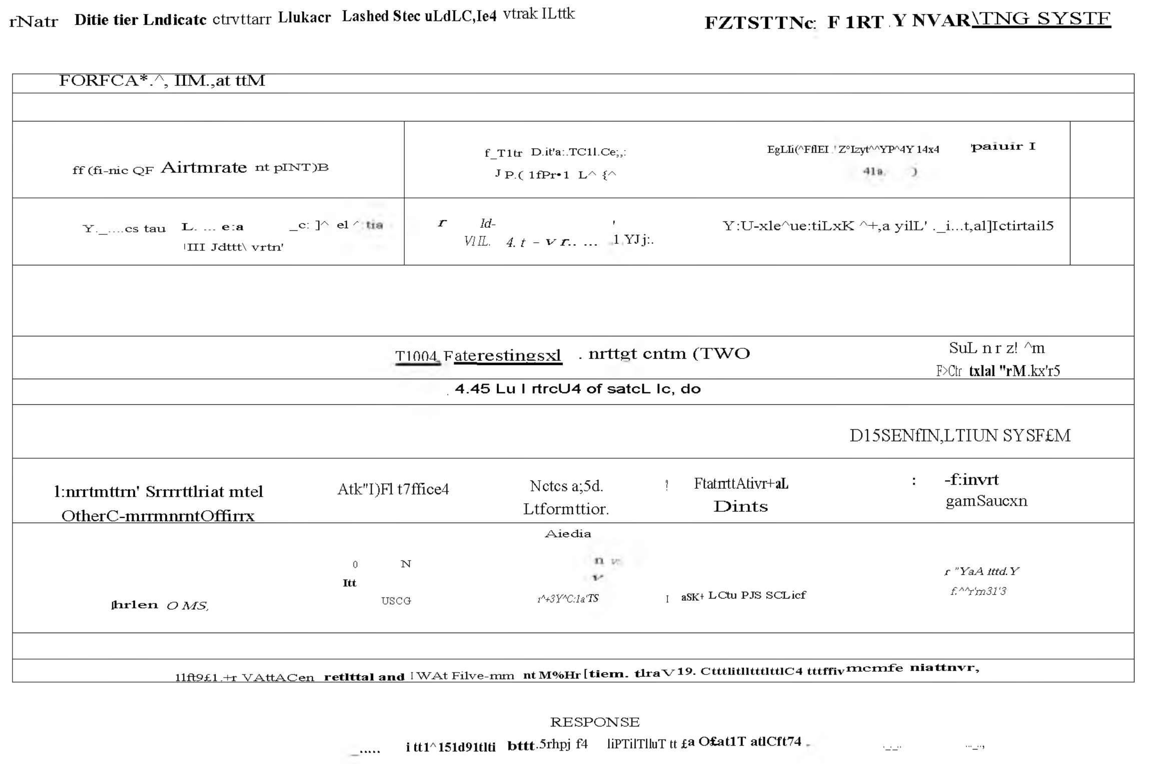
***Source:** 1. Manual for community-based flood management: Bangladesh; 2. Rahman 2006; 3.Flood and Weather Situation report of DMIC, DMB on 1 October 2007. 4 Islam 2000. 5. CEGIS, 2007, Brammer 2004.*

4.2 Forecasting

Flood forecasts serve many purposes in support of planning and flood management, and in reducing losses by affected people. In Bangladesh, forecasts for flood management are related to forecasts of water levels or discharges in the river system. However, even though there has been great success in forecasting water levels in the river system of Bangladesh, there has been little progress in operational flood forecasting in the floodplain.

Three different time scales are relevant for flood management: 1) short-term for about -one to three days, 2) medium-term for about -four to 15 days, and 3) long-tern up to seasonal prediction (RTi and EGIS 2000, and FFWC 2002). The uncertainty of the forecast increases with an increase in lead-time, but longer leads offer greater potential for the affected stakeholders to adapt and minimize losses. The Flood Forecasting and Warning Centre (FFWC) of the Bangladesh Water Development Board (BWDB) is responsible for the forecasting of floods and dissemination of flood warning. So far, FFWC is able to forecast only on a short-term scale, approximately two to three days.

The data, forecasting and dissemination components of the Bangladesh early warning system are shown in *Figure 3.1.* Several organizations provide data for the FFWC system, including the BWDB and the Bangladesh Meteorological Department (BMD). Additional data sources include SPARRSO and Joint Rivers Commission (JRC). FFWC disseminates warning information to a number of government offices, the news media, and non-governmental organizations. Nonetheless, the warning information rarely reaches the inhabitants of the floodplains (ADB, 2006).



(Source: Early Warning System Study, ADB, 2006)

Figure 3.1 : Existing Early Warning System

4.3 Flood Forecasting and Warning Center (FFWC)

The BWDB Act of 2000 stipulates that FFWC, established in 1972, should conduct flood and drought forecasting and warning. The center has direct communication with BMD and SPARRSO and coordinates its activities with the Disaster Management Bureau (DMB). It has access to all available data in BWDB. FFWC has a real-time data collection network of 56 rainfall stations and 86 stream gauges all over the country (ADB, 2006).

Since 1995, the Danish Hydraulic Institute (DHI) in collaboration with the Institute of Water Modeling (IWM) has provided technical support to FFWC to develop hydrological and hydrodynamic models to simulate and predict floods in the river networks of Bangladesh. Funded by DANIDA and other bi-lateral donors, FFWC is equipped with modern electronic equipment. It downloads satellite images (NOAA 12 and 14) through automatic picture transmission receiving stations. In addition, it receives observed and forecasted water level and rainfall data from India at certain times under an agreement between the two countries.

At present, FFWC makes short-term (one to three days) forecasts, with the developed model at 52 locations covering most of the riverine flood prone areas of the country. Although FFWC has a model for medium-term (four to 15 days) forecasting, it does not have operational tools for forecasting the flood levels at the country's boundary. No model is available for long-term forecasting. FFWC has a capacity for dissemination at the national level through its website, email, fax, and telephone and at the *upazila* level via BWDB field offices. However, at the union level, dissemination arrangements are weak and there is no dissemination at the local level. The FFWC daily activity flow chart is shown in *Figure 3.2*.

The four main activities of FFWC are data collection, preparation, output/prediction, and dissemination.

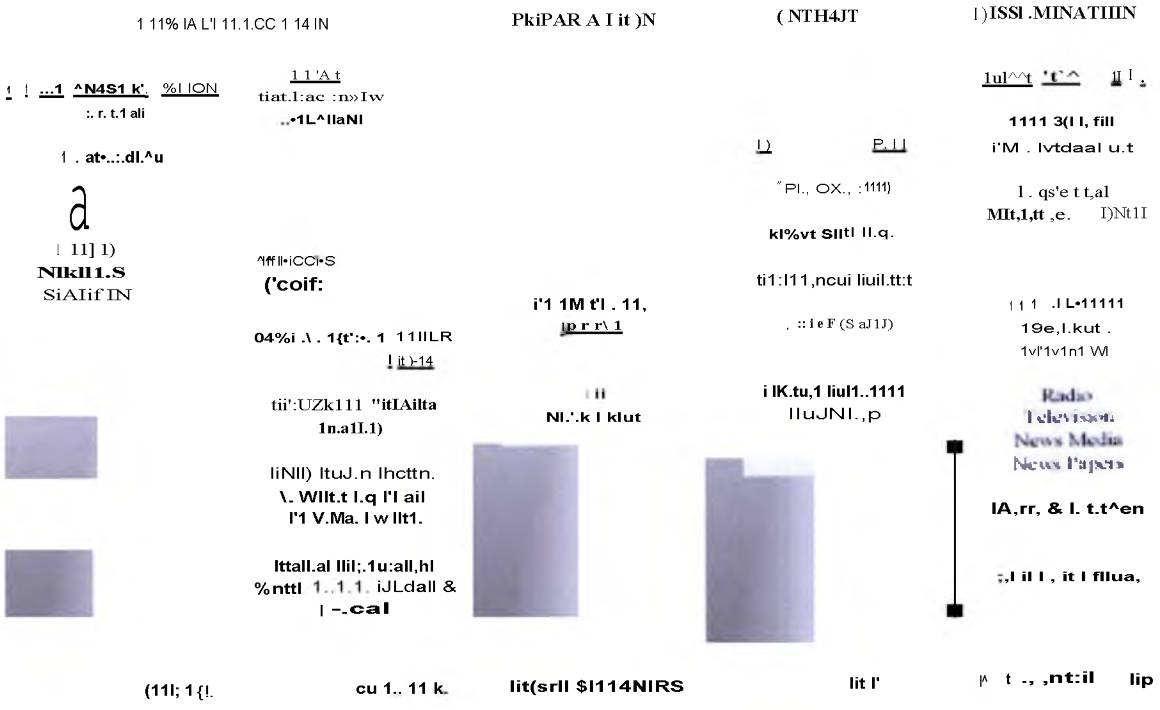
Data collection. Hydrological data is received from the field networks of BWDB. From April to September, water level data is collected five times daily from 86 stations, while rainfall information is collected once a day. Data is also collected from the automatic telemetry system operating in four stations around the capital city of Dhaka. Limited data on water level and rainfall forecasts are received from Indian stations through the teleprinter link of the Bangladesh Meteorological Department (BMD).

Preparation. Estimates of the rise/fall of river water levels and rainfall in the catchments beyond the national boundaries are inputs for computer models. To estimate the rainfall situation, imagery from the NOAA satellite at FFWC, and from the Geostationary Meteorological Satellite (GMS) at SPARRSO are collected and used along with water level forecast and surface charts with pressure isoline from BMD.

The collected data are fed into the computer database and checked. The trend of the hydrograph extrapolated up to the period of forecast from the levels of the previous few days, the response characteristics of the rivers, the effect of rainfall on water level, and the data related to water level and forecast received from India are all considered as the basis for the preparation of flood forecasts.

Output/Prediction. After preparation, the model is run for 30 to 40 minutes to calculate the forecasts. These forecasts are used in flood bulletins and for the preparation of flood warning messages.

During the monsoon period, FFWC runs daily flood bulletins, special as well as monthly and annual flood reports, and conducts flood mapping. During the dry period, it conducts weekly and regional flood monitoring, and produces out a dry season bulletin. *Figure 3.3* shows the outputs of FFWC.



(Source: FFW(BWDB)

Figure 3.2: FFWC daily activity flow chart

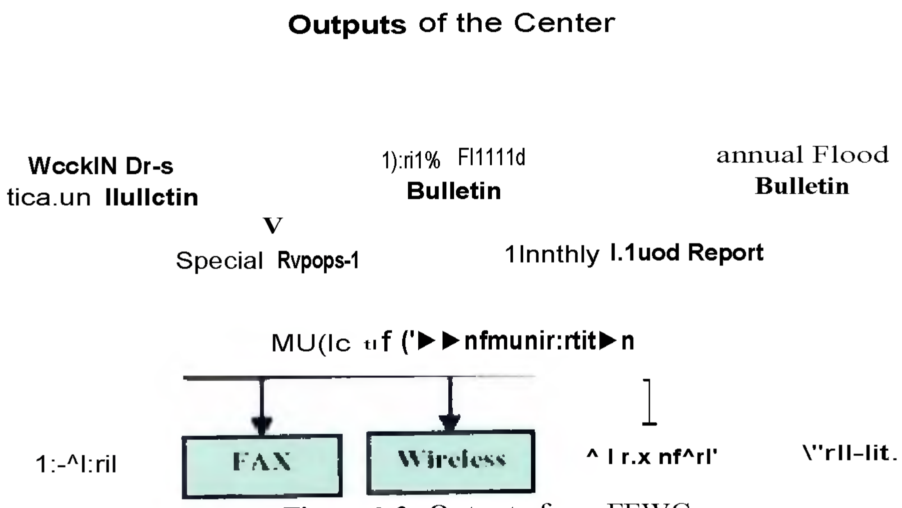


Figure 3.3: Outputs from FFWC

- **Dissemination**. The flood forecast bulletins and the flood warnings are disseminated to over 100 listed recipients. They include all the concerned offices of the government of Bangladesh (from the office of the President, Prime Minister, and Ministry of Disaster Management and Relief down to the deputy commissioners of each District), electronic and print media, selected foreign missions located in Dhaka, and some bi-lateral donors, as well as national and international

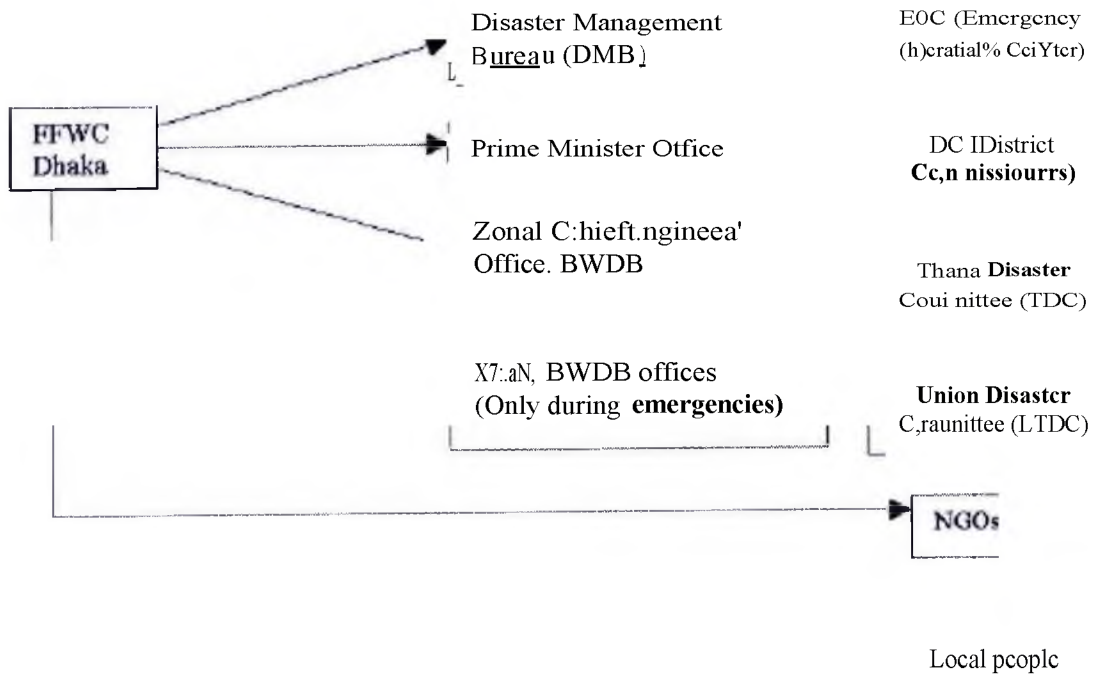


Figure 3.4: **Dissemination** from FFWC

Warning Product **Dissemination Routes**

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The FFWC **website is located** at http://www.ff,,vc.gov.bd. The web **site is comprehensive and provides bulletins and water level plots**. The ability **to interact with the site and its various products is one of the strengths of this dissemination medium.**

5.1 Overview of CFIS Flood Forecasting System

The CFIS project developed an operational system for the study area that produces accurate, local daily flood forecasts for the target communities. Along with frequency analyses using historic data, these forecasts also were used for determining the risk to communities from flooding.

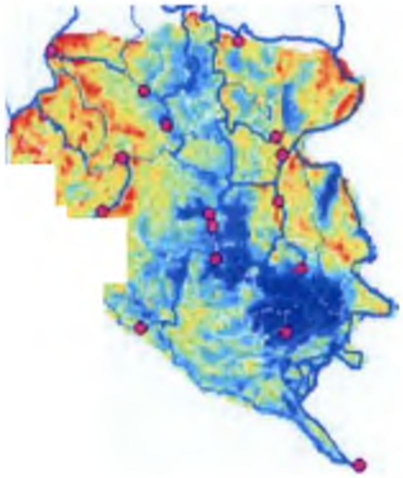

Figure 4.1: Example of Forecasted Flood Map for the CFIS Project Area Produced by WATSURF

The relational model WATSURF, described in detail below, was developed to forecast water levels in the floodplain based on regression relations between 17 floodplain gauges and 3 river system gauges. The floodplain gauges were setup and maintained by the CFIS project, and used to determine their relation with the established river gauges that are observed and maintained by the Bangladesh government, and for which the government's flood warning system is operated. As a GIS-based model, WATSURF extends the point forecasts for the 17 floodplain gauges to a continuous flood forecast map for the entire project area, as shown in *Figure 4.1.* From the forecast map, WATSURF extracts a specific forecast for any point within the study area and creates a SMS text message that is transmitted to mobile phones at selected sites in the field.

Individuals were selected by the local community to serve as operators, to receive the SMS message, and to operate a flag system and bulletin boards for informing the community of the local flood forecast. The message and symbols were designed with active participation of the local people. The flood warning messages, expressed in the local measuring unit *"bighat"* (one *bighat = 22* cm), were generated by WATSURF and sent via SMS to mobile phones of the flag operators, who in turn hoisted the colored flags to symbolize the flood forecast. This chapter describes the CFIS flood forecasting system including data inputs, the study area, WATSURF, and the automated SMS dissemination. The evolution of the local warning system is described in *Chapter 6.*

5.2 WATSURF

At the heart of the CFIS Flood Forecasting System is WATSURF, a relational model, developed to forecast and disseminate water levels in the floodplain. WATSURF is an ArcGIS tool written in Visual Basic (VB) to run in ArcMap GIS environment. WATSURF uses regression relations between 17 of the CFIS floodplain gauges and 3 FFWC/BWDB gauges on the main rivers. As a GIS-based model, WATSURF extends the point forecasts for the 17 floodplain gauges to a continuous flood forecast map for the entire project area. Entire information regarding WATSURF is derived from the document *WA TSURF Model* by CEGIS 2003 and *CFIS.final report.*

From the forecast water level map, WATSURF extracts a specific forecast for any point within the study area and creates a SMS text message that is transmitted to mobile phones at selected sites in the field. At each field location, a volunteer was contracted to help disseminate the flood warning information. Each day during the flood season, the volunteer received an SMS message describing the category of the water level change in the next 48 hours and raised color-coded flags to match this change. During the 2007 flood season, in addition to the flag operators, SMS text messages were sent out in bulk to registered members of the community directly to their cell phones. Thus with the support of WATSURF flood forecasts were disseminated.

There are a number of steps between data processing and dissemination of the flood information. The overall process of the CFIS Flood Forecast System/WATSURF is shown in *Figure 4.2.* The major components in this figure are described in the following sections of this chapter.

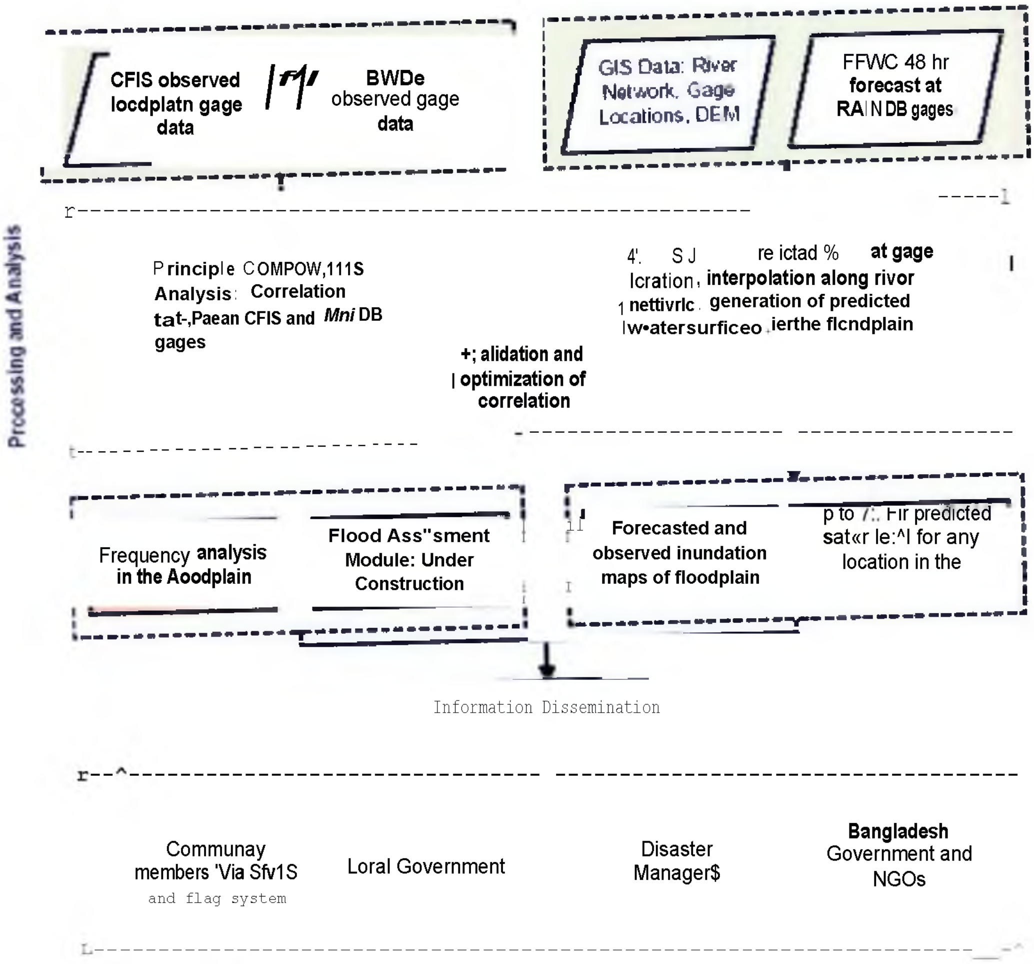

Figure 4.2: CFISIWATSURF Operational Flow Chart

5.2.1 Data Inputs

The GIS inputs to WATSURF consist of three datasets: DEM, river network, and gauge location. The rivers within the study area were ranked in orders (one to eight) according to the flow capacities and connectivity. River of order one is larger than two, and so on. River lines were split at gauge locations to create nodes (gauges). This data structure was necessary for the program to interpolate water levels between nodes.

WATSURF's forecast required observed and predicted water levels at the reference gauges (Sirajganj and Aricha) and relational equations between the reference gauges and each field gauge. These inputs were used to estimate water levels at the gauge stations, which in turn were used to generate forecasted water levels through the entire study area.

Because of analysis of the water levels of contributing rivers, FFWC gauge **49 (Sirajganj) and 50.6 (Aricha) on the Jamuna river, located upstream (about 55 km) and downstream of the study area, respectively, were selected to be used as the reference stations. Measured and forecasted water levels at the reference gauges are posted on the Web by** FFWC (www.ffwc**.net) and are read directly** by the WATSURF **program.**

The equations relating reference water levels to predicted gauge water levels were derived by regression analysis of the data collected during the 2003 season, as described in the following section.

5.2.2 Relational Equation Development

The principle components analysis was performed in 2003 to create a relationship between the water levels of the FFWC forecast points, or reference gauges, and the water levels at the individual field gauges within the study area.

- Time Series Data Used. **Data were used** for two FFWC forecast points-gauge 49 at Sirajganj and gauge 50.6 at Aricha (Figure. 4.9). Data were also provided for one **regular, non-forecast** point 137A at Tora. Field data for the flood season of 2003 were provided at 12-hour **intervals for 17 gauges labeled** GO 1, G02, ... G 16, G 17 by CEGIS. For analysis, additional **time series** were created by lagging Aricha and Sirajganj data at intervals up to 120 hours. Similarly, additional **time series** were lagging it negatively, or shifting values backward.
- Correlation Investigation and Lag-time Consideration. Correlations were calculated for each gauge **against** all other gauge **time series**. For the CFIS purpose of

Fi ure 4.3: Location of FFWC Forecast Points

developing predictions, only the correlations between the field gauges and the various Aricha, Sirajganj, and Tora time series were considered. Limitations were imposed on the period of analysis and minimum values at Sirajganj and Aricha. The correlations were recalculated. This process was repeated in an attempt to determine the best correlation through iteration.

Results of the correlations showed incremental improvements with Sirajganj, the further the Sirajganj time series was lagged. Gauge G01 correlated worst (of those investigated) with the non-lagged Sirajganj. Review of the actual time series suggested a physical lag time of approximately 12 to 72 hours. Although the statistics improved beyond this time, they were judged meaningless for predictive purposes. Perhaps they have some meaning in suggesting significant system memory, but the limited data (from one season only) did not provide means to make rational, useful conclusions.

- Tora as Predictor. While many of the field gauges closer to the outlet of the basin correlated well with the Tora gauge, it was not used as a predictor for the field gauges mainly because FFWC does not forecast for the Tora gauge station. It would be useful if FFWC forecasted at Tora gauge station.

- Principal Components Analysis and Equation Development. With the understanding gained in the initial gauge analysis, and by enforcing lag time constraints, a principal components analysis was conducted for each gauge against Aricha and appropriate Sirajganj time series. Only increments of 24 hours were allowed, considering that only 24-hour values were available at Sirajganj. It was found that the exclusive use of the 72-hour lag of Sirajganj best described six of the gauges, and a 48-hour lag of Sirajganj best described six other gauges. The remaining four gauges, which corresponded best with Sirajganj, were predicted by a combination of Sirajganj and Aricha lag time series.

5.2.3 *Community Flood Information Dissemination*

One of the main activities of the CFIS project was to develop and operate a system that disseminated flood forecasts to the floodplain inhabitants. The primary system designed in the beginning of the project used a system of volunteers receiving SMS messages about the flood and then operating a series of flags to inform the surrounding communities about the flood forecast. During the last year of the study, 2007, this flag network was complimented with a more direct communication to the local communities during which SMS messages were sent directly to registered cell phone users in the study area. This more direct communication was possible during the last year of the study because of the rapid growth of cell phone coverage, and their use, in the area. In addition, the CFIS project secured an operating agreement with one of the major cell phone operators in the country that provided the SMS message dissemination at no cost as a social service to the community.

In the initial stages of the CFIS project, prior to the flood season 2004, at selected locations throughout the study area, volunteers were solicited to help disseminate flood information. Each day during the flood season, the volunteer received an SMS message to his or her cell phone (initially provided by CFIS) describing the magnitude of the forecast water level change in the next 48 hours. This SMS message was generated and sent automatically to the volunteer in the study area. For simplicity and local effectiveness, the value was sent in the local measurement unit, *a bighat* (approximately 22 cm). Each volunteer also was equipped with a flagpole, where he or she could raise blue or white flags. If the water was predicted to rise in the next 48 hours, the operator would raise the number of blue flags corresponding to how many *bighats* the water level would rise. White flags were raised to signify a decrease in the water level.

For clarity, it was also necessary to define a bound around zero for which no change in water level was sent. This bound was one-half *bighat.* One flag represented a change of between 11 cm and 33 cm, and two flags represented a change of 33 cm to 55 cm and so on.

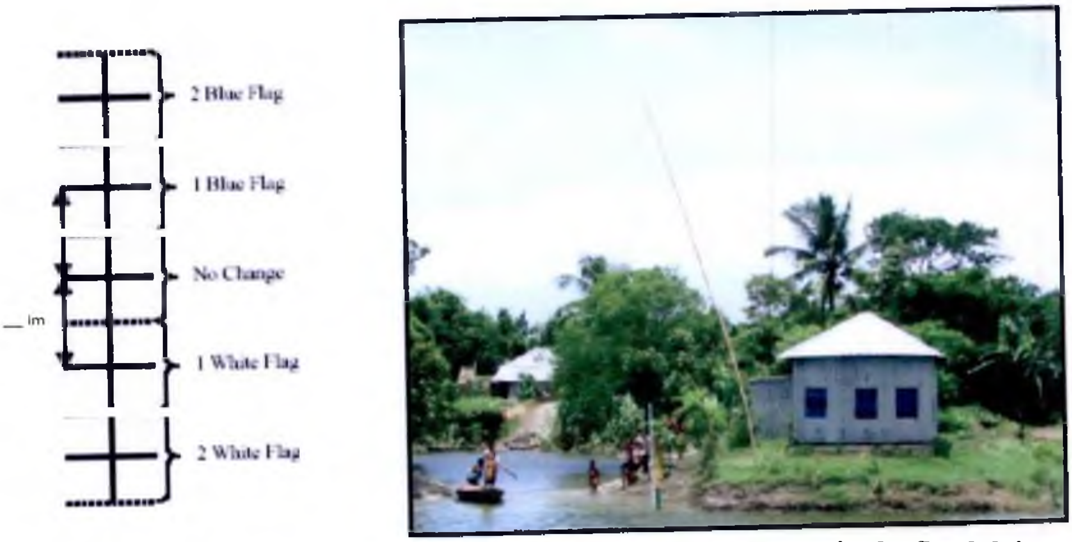

Figure 4.4: Schematic of Flag System, and a flag system in operation in the floodplain

In addition to the blue and white flags, communities also identified flood danger level in the field. Three different levels where defined by the colors green, yellow, and red, which represented a normal, moderate, and high flood level, respectively. These levels were surveyed in the field and input into WATSURF. Therefore, WATSURF also output the current danger level at each field location. For the first two years of operation, each flag operator also was given a separate pole in which he or she raised a green, yellow, or red flag when an SMS informing of the danger level was issued. This system of communicating the present danger level was confusing to the local residents and did not offer much useful information for them. It was discarded after the second flood season of operation.

5.2.4 WATSURF Modules and Information Products

- WATSURF Modules. WATSURF was developed in a modular format. As more functionality is needed, it easily can be built into the program. The following describes the modules that were incorporated into the current version of WATSURF.

  1) Adding Module: The adding module was developed to easily add dissemination points for water level messages. The user can easily expand the dissemination coverage by updating the database and spatial files.

  2) SMS Module: The SMS module was developed to automatically disseminate community flood messages over the commercial cellular network. The module sends SMS messages from the WATSURF software to the following levels:

- Union bulletin board
- Field volunteers (flag operators)
- Registered users

3) Database Module: The database module was used to archive incoming SMS messages from the gauge operator in the WATSURF database.

4) Monitoring and Assessment Module: The monitoring and assessment module generated tables and graphics based on the predicted and observed water levels. The system analyzed the observed water level received through SMS, against the predicted water level, and then generated a report that was sent to the quality control managers. The module also is able to produce evaluation reports on the flood prediction utilizing all the floodplain gauges.

Information Products. WATSURF produced four types of products for the government administration, community, and households. These products were generated in the form of table, map, and text message, and disseminated to the target groups through fax and mobile SMS service. A list of the products is shown in *Table* 4.1. A sample of some of the products and description is provided in the following sections.

Table 4: List of WATSURF Products Table

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a. District level flood situation

Water level situation and forecast for 24 and 48 hours at gauge stations in the main rivers near Tangail and Manikganj districts were presented in tabular form and sent district and *upazila* administrations via Fax. An example of these district level products is shown in *Figure 4.5* **and 4.6**. *Figure 4.5* shows danger levels, water level on the previous and current day, and expected levels in 24 hours and 48 hours time at the FFWC gauging stations in the main rivers. From this message, the government officers could understand the present and future flood situation around their districts.

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তারিখ ঃ ২৯-সেপ্টেম্বর-২০০৭

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Figure 4.5: Flood situation information for Manikganj District

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Figure 4.6: Flood situation information for Tangail District

b. Upazila 48 Hour Flood Warning

Two types of products are produced for *upazila-level* flood warning: one is a 48-hours *upazila* flood forecast map *(Figure.* 4.7) showing forecasted water level change by symbol at each gauge station in the *upazila,* and the other is a 48-hours *upazila* flood forecast table *(Figure. 4.8)* showing magnitude of forecasted water level change at the same gauges. In the 48-hours upazila flood forecast map, up arrows or down arrows mean rising or falling of water level where each arrow represents a magnitude of one *bighat.* The map and table are produced daily with Bangla notations and exported to MSWORD for dissemination to the respective *upazila* office through Fax. From this information, the *upazila* officers can understand the future flood situation at each gauge station located in selected unions in the *upazila.* The information dissemination was continued up to 2007 in two *upazilas.*

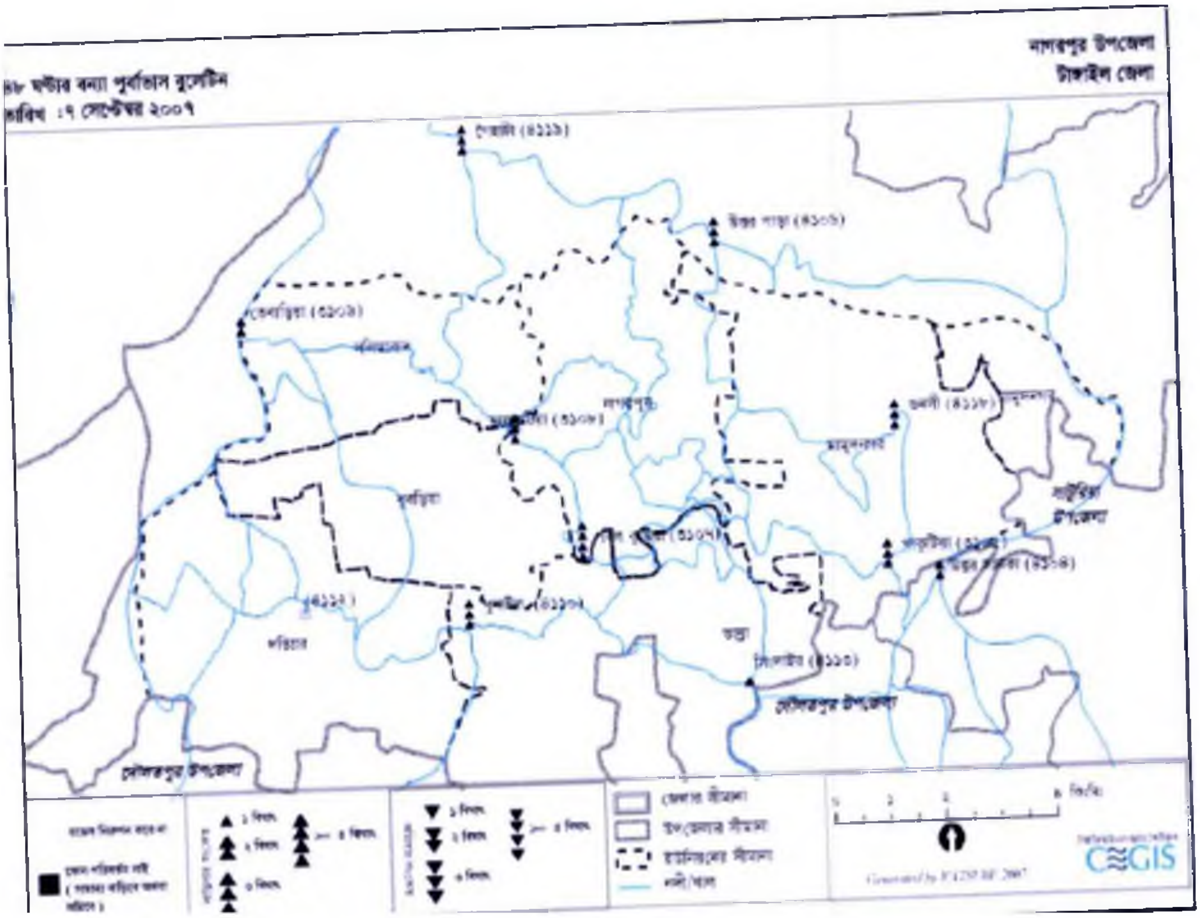

Figure 4.7: 48-hour *Upazila* Flood Warning Map showing rise/fall of water **level in gauges**

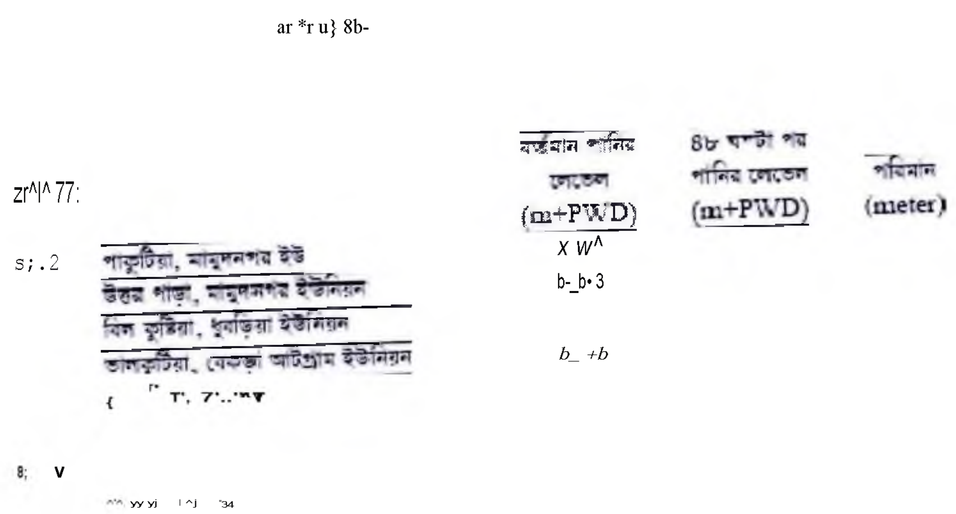

Figure 4.8: 48-hour *Upazila* Flood Forecast Table

c. *Union Level 48-Hours Flood Forecast*

At the union level, bulletin boards in 13 union *parishads* of Daulatpur and Nagarpur *upazilas* were set up to display *mauza*- and union-level flood warnings. Forty-eight-hours flood forecast messages were sent to the selected bulletin board operators in the respective unions through mobile SMSs. The mobile SMSs contained the name of the *uazila,* acronyms of the *mauza,* and the symbol for water level rise (+) or fall (-). The format of the mobile SMS is shown in *Figure 4.9.* The bulletin boards were used by union parishad chairmen, members, and DMC members. *Figure 4.10* shows one of the bulletin boards set up at Mokhna Union *Parishad* of Nagarpur *Upazila.*

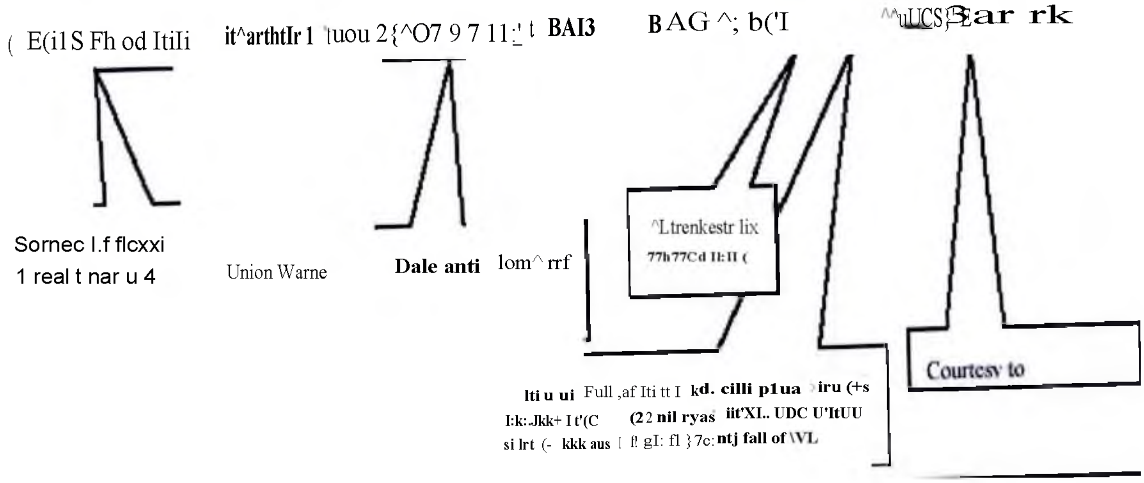

Figure 4.9: Format of union level, 48-hour flood warning via mobile SMS

Figure 4.10: Bulletin Board at Mokhna Union *Parishad* of Nagarpur *Upazila*

d. Community ***and Household*** *Level 48-Hours Flood Warning*

At the community and household level, mauza-specific, 48-hours flood warning messages were sent to the flag operators and households through mobile SMSs. The format of mobile SMS is shown in *Figure 4.11.*

Flags were hoisted at selected places, such as rural markets, schools, or offices, in each *mauza* by the flag operators to show the expected change of water level in that specific *mauza (Figure. 4.12).* The operator hoisted the number of flags according to the magnitude of the rise or fall, and the direction of change was indicated by the color of the flags. For example, if the flag operator received one plus sign (+) via SMS message for the location, the operator would hoist one blue flag; if the SMS was two minus signs (--), the operator would hoist two white flags.

The evolution of these local warning systems is discussed in *Chapter 6.* During the 2007 season, a campaign was undertaken to register individual mobile phone owners to receive the SMS message for their specific location. At the household level, registered mobile phone users received the same mobile SMS as the flag operators. The registered users were trained to understand the flood forecast by converting the plus **or minus sign into** forecasted change in water level.

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Figure 4.11: Format of Mobile SMS for Flag Operators and Households

Figure 4.12: Flag **hoisted at the community at Bhalkutia** *Mauza,* Nagarpur *Upazila* showing **rise in** water level (blue flag) by *3 bighat*

5.2.5 Partnership ***with Banglalink*** *and Direct SMS Use*

CEGIS and RTi presented the concept of the CFIS project, and identified the needs and benefits of a flood forecasting system in flood vulnerable communities, to Banglalink (a private mobile operator in Bangladesh). Through KII a recommendation came that the CFIS concept be replicated throughout Bangladesh. Understanding the importance and benefits of community-based flood forecasting, Banglalink expressed their interest to participate in disaster management activities in the disaster prone areas of Bangladesh through providing support to the flood-forecast SMS service under the Corporate Social Responsibility (CSR) program of Banglalink.

Through KII it was revealed that a technical team was formed to develop the format of communication protocol between CEGIS and Banglalink. CEGIS prepared flood-forecast SMSs for bulletin board writers, flag operators, and households using WATSURF (Figure 4.21) in text file format, then uploaded the text files of SMS to Banglalink's website, http://202.22.194.79/smscorp0 *(Figure. 4.14)*. A pre-set database in the Banglalink server determined which SMS would go to which mobile number. The SMSs were forwarded to the mobile numbers through two or three routings within 30 minutes.

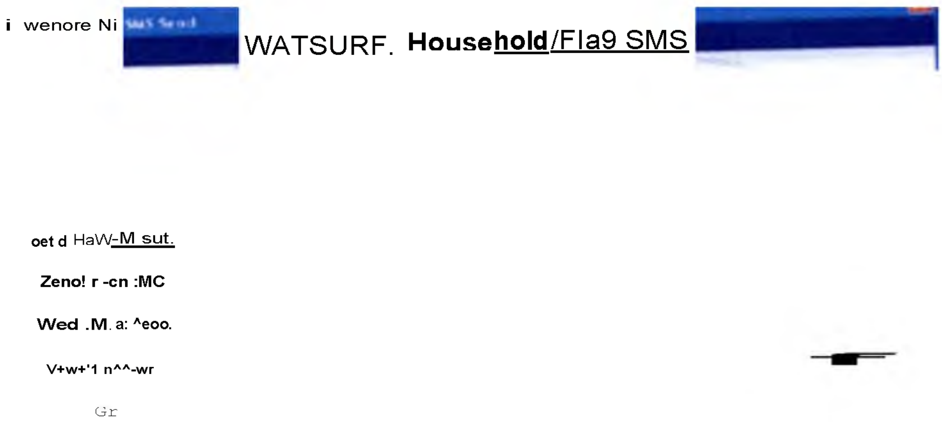

Figure 4.13: WATSURF **tool where a text format of the messages is generated by clicking at the "Text Message" button**

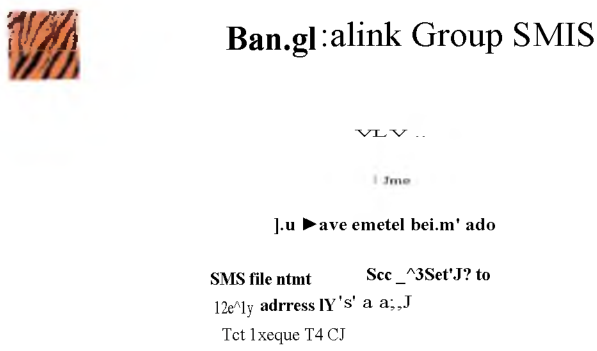

Figure 4.14: Uploading text files of flood-forecast SMS to the Banglalink website

6.1 Year 2003

The evolution of warning dissemination system is derived from *BDPC's yearly final reports (2003, 2004, 2005, 2006, 2007)*. **The first year of the CFIS project was spent selecting study areas and for assessing baseline conditions, assessing the need for early warnings and coping means of the community members, identifying change agents and volunteers, and identifying media for flood information dissemination. Through a participatory process, BDPC identified three different colored flags to indicate the flood situation. A green flag indicated a normal flood situation, a yellow flag indicated a moderate flood situation, and a red flag was hoisted to indicate a severe flood situation. Flood markers were installed at well-known, visible locations that were relevant to the majority of the community, and established risk-map billboards in visible places so that people could identify the risk to their houses** *(Figure 5.1)*.

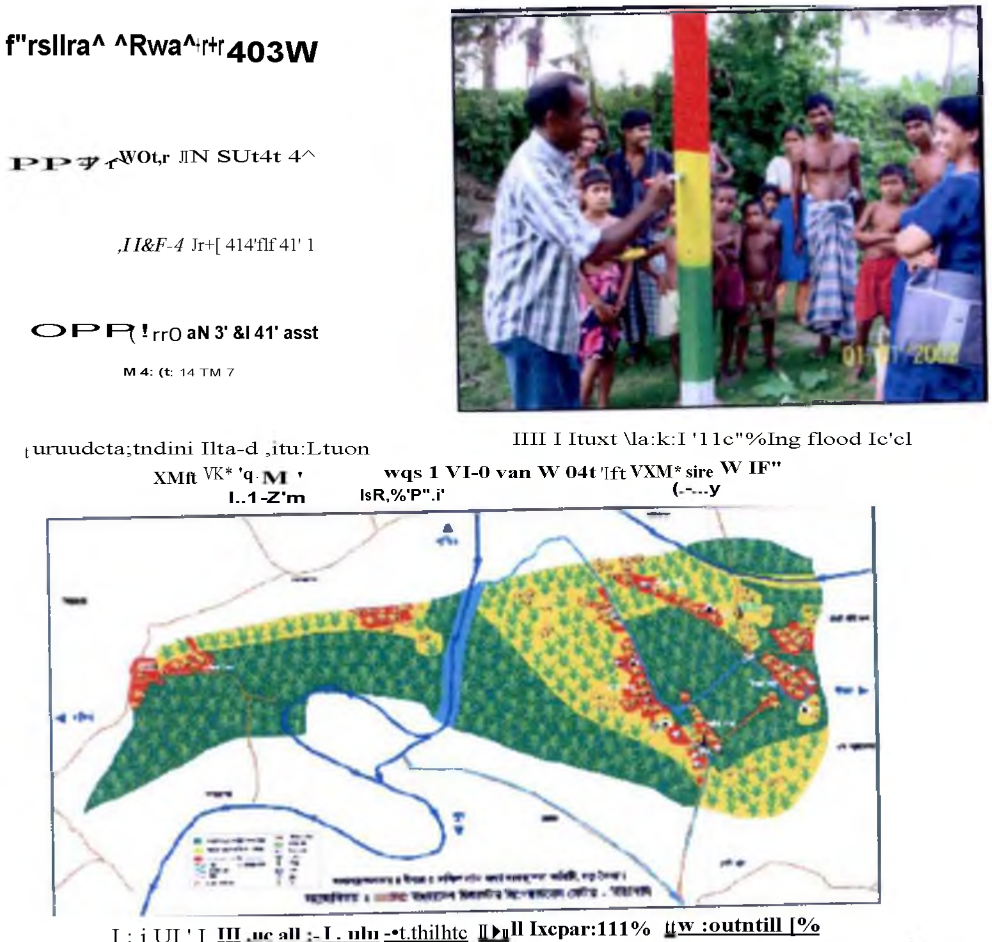

Figure 5.1: Examples of materials used for raising awareness about flood risk in the community

6.2 Year 2004

In 2004, Bangladesh faced a moderately severe flood and the CFIS intervention areas were inundated. Unfortunately, CFIS became operational before the flood peak, but after the initial on-rush of flood waters into the study area. Moreover, the system of two types of flags and lack of experience in the system caused confusion in the dissemination and interpretation of information and warnings. The flow of warning information dissemination for 2004 is shown in *Figure 5.2.* BDPC received flood warning through SMS and informed the flag operator of the flood warning who hoisted flags accordingly. Although a simple linear flow of information was involved, it was not effective because of the confusion described above.

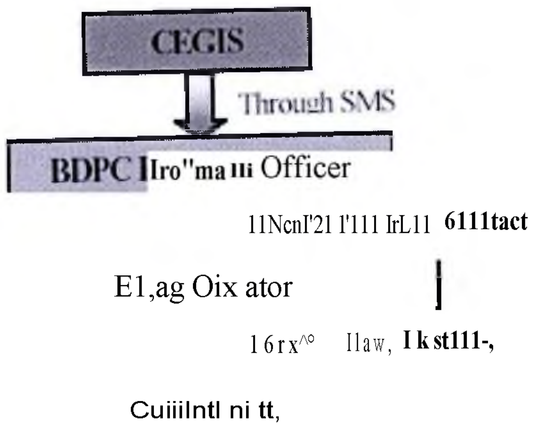

Figure 5.2: CFIS **flood warning dissemination** pathway in 2004

6.3 Year 2005

Based on the lesson learnt in 2004, particularly the lack of understanding by local staff and volunteers, the dissemination method was revised for the 2005 monsoon. Early warning dissemination started in the field on 13 July and continued until 17 September 2005, with 51 flood information messages received, out of which 49 messages were received through SMS, and two messages came through mobile phone on two days that the mobile phone operator's text message servers were not functioning. Due to the server failure of Grameen Phone (the leading mobile phone operating company in Bangladesh), messages from CEGIS on 22 July and 30 August were not received by the field organizations and individuals.

It was reported that water levels did rise in most areas where flood warnings were disseminated, although in Baraboinna Village, the water level actually fell in the following 48 hours in 19 percent of the areas that received warnings. The magnitude of predicted and actual floodwater level changes differed considerably, as described for the overall study in Chapter 6. Another problem was that the flag operators hoisted two types of message-indicating flags: one for the existing flood situation and another for the predicted change. Consequently, a possible five colors of flags were used. Although the flag operators understood, the villagers were still confused about the meaning of so many colors.

6.4 Year 2006

The main lesson learned from these two pilot areas in 2006 was that messages were more easily understood when the flood situation flags (green-yellow-red) were removed from the system. It was decided that only flags for indicating water increase and decrease would be used in the communities. In addition, after the second year of operation, the concern shifted to sustaining the system, the warning dissemination pathways were revised, and the UzDMC and UDMCs were included. Mobile phone use in the flood warning system was expanded by providing two mobile sets to UzDMCs and UDMCs to inspire and involve those bodies. The warning flow for 2006 evolved to that shown in *Figure 5.3.*

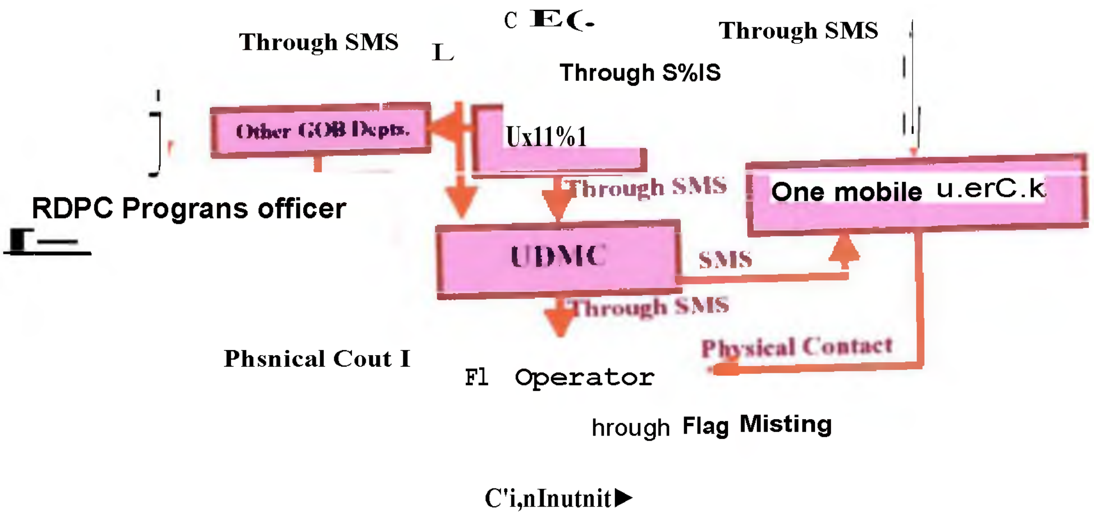

Figure 5.3: Flood warning dissemination pathway in the two pilot areas in 2006

The *Upazila* Disaster Management Committees (UzDMC) assigned as CFIS project implementation officers were the member secretaries of the UzDMCs. Their responsibility was to receive flood warning from CEGIS through mobile SMS and transmit the message to the other *upazila-level* government officers from different departments and to all the Union Disaster Management Committees (UDMC) in their *upazila*. The responsibility of officers from different government departments was to inform communities of flood warnings through their field level staff, if they considered that the predicted flood would threaten the sector and field activities of their department. The UDMCs selected the union *parishad* secretaries, who were also the member secretaries of the respective UDMCs, to receive the flood warning messages sent from the UzDMC. The selected village mobile users, who were the change agents (active over the past three years in CFIS), passed on the warning message to the flag operators. Flag operators were the final disseminators of the warning messages. To ensure flag hoisting in the villages, CEGIS also sent the same warning SMS not only to the UzDMCs, but directly to the UDMCs and one pre-selected change agent with a mobile phone. Under CFIS, there were two flag sites in each *mauza*. In addition, for effective warning dissemination and to enhance discussions regarding CFIS, the Village Flood Management Committees were expanded to include 20 change agents and 22 volunteers in Dhunail, and 2 separate committees for 2 wards within Baraboinna, comprising a total of 55 change agents and 59 volunteers.

In 2006, the early warning dissemination began operations on 13 July and continued for 90 days throughout the monsoon season. However, the field staff intervened because 2006 was one of the driest monsoons on record and, although people reported that the predictions were generally accurate, they had little interest in the forecasts.

6.5 Year 2007

Since the 2006 monsoon was dry, it was not possible to test the functionality of the CFIS modifications introduced that year. However, in discussion with different government and village level key actors, and through discussion among RTi, BDPC, and CEGIS, it was decided in 2007 to send SMS messages for flood information to more government officers and directly to village level people who could play an important role in warning dissemination. To follow this saturation approach, BDPC registered as many as 99 mobile numbers for automatic SMS receipt at household, community, and institutional (government and NGO) levels.

Cell phone communication through SMS was the key media for the flow of warning message in 2007, complemented by flags. When the CFIS project began in 2003, mobile phone ownership and network coverage in rural areas was low, and it was hardly imaginable that mobile technology would expand as rapidly as is underway. However, by the end of 2006, most of the CFIS area villages had mobile network coverage and many of the villagers in the intensives intervention sites at Baraboinna and Dhunail began to use mobile phone. The early warning dissemination of 2007 had three levels for these two villages:

I. **Household** Level - Mobile phone users of Baraboinna and Dhunail who were interested in receiving SMS early warnings from CEGIS directly were enlisted and received automated SMS. They used the messages for their own preparedness activities as well as disseminating the message to their neighbors.

II. **Community** Level - CEGIS sent SMS directly to the flag operators, who were oriented and who passed on the message. For each flag site, three mobile users agreed to pass on the message, increasing the probability through crosschecking and peer pressure that the flag would be duly hoisted. Again, each group of mobile users linked with a flag operator was to receive SMS from the UDMC. However, the UDMCs were found to be indifferent to transmitting the messages, and the only messages the users received were the automated ones sent directly by CEGIS.

III. **Institutional Level**

Upazila - The UzDMC received messages from CEGIS through SMS. The UzDMC's responsibilities were to transmit the messages to the UDMCs and all the *upazila-level* government officers by SMS, and to monitor whether the UDMC transmitted these messages to the mobile users properly. The UzDMCs used the warnings for their own planning during the 2007 flood, and transmitted the messages when the warnings were considered to be threatening. The responsibility for message transmitting was completely focused on Baraboinna and Dhunail; when the UzDMC felt the situation was sufficiently bad, it decided to warn others. However, despite CFIS work to define the relevance of local flood levels to the communities, the UzDMC was not given specific guidelines on when it should pass on warnings; instead, it depended completely upon its general understanding of the situation. In addition, the UzDMC did not monitor whether the UDMCs and other government departments acted accordingly. The other upazila-level government officers were not very serious in warning local people about floods through their field staff.

Union Parishad - UDMCs received messages through SMS from the UzDMC and CEGIS at the same time. The responsibility of UDMCs was to transmit the message to the flag site mobile users and monitor flag hoisting accordingly. However, the union *parishad* chairmen, despite being the chairpersons of UDMCs, did not show much interest in the system. The UP secretaries, also the secretaries of the UDMC working under the direct orders of the UP chairmen, were expected to implement the warning system, but were inactive presumably because of a lack of direction and priority set by their chairmen.

NGOs - CEGIS also sent SMS warnings to NGOs active in the two *mauzas.* These included BRAC, STEP, Grameen Bank, PROSHIKA, ASA, and Alor Prottasha. They used the information for their own project activities and warned their project staff and participants. ***Hat-Bazar-Mosque committees*** - CEGIS also sent warning SMSs *tohat,* bazaar, and mosque committees in 2007. These committees used the flood warning for their own preparedness and disseminated the message to people involved in their activities.

SchooUMadrasa - Local village school and madrasas played a vital role in disseminating the flood forecasts received from CEGIS through SMS. The school and madrasas could effectively reach local households by sending warning messages through their students. The overall system for flood warning messages in 2007 is shown in *Figure 5.5.*

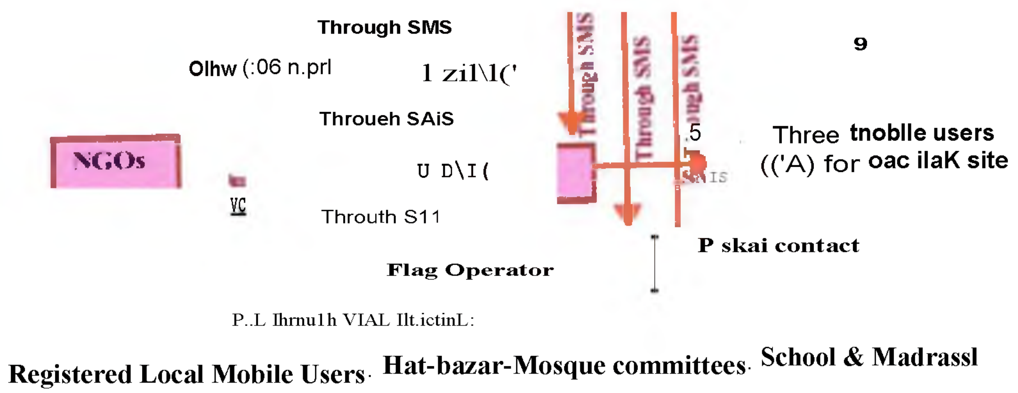

Figure 5.5: Flood warning dissemination pathway in the two pilot areas in 2007

Although the stakeholders of all levels received SMS warning messages from CEGIS, the emphasis was on involving the UzDMC and UDMC through the warning flow system as they were the established government institutions at the local level.

In 2007, CEGIS began sending warning messages to most stakeholders on 8 July, but delayed sending the messages to the *upa:ila* and union levels until the flood levels began to rise on 31 July. In these two pilot areas, the UzDMC and UDMC in the flood warning system were involved for a shorter period in the hope of keeping their interest alive. Messages continued to be disseminated up to i i October. The flag hoisting activities of the flag operators was monitored, and it was reported that the flag raising was fully consistent with the SMS messages. However, the main problem in the 2007 flood in Bara Boinna was that the overall slow-onset flood was transformed into what was, in effect, a flash flood. The flash flood occurred because the bank of the river was high and the land area was low, while the mouth of the canal that flowed through the village and connected with the river was closed due to siltation in the 2004 flood (there was no flood in 2005 and 2006). The canal did not connect with the river, therefore water levels inside the village did not respond to river levels. The local people could not see the changed water level in their village until the water overflowed the river bank within a night, flooding their fields under two to three feet of water. At that time, people saw that the flood predictions matched their observations. From that time onward, the people in Baro Boinna used the disseminated flood predictions for the higher lands that were yet to be inundated.

POTENTIALITY OF MOBILE NETWORK FOR DISSEMINATING FLOOD WARNING

7.1 Assessment of CFIS

CFIS could be termed as an action research and development project. Over the course of the project, much was learned about warning system performance and applied in consecutive years to develop a better framework, strategy, and plan of warning dissemination. Destructive floods are not desirable, yet for testing the system, a serious flood was essential. During the last year of the project, the area experienced two serious flood peaks, providing an opportunity to assess the system performance and its effectiveness for the people at risk. The community- and household-level warning dissemination system was developed through a participatory process. The volunteers and change agents contributed to planning the system and to modifications during the project on behalf of the communities. After training by BDPC, the change agents and volunteers also had the opportunity to more effectively enhance community response to the flood forecasts. Every year, just before the monsoon, the trained change agents and volunteers organized household-level discussions about how to interpret the flags, understand the risk in connection with the hoisted flags, and how to prepare. Thus, the communities were better prepared to make use of any flood warning information received.

Md. Aslarn Sheikh, a farmer of Dhunail Village, received a warning SMS on his mobile on 27 July 2007. He decided to harvest his gourd field although the gourds were not mature. During normal conditions, he would have harvested later to earn about Tk 12,000. By harvesting early he earned only Tk 8,000, but within 48 hours he realized that he did the right thing. The flood that came would have destroyed the entire crop and he would have had no income whatsoever.

Source: *FGD with villagers*

The interview with BDPC's Programme Coordinator reveals that the basic challenge faced in the CFIS project was to disseminate useful and timely flood warnings, and related information to the communities. In these two pilot areas, the dissemination was overall successful, especially in 2007. To ensure location specific early warnings to communities, two routes of dissemination were adopted: one through government channels (UzDMCs and UDMCs) and the other from the forecast agency (CEGIS) direct to the community through mobile SMS, with each having a route into a third visible warning (flags). The second warning dissemination pathway using SMS worked effectively. Through the FGD with villagers it was known that the flags showing the flood forecasts were regularly hoisted and were found to be consistent with the provided information. The communities were interested in receiving early flood warning during the 2007 monsoon. People of different professions made use of the flood information and reported that they reduced their losses and damages from what they might have been otherwise (see *Section 6.3.3).* Conversely, there were some people who did not take interest in or respond to the flood warnings, and some regretted this consequently.

In Bara Bania, Mr. Manik Mondol did not heed flood warnings received on 27 July 2007. His jute field was flooded within 48 hours and, as a result, he had to sell the damaged jute at a low price, losing Tk 8,000. After that, he realized he should have responded to the warning.

Source: *FGD with villagers*

Dissemination of early warning messages was not an assigned responsibility for the local *upazila* administration or local union *parishad* government, and there was no accountability for failing to perform responsibilities under the **standing order on disaster; the reasons are that the government bodies only used the information for their own purposes such as planning relief distribution and response activities.** They **did not take an active role in disseminating warnings to the public or for monitoring CFIS dissemination activities in the two study areas.**

7.2 Warning Use and Impacts

7.2.1 Overview of Warning Dissemination and Use in flood 2007

A total of 443 mobile phones were registered to receive SMS flood information in the two *upazilas,* of which 415 were individual households, 15 were flag operators, and 13 were union *parishad* bulletin board writers. Among the 415 households, 72 households lived in the two intensively supported *mauzas* (Dhunail and Baraboinna). This arrangement in 2007 reflected the project plan to saturate the communities with flood information. There were two flag sites in Bara Boinna and two in Dhunail, with three change agents/volunteers with mobile phones for each of the flag sites who were responsible for disseminating SMS warnings and ensuring flag hoisting through the flag operators. However, in 2007, community level message dissemination was developed that not only was dependent on the change agents and volunteers, but on community mobile users and other local institutions. Boys and girls in the community, those attending school as well as those who did not, could interpret the color and number of flags. Almost all households reported that they had access to flood warnings (see below) and the dissemination of warning messages was as expected. In 2007, two flood peaks occurred. FGD with villagers witnesses that both times, CFIS worked well at community and household levels, and was helpful in reducing people's losses and damages. Evidence of the use of the warnings is given in *Tables 5.1 and 5.2.*

Just over two-thirds of households in the two *mauzas* were interviewed after the first flood peak, and about 40 percent after the second flood peak in 2007 *(Table 5.1).* Approximately two thirds of respondents were housewives since men were often away working when interviews took place, and over 80 percent were over 30 years of age.

^I^▶„^.Y.^: Respondent characteristics for flood information use survey 2007

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ource: *CF1S Yearly final report, 2007.* D11VC

7.2.2 Type of Use of flood **warning in** *flood 2007*

The most common uses, reported during FGDs with villagers, for warnings were for activities that households might undertake as typical flood and monsoon preparedness in Bangladesh, namely storing fuel, and tending livestock *(Table 5.2).* Between one-half and one-third of households made rafts as a means of escape and temporary movement during floods, although few prepared for flooding inside their houses.

i auic J.'&: Type of use made of early flood warning in 2007

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ource: *CFIS Yearly-final report, 2007. DfD/*

7.2.3 Loss ***reduction*** *with flood* ***warning*** *in flood 2007*

Flood warnings also were expected to reduce flood losses to agriculture and other economic activities. However, none of the other project and control households reported crops in the monsoon and so it was not possible to attribute any change in net returns to agriculture to flood warnings, although some of the projects direct contact households reported saving their crops. For other economic activities, both project and control households took damage saving actions with broadly similar benefits *(Table 5.3).* The direct contact households tended to spend more on damage saving actions, possibly having greater confidence due to the warning system, although the few fish farmers who tried to protect fish spent more than was financially worthwhile for them.

Table 5.3: Households that took loss-reducing actions for non-crop economic activities

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8.1 Main Findings and Lessons Learned

The CFIS project has demonstrated that it is possible to generate reasonably accurate flood forecasts, particularly of forecasted water level change, for specific local areas of floodplain, and to disseminate the appropriate local warning messages through an automated system based on mobile network to the many people living within the floodplain through a mixture of direct SMS, flags, and word of mouth.

8.1.1 Achievements in CFIS

Specific major accomplishments and findings include:

- Developing innovative dissemination methods that are semi-automated, where one operator can reach thousands of people through the rapidly expanding coverage and ownership of cell phones - SMS messaging directly to the community (developed in 2007) is the future. SMS text messaging allows for forecast information to be fed through multiple pathways to local governments, to key opinion leaders-such as school teachers, imams, and shopkeepers-and directly to vulnerable households. Recipients had previously agreed to, and succeeded in, passing on warnings to their neighbors and wider community, and this was reinforced by a network of flag sites, bulletin boards, and awareness raising exercises.
- Using public-private partnership and cell phone technology to disseminate flood warning information is also an important trend. The opportunity for partnerships is growing rapidly, particularly for using technology for development. All of the three cellular telephone companies approached by CFIS were interested in supporting the project with low- or no-cost dissemination of flood forecasts via SMS as an area of corporate social responsibility. CFIS secured an agreement with Banglalink, the second largest mobile company, for transmitting flood forecasts via SMS for both the 2007 and 2008 flood seasons at no cost. This pilot arrangement is the first known in Bangladesh for using mobile phone technology to disseminate early warning messages; such arrangements will be critically important as effective, low-cost methods for operational early warning for floods and other hazards.
- CFIS works! Communities developed their own preparedness plans and people use and appreciate the flood warnings and information that reach them, and have shown

that local community organizations and institutions, when guided by NGOs, are effective warning agents.

- Centrally, the Flood Forecasting and Warning Center is enthusiastic about the approach and reaching communities with warnings.

The positive results in 2007 raise the scope for replicating the CFIS concept through projects and organizations such as the Comprehensive Disaster Management Project, WFP, and other government projects. A more intensive community-based warning dissemination mechanism was developed and demonstrated to work in two pilot villages.

This success depended on:

1. Relevant and timely flood forecasts reaching local warning dissemination agents.
2. These agents implemented multiple effective warning dissemination mechanisms that were self reinforcing.
3. The communities were consulted about, and took ownership of the system.
4. Local people developed their response capacity to the specific flood warnings they could expect, and could interpret their own livelihood implications and make appropriate responses.

8.1.2 Qualifications and Issues

The use of SMSs for warning dissemination to the public was very effective in directly reaching households, and it reinforced messages for flag hoisting for community level dissemination, which was also highly appreciated by local people. However, in the future, the flag operators expect to receive some payment for the service they provide. The schools played a significant role for warning dissemination and awareness building. It was reported that even young schoolchildren were well aware of flag meanings and they updated their families on water level information every day during the monsoon. The *hat* and bazaar committees shared the information among local people for their safety. Hence, the set of local stakeholders and mutually reinforcing messages from several sources helped to ensure that warnings reached those people living close to the flag posts. However, this appeared to result in a division of local communities - those who got warnings from multiple sources and those who were left out. Lastly, establishing formal and effective flood warning dissemination systems that meet community needs will require long-term attention.

8.1.3 Opportunities

Based on this pilot project and the lessons learned, there are now major opportunities to improve the lives of floodplain people through expansion of the CFIS approach:

- **People use and want flood information.**
- **Private sector development in cellular phone/SMS technology is tremendous.**
- **Cell phone companies are interested in offering warning services as corporate social responsibility.**
- **Public-private partnerships could include free flood warning services, more detailed flood information where customers pay for SMS, and joint sponsorship of expanded** CFIS.
- **There is substantial scope to leverage support through other existing projects and the current interest of development partners.**
- **The approach and warning dissemination methods can be adapted for use in all types of flood hazards in Bangladesh, including flash floods and cyclone storm surges.**

8.1.4 Limitations

WATSURF is a very expensive **to maintain**. FFWC already faces difficulties to maintain the guages in main river points. Though WATSURF model is proved to be very efficient but it is almost impossible for FFWC to **maintain** such a huge number of guages and manage such a bulk of information with its existing limited resource and capacity. This model is applied to produce **area** specific flood information **in some** portions of two flood prone upazilas only. To cover the entire floodplain of Bangladesh with this model seems ambitious. But it **is at least** possible to disseminate FFWC'**s existing** flood information through SMS using the symbols (i.e. `-' and `+') for greater dissemination of flood warning in floodplains. So, one of the existing three major limitations of flood forecasting and warning system, i.e. warnings are not **area** specific, cannot be addressed if WATSURF cannot be exactly adopted by FFWC.

8.2 Recommendations

8.2.1 Expansion and Replication

The effectiveness of SMS information dissemination raises the issue of message costs - each SMS, even in bulk, would cost about I Taka, and if 90 messages were issued in a flood season for each of the millions of floodplain inhabitants who by now have mobile phones, the commercial cost would be quite large. Contrasting this is the opportunity for mobile phone companies to make an innovative public-private partnership and provide such a service free or highly subsidized, as part of the corporate social responsibility of a rapidly growing and very profitable business. The most feasible approach, therefore, is to disseminate flood information in the floodplains depending on mobile network. This can be done through orienting local governments and administrations regarding flood information symbols.

8.2.2 National Institutional Arrangements

Currently in Bangladesh, there is a wealth of government agencies involved in flood management and response, but a lack of clear legal responsibilities for providing flood warnings (something that internationally is an important aspect of effective systems). Moreover, there is a lack of organizations that have a large workforce on the ground that could disseminate warnings. CFIS addressed this through a mix of voluntary visual and individual warning disseminators linked with the ad hoc VFMCs. Any links with national institutions came through CEGIS. For the long-term mainstreaming of CFIS type of initiative, it should be formally linked to FFWC under a long-term agreement with CEGIS. As a government supervised organization, CEGIS has a mandate to support bodies such as FFWC under the Ministry of Water Resources. This would take care of forecasting and warning message generation. The combination of public-private partnerships for SMS and local government and local informal institution/CBO partnerships for flags and local warning networks, would maintain the warning dissemination system. To oversee this, one unit would need to be established to review operations and advise the stakeholders in the system, as well as to be a channel for feedback to the technical flood forecasters for identifying any need to update or adjust the system.

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