Bangladesh

Flood Warning

Manual

Final Draft May 1997

Foreword

This Bangladesh Flood Warning Manual has been prepared as part of the Flood Action Plan, FAP10 Expansion of Flood Forecasting and Warning Services. The framework for a comprehensive and integrated approach to flood preparedness and response is presented in the form of a Flood Forecasting, Warning and Response System (FFWRS) for Bangladesh. This Manual describes the principles and components of the FFWRS in non-technical language.

The Manual provides background information on flooding in Bangladesh, set within the context of the Bangladesh Water and Flood Management Strategy, and describes the complexity of the flood problem of the country. It defines the components of a flood warning system and describes a suite of information and warning products. The role of public education in improving responses to flood warning and most importantly the significance of effective dissemination of warnings are amplified. It also underscores the crucial roles of the Flood Forecasting and Warning Centre of Bangladesh and Disaster Management Bureau in the process.

It is intended that the Manual will assist elected representatives, policy makers, officials and others who contribute to the development of strategies for flood management in their tasks. It also provides guidance to anyone who has a role to play in flood warning and flood response activities. The importance of an integrated approach across all agencies with a role to play in flood preparedness and response, inherent in the Standing Orders for Disasters, is fully recognised in the FFWRS.

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Executive Summary

Floods are normal events in the deltaic plains of Bangladesh. They often have disastrous consequences: great loss of property, human suffering and impoverishment of the poor. The expansion of Flood Forecasting and Warning Services (FAP 10), which is an important non-structural project of the Flood Action Plan (FAP), now forms Project 20 in the Bangladesh Water and Flood Management Strategy. It aims at providing improved flood forecasting and warning services; in particular to empower vulnerable people, at grass-roots level, to cope more effectively with flood disasters.

Chapter One describes the nature and causes of flooding in Bangladesh, and places flood warning in the broader context of the Bangladesh Water and Flood Management Strategy and non-structural approaches to flood management.

Chapter Two develops the principles of the total Flood Forecasting, Warning and Response System and describes its basic components: forecasting, interpretation, dissemination, response and review. It discusses the important roles that the media, public education, and public participation contribute to the system.

Chapter Three explains how forecasts of future river levels are produced and describes how this critical role is performed by the Flood Forecasting and Warning Centre of Bangladesh Water Development Board.

Chapter Four discusses and explains the principles and processes required to convert the essentially technical information contained in flood forecasts into meaningful warning messages. Simple messages are used to communicate only essential information.

Chapter Five covers the dissemination of warnings and the associated communications arrangements. The FFWRS uses two complementary routes to get warnings out into the community. Warnings are issued to TV and Radio for broadcast on national and local services in all appropriate languages and dialects. Warnings are also transmitted to Deputy Commissioners [using one of the Government departmental radio systems] and then onward to Thanas for local distribution. Flood Marker Posts installed in villages provide a local reference level that can be related to the warning message.

Chapter Six discusses the importance of regular review and refinement of the FFWRS in order to improve its effectiveness year on year by learning from experience in its application.

The flood problem in Bangladesh is extremely complex. There is a number of reasons: the country is an active delta; it has extensive flood plains into which about 1.7 million km^2 drain; and it has an extensive network of rivers and canals. Unplanned and unregulated construction in the flood plains impedes the natural flow of water. Flooding leads to frequent and increasingly costly damages.

Regular inundation in most years of low lying farm land is a very common feature of Bangladesh. Three types of river flood cause disruption and damages in Bangladesh - Monsoon Flood, Flash Flood, Rainfall Flood. The three main categories of flood intensity are Medium, Severe and Catastrophic.

An effective warning system can reduce flood damages. The FFWRS presents a flood warning philosophy to inform and guide effective flood warning practice in this country. The phasing of flood warnings has been devised to correspond with the onset and severity of damage caused by increasing flood intensity. The Flood Watch is the first phase which, in line with the Standing Orders for Disasters, alerts agencies responsible for flood mitigation at an early stage about a possible threat of flood. No warnings would be issued to the public. Flood warnings are issued to the public for Medium, Severe and Catastrophic floods.

The construction of effective flood warning messages is a complex task. Messages need to be short, informative and prompt a response from recipients. The model messages are presented in Appendix 3.

The effective dissemination of flood warnings is a challenging task in the flood prone terrain of Bangladesh where the communication network is developing slowly and illiteracy is high. A major consequence of flooding is the disruption of all forms of the communication network. The manual stresses the need for developing and using all channels - mass media and interpersonal communication, using local dialects for widespread dissemination of flood warnings.

Comprehensive reports are required by decision makers and executive agencies. The FFWRS replaces Flood Bulletins and Flood Summaries, with a number of more functional products which includes a Daily Rainfall and River Digest, Daily Flood Bulletin and Weekly Flood Bulletin. Flood Warnings are separated from Forecasts and other products to make them stand-out as urgent and important.

The dissemination of warnings does not automatically lead to appropriate responses from the vulnerable population. A full understanding peoples' flood behaviour may take years to achieve. Messages will need continuous refinement to be effective.

As the FFWRS requires a staged development, its performance must be continuously monitored and evaluated. Review and feed back have been built into the FFWRS of Bangladesh to ensure it will be of value to many agencies, but most particularly to the Flood Forecasting and Warning Centre, and to all others concerned with responding to floods.

The Manual provides an indispensable guide to 'best practice' for the delivery of warning services and contributes towards achieving the goals proposed by the Water Resources and Flood Management Strategy of Bangladesh.

Chapter One

The Flood Problem in Bangladesh

1.1 Bangladesh is a young delta formed by deposits of mud and sand left behind by three of the largest river systems of the world - the Ganges, Brahmaputra and Meghna as they eventually empty into the Bay of Bengal. The processes of siltation, changes of the river system and tectonic movements are still going on.

1.2 Flood occurs at a high water stage when the flow overtops natural or artificial embankments along a stream. The Ministry of Water Resources also views it as the rise of water in a natural stream above the level associated with the beginning of damage. Damage usually starts when the flow overtops the river banks. (Ministry of Water Resources, 1995a).

What is flooding?
When the level of water in a stream overtops natural or artificial banks, water overflows on to the flood plain and affects human activities. Flooding occurs when water levels rise above the level associated with the beginning of damage and disruption.

1.3 About 80 percent of the country lies in flood plain. Half of the country is within 8 metres above the mean sea level. Normal monsoon rainfall submerges about 20 per cent of the land (Sklar and Dulu 1994). This inundation is a normal phenomenon in Bangladesh, but often it can become a more extensive flood disaster.

1.4 Flood disasters have been causing enormous damage to life and property and immense human suffering over a long period of time. In 1955 about one third of the country was affected by floods. Catastrophic floods occurred in 1987 and 1988. The flood in 1988 affected 90,000km^2 of the area and 30 million people. A total of 2,330 (ISPAN 1992) people died as a direct result of the flood. The damage was estimated to be $US1,200 million (ISPAN 1992a).

What is disaster?
A disaster is an extreme event which needs exceptional response measures requiring additional resources often from an external source. It causes severe damage and losses to people and society in a way that normal activities are seriously disrupted. (A more detailed definition is given in the Standing Orders for Disaster.)

1.5 The spectacle of death and destruction during the flood of 1988 galvanised the government of Bangladesh and donor countries to implement a comprehensive Flood Action Plan (FAP) from 1990. One of the major objectives of the FAP was to explore the flood problem in Bangladesh. Establishing an effective flood warning system is one of the projects in the Plan.

Flood Problem

1.6 An understanding of what causes floods and the principles for flood management is required to appreciate the basis on which the flood warning system has been developed. Discussion is simplified by the use of common terms for the types and intensities of flood.

Causes of Flooding

1.7 Floods in Bangladesh occur for a number of reasons. The main causes are excessive precipitation, the low topography and flat slope of country.

- The geographic location and climatic pattern: Bangladesh is located at the foot of the highest mountain range in the world, the Himalayan range, which is also the highest precipitation zone in the world. This rainfall is caused by the influence of the south west monsoon. Cherapunji, the highest rainfall area in the world, is located a few miles northeast of the Bangladesh border.

- The confluence of three major rivers: the Ganges, the Brahmaputra and the Meghna. The runoff from their vast catchment (about 1.7 million km^2) passes through a small area: only 7.5 percent of these catchments lies within Bangladesh. During the monsoon season the amount of water entering Bangladesh from upstream is greater than the capacity of the rivers to discharge it to the sea.

- Bangladesh is a land of rivers: there are about 230 major and minor rivers in the country. The total annual runoff of surface water flowing through the rivers of Bangladesh is about 15,000 billion cubic metres per year (BANCID, 1995).

- Man-made Environment: the construction of embankments in upstream catchment areas reduces the capacity of the flood plains to store water. Higher flows are passed downstream and increase the flood levels downstream in Bangladesh. The unplanned and unregulated construction of roads and highways in the floodplain, without adequate culverts, creates obstructions to flow. These increase the impacts from flooding at a local level in Bangladesh. Embankments create particular difficulties for providing effective warnings since it is difficult to predict the movement of the flood waters.

- The influence of tides and cyclones: the frequent development of low pressure areas and storm surges in the Bay of Bengal can impede drainage. The severity of flooding is greatest when the peak floods of the major rivers coincide with these effects.

- Long term environmental change: climate changes could influence the frequency and magnitude of flooding. If patterns of rainfall change to give higher monsoon season rainfall more flooding would take place and may occur more often. A higher sea level will inhibit the drainage from the rivers to the sea and increase the impact of tidal surges. Deforestation in hilly catchments causes more rapid and higher runoff, and hence more intense flooding.

Flood Types

1.8 River flooding in Bangladesh takes three main forms as a result of different rainfall and hydrological conditions. Each form has a distinctive hydrograph shape (rate of rise and fall of the river) and characteristics:

1.9 **Monsoon Floods:** Major rivers and their side channels overflow causing extensive areas of inundation. The rivers rise slowly and with a slow recession may remain high for many weeks. Flood peaks occurring simultaneously on the three main rivers can cause particularly extensive flooding.

1.10 **Flash Floods:** Flash floods occur mainly in eastern and northern rivers accompanied by a rapid rise and fall in water levels. The sudden onrush of water from nearby mountains and high flow velocity cause intensive damage to crops and property.

1.11 **Rainfall Floods:** High local rainfall intensities and long duration monsoon rainfall cause flooding due to inadequate local drainage. The typical hydrograph shape has a steep rising limb and a slow recession.

1.12 **Coastal Flood:** The low-lying coastal area of Bangladesh has a complex network of estuaries and tidal floodplain. This area is frequently flooded by high sea levels and waves resulting from cyclonic storms in the Bay of Bengal.

1.13 The following excerpt succinctly describes the pattern of flooding in Bangladesh.

The normal sequence of flooding starts with flash floods in the northern and eastern hill streams during the pre-monsoon period in the months of April and May. The monsoon sets in the June, and the Meghna and Brahmaputra generally reach flood peaks during July and August, respectively, whereas the Ganges normally peaks during August and September. Heavy flooding generally occurs during August and September.

The Ganges begins to rise in May, and the period of maximum flow is well centred in July and August. Occasionally, September is a month of severe flooding. Floods in the Ganges basin in Bangladesh are mainly in the form of overbank spilling. Frequent overbank spilling with inundation for a considerable period is observed mostly in the areas southeast of Gorai. The flood situation deteriorates when the Brahmaputra remains in spate, transmitting backwater into the Ganges.

The Brahmaputra starts rising in March due to snow melt in the Himalayas, which causes a first peak in May or early June. It is followed by subsequent peaks up to the end of August, caused by the heavy monsoon rains over the catchment. The response to rainfall is relatively quick, resulting in rapid increases of water level in the river. Six to ten days elapse from a period of rainfall in the upper catchments until the corresponding peak is felt within Bangladesh.

Flooding in the Brahmaputra is characterized by large -scale overbank spilling; erosion at various locations leading to lateral shifting, pronounced on the right bank; formation and disappearance of shoals; and conveyance of a huge silt load carried from upstream. Water backup is observed in the Atrai area of the northwest region during the high river stage of the Brahmaputra. When a peak stage of the Brahmaputra coincides with a peak stage of the Ganges, heavy flooding occurs.

Source : Nishat and Hossain, 1989 : 32.

Strategies for Flood Management

1.14 There are two main approaches for flood management- structural and non-structural.

Structural Measures of Flood Management

1.15 The structural approach uses physical prevention or diversion of the flood to reduce the impact. Structural measures include construction of dams and reservoirs to hold flood water and the building of embankments to prevent water inundating flood prone lands. Other measures include river training or straightening of channels to permit a faster flow of water.

Non-Structural Measures of Flood Management

1.16 Non-structural measures of flood management reduce flood losses through regulations for construction and other activities on the flood plain, and by preparing and empowering vulnerable people and communities to cope more effectively with flooding. These include zoning controls, regulation of constructions in the flood plain, flood proofing of dwellings, flood forecasting and warning systems, flood preparedness, public education and flood insurance.

1.17 A flood warning system must be part of a broad flood management perspective with the emphasis on co-ordination between flood warning and other flood mitigation measures.

1.18 The objectives of flood warning are to enable and persuade people and organisations to become prepared for the flood and take action to increase safety and reduce damage. Its goals are to alert the 'combat' agencies to enhance their preparedness and to motivate vulnerable communities to undertake protective measures. These measures include (inter-alia):

- stocking up on food, fodder and other essentials
- construction of raised platforms for stocking up essentials
- provision for safe drinking water
- reinforcement of dwellings
- preparation for evacuation
- taking shelter

1.19 The Government of Bangladesh has recently published a report describing a comprehensive Water and Flood Management Strategy (Ministry of Water Resources, 1995b). The minimum intervention approach strengthens the capacity for flood forecasting and disaster management.

Disaster Management

1.20 Flood warning can only be fully effective within a wider disaster management framework that ensures local level flood preparedness. This is provided by the Disaster Management Bureau and the Standing Orders for Disasters (SOD), which require the local administration to disseminate warnings to the communities at risk. SOD also define the roles of those who must provide facilities for evacuation, flood shelter, emergency provision of food, essential medical supplies, pure drinking water and undertake other necessary measures.

Flooding Impacts and Damage

1.21 Flood severity has been classed in four levels according to their impacts on the community and the magnitude of damage. Table 1 is a matrix illustrating the features of the annual inundation and flood severity. It demonstrates how with increasing severity the nature of the advice to the population at risk needs to change. It provides the basic framework for a system of phased messages (see Chapter Four) and guides their design plus the development of publicity and educational materials.

1.22 **Normal Flood:** Regular inundation of low lying farm land is common in Bangladesh. It occurs almost every year and farming practices are well adapted. No warnings are issued, but forecasts issued to local Agriculture Officers enable them to issue advice on cropping and sowing to minimise crop losses.

1.23 **Medium Flood** causes some economic loss and damage to property but is not extensive or too serious. A medium flood affects farmers and others living in low lying areas and on land adjacent to rivers. Loss of life is unlikely as the affected populations are already prepared to respond to such a flood since they experience this regularly, about every 3 years.

1.24 **Severe Flood** occurs as river levels continue to rise affecting larger areas and those parts of the population less familiar with flooding. It inundates some urban areas and the risk to life is higher. Economic and property damage would be significant. This scale of flooding is likely to be experienced once in every 6 years on average. Warning messages contain outline guidance on flood response.

1.25 **Catastrophic Flood:** an extremely devastating flood, with impacts comparable to those of 1987 and 1988. Most of the population will be affected and serious damage will occur. Warning messages contain advice to those affected on what action they need to take, since many people, especially those living in urban areas, are unlikely to have experience in coping with such a flood.

TABLE 1 - FLOOD INTENSITIES AND CLASSIFICATION INTO PHASES FOR WARNING MESSAGES
(*Frequencies and inundation figures based on BANCID & Report on Floods of North Bengal in 1995)

FLOOD INTENSITY	NORMAL	MEDIUM	SEVERE	CATASTROPHIC
FREQUENCY	every other year	1in 3 years	1 in 6 years	1 in 9 years
LIKELY STATE OF PREPAREDNESS	high through experience	adequate but limited	some but limited	minimal, soon forgotten
IMPACT & DAMAGE	minor	some economic loss in low lying areas	high economic loss and risk to life	major and extensive economic loss; serious risk to life
AREAS AFFECTED	agricultural land	rural communities	rural and some urban	everywhere
INUNDATION	limited to low areas	affects <25% of country	affects 25-35% of country	affects >35% of country
COMMUNICATIONS	minimal effect	local disruption	serious disruption within affected areas	widespread across country as a whole
PROPERTY AND INFRASTRUCTURE	minor, if any	mainly rural affected	heavy losses	major losses
WARNING MESSAGE PHASE	forecasts only	1. GENERAL	2. SEVERE	3. WIDESPREAD
COLOUR		blue	red	red (top of band)
NEED FOR ADVICE IN WARNINGS	advice from local advisors who receive forecasts	some in general terms (most will have flood experience)	considerable (prior experience is likely)	total (many will have no recent experience of a flood and not be prepared)

Chapter Two

The Total Flood Warning System

Why are Flood Warnings needed ?
Flood warnings provide prior notice about the threat of impending flood hazards to enable `combat agencies' and vulnerable people to take appropriate action for minimizing the impacts of flooding before it occurs.

How can the effectiveness of Flood Warnings be assessed ?
Flood warnings are effective if they persuade people to prepare for floods and 'combat agencies' to carry out disaster management activities. The effectiveness of the warning can be assessed through an examination of the effectiveness of components of the total flood warning system.

Flood Forecasting, Warning and Response System (FFWRS)

2.1 The WMO Guide to Public Weather Services [WMO No. xxx] proposes a set of Guiding Principles on the supply of information to the population. These have been amended for application to flood warning in Bangladesh.

2.2 The Water Resources and Flood Management Strategy of Bangladesh has given particular emphasis to the development of forecasting and warning services. Effective flood warning requires a total systems approach. It is a system with a number of components each of which is essential for achieving the goal of flood warning - reduction in damages. It is also a process which involves coordinated activities by many agencies and people. The components of this total system make up what is referred to as a Flood Forecasting, Warning and Response System (FFWRS). This term will be used to describe the system throughout this manual.

Guiding Principles for a Flood Warning Service in Bangladesh

1 The population has a right to a basic service providing Flood Warnings for their safety, security, convenience and economic benefit.

2 All publicly disseminated Flood Watches and Flood Warnings will originate from FF&WC as the single official source. All media organisations will identify FF&WC as the originating authority.

3 River Forecasts, Flood Watches and Flood Warnings will be issued, whenever possible, to provide sufficient advance warning of significant events to enable the public to take action to minimise adverse impacts.

4 River Forecasts, Flood Watches and Flood Warnings will be expressed in clear, concise and unambiguous terms and in languages readily understandable by the public.

5 Appropriate dissemination methods will be chosen to ensure the widest possible distribution of all products. Priority and particular attention will be given to Flood Watches and Flood Warnings.

6 Arrangements will be developed with the media and Disaster Management Bureau to ensure that Flood Watches and Flood Warnings are delivered in the most effective and efficient manner.

7 Emphasis will be placed on educating the public to understand the role of FF&WC, its products and their relevance to flood preparedness.

8 Regular consultation will be held with users and other agencies to explore ways in which FF&WC services can be refined to best meet their needs.

9 The accuracy, timeliness and distribution methods of River Forecasts, Flood Watches and Flood Warnings plus the penetration of their dissemination will be continuously monitored and verified. Information obtained will be used to revise and improve the service.

2.3 The broad definition of a Flood Forecasting, Warning and Response System (FFWRS) is a system which integrates flood forecasting, assessment of flood impact, the dissemination of warning messages and the responses by both the agencies involved in flood mitigation and by the public in the threatened communities. FFWRS as consists of five components.

The Five Components of the FFWRS

Forecasting: Forecasting predicts the occurrence and magnitude of a flood in advance on the basis of previous and current meteorological conditions, water levels, river flow velocities and other hydrological characteristics.

Interpretation: Identification of probable impacts of flood upon vulnerable communities in advance, plus the use of signs, symbols and words to warn people about the onset of flood and its probable impacts.

Dissemination: Communication and distribution of warning messages to agencies involved in flood mitigation and, most importantly, to the threatened communities.

Response: Preparation and action by concerned agencies and threatened communities for protection against flood hazards in response to warnings.

Review and Analysis: Continuous monitoring of the performance of the various components of FFWRS for its improvement.

Developing an Effective Flood Warning System

Flood Warning
A notice of impending flood threat issued to the public by the competent authority (FF&WC) so that people and organisations can undertake necessary precautions or protective behaviour or help towards their achievement.

2.4 A successful and effective FFWRS depends upon many factors. It calls for a good level of forecasting accuracy. It needs sound technological and organisational infrastructures and particularly needs effective inter agency liaison. It also requires effective communication. This demands correct interpretation of technical data; easy to follow messages with adequate information and successfully delivered to threatened households. Messages should be delivered through all possible communication channels and be communicated in all major dialects, so that they can be understood and followed by different regional and cultural groups. It is important to appreciate that exposure to flood warning messages does not automatically lead to protective behaviour among the threatened people.

2.5 Flood forecasts have no value if they are not received by the agencies and people concerned and acted upon. Until recently, considerable emphasis has been given, in many countries, to flow forecasting and modelling. This had led to a wrong notion that forecasting is the only key component of a flood warning system. Consequently, weaknesses of warning systems have been attributed to inadequate technological infrastructure, often resulting in further emphasis on and investment in technical solutions. It is now recognised that inadequate attention has been given in the past to the non-technical features of a warning system (eg dissemination, flood education and preparedness). As a result these have been weak elements of many flood warning schemes worldwide.

2.6 Flooding in Bangladesh can cover almost 90,000km^2 (see Figure 1). It will never be possible to provide accurate forecasts of river levels at all points on the river systems so some extrapolation will always be necessary. Nevertheless useful warnings can still be provided to allow appropriate response measures to be taken and, with regular review, the forecasts will continually improve.

2.7 A vigorous programme of public education about flood hazards and protective measures is necessary to achieve positive responses. There must also be adequate physical facilities, other resources and trained manpower at the local level for a fully effective initial response to all flood emergencies.

2.8 An effective FFWRS consists of the following elements and development activities:

- implementing an integrated planning process to develop all elements of the ffwrs
- identification of all the stakeholders
- establishment and definition of roles, responsibilities and of boundaries among different stakeholders
- promoting cooperation between agencies
- identifying and resolving potential bottlenecks or conflicts among different stakeholders
- developing forecasting and warning procedures: good forecasts of river flow, simple warning messages
- developing arrangements for rapid dissemination
- creating appropriate back up procedures in case of the failure of the main system
- adopting and implementing training and public education programmes for stakeholders

Identifying Stakeholders

2.9 In any FFWRS there are many stakeholders (agencies and groups) with different interests, roles and responsibilities. The communities at risk, which consists of a number of smaller groups scattered over different areas with varying needs, are also key stakeholders.

figure 1: Map of Flood Forecast Stations and Extent of Flooding in 1988

Stakeholders in the Flood Forecast and Warning Response System

Agency/ Group	Role/Interest
Bangladesh Flood Forecasting and Warning Centre	forecasting and warning
Ministry of Water Resources	broad flood protection measures
Ministry of Disaster Management and Relief	warnings, relief, rescue and rehabilitation
Disaster Management Bureau	dissemination of warnings, public education, training and establishment of disaster management networks
Ministry of Information	dissemination of flood warnings
Mass media Radio, TV, Press	dissemination of flood warning and feedback on flood situation
Police/Ansar/VDP	dissemination of warning, rescue and relief
Bangladesh Meteorological Department	weather forecast
Space Research and Remote Sensing Organisation	analysis of satellite images of weather condition
Army(when called upon)	rescue, relief and rehabilitation
Deputy Commissioners and TNOs	dissemination of flood warning and feedback on flood situation, rescue and relief
Ministry of Communication	dissemination of warning, rescue and relief
Ministry of Fisheries and Livestock	provide protective measures for fishing boats and vessels, preparation for providing veterinary services
Ministry of Agriculture	advice on cropping pattern, planting, harvesting, supply of inputs in the post-flood phase
Ministry of Health and Family Welfare	provide general medical advice; provide specific health advice to vulnerable people; provide medical service and medicines during and after flood
Bangladesh Red Crescent Society	warnings, relief, rescue and rehabilitation
NGOs	warnings, relief, rescue and rehabilitation
Fire services	rescue in urban areas
Urban authorities and communities	protective measures
Local Government agencies	protective measures
Rural Communities	protective measures
Roads and Highways	main road communications
LGED	rural road communications

Extreme Flood Events

2.10 An important component of planning for flood warning systems is to make them robust enough to be able to deal effectively with floods which are greater than those in the past.

> Catastrophic floods are a constant threat to Bangladesh. Agencies and communities must recognise that they will have to face flood disasters greater than those they have dealt with in the past. Flood Warning Systems must be robust enough to cope with calamities which are unprecedented and worse than those experienced in the past, or expected.

2.11 The flood which occurred in 1988 in Bangladesh is a good example of a catastrophic flood event. That flood began in early July and lasted until the end of September. The whole country had turned into a mass of water marooning 5 million people.

2.12 Two examples illustrate and underscore the importance and need for effective flood warning of extreme flood events. The first is a description of an experience in 1988. When the 'fury of water' caught people unaware.

BWDB Estimates of 1988 Flood Damage

affected area	89,970 km^2
affected people	30 million
houses damaged:	
totally	989,347
partially	1,477,772
loss of human lives	2,330
loss of cattle heads	64,170

Source: Ahmed 1989; Siddiqi 1996; ISPAN 1992a

> *Another question is whether it is possible to forecast the occurrence and incidence of flood before hand and if so, why this has not been done. In many areas, people were caught completely unprepared. Several million people were marooned and there was no warning. The city of Dhaka was gripped by flood water all of a sudden and many of them could not even manage a few hours time to shift their valuables to other places.(Ahmed 1989:11).*

2.13 The flood of 1995 was again unexpected as it happened at the end of the monsoon flood season. Although warnings were issued, their dissemination was extremely inadequate. An editorial of the Daily Star (30 October 1995) remarked:

> *The daily average rainfall surpassed previous records both inside the country and as well as in the upper riparian regions. The Met Office only underlined this phenomenon in broad terms but could not predict the timing, duration and nature of an upcoming flood.*

2.14 This was both an unexpected flood, as the exceptional rainfall had not been forecast, and in some places was like a flash flood due to the short lead time for warning. The significance of any warning messages were not appreciated nor did they get across clearly to the media or public.

Role of Response Agencies

2.15 Organisational preparedness is essential to ensure that activities such as sheltering and feeding people, giving them relief and other related operation can be rapidly mobilized.

2.16 For warnings to be effective agencies involved in `combat' activities must know what roles they are supposed to play after the warnings have been issued. (Community responses follow from and also depend upon agency responses.) Flood warning responses are likely to improve with the improvement of flood mitigation services by agencies. Flood response planning can guide the design of the warning system, in particular the requirements of flood forecasting.

Public Education

2.17 Public education can play an important and major role in enhancing preparedness for flood by ensuring that communities can cope better with flood disasters. The frequency of flood events and their severity require that all techniques of public education are exploited to their fullest potential.

2.18 School text books require information on floods and flood warnings. Non-formal education and adult literacy campaigns should incorporate these issues. Booklets, posters and manuals on flood should be provided to all libraries, thana headquarters and union parishads of the country. Every NGO should impart warning and preparedness knowledge about flood.

2.19 Newspaper features, radio and television talks before the flood are also important means of public education. Displays of flood maps and action guides in schools, union parishads and Thana headquarters should be available. The anniversary of a particularly significant flood should be used as an occasion to raise flood awareness.

2.20 Flood markers in vulnerable villages or unions indicate the level of past floods to local people. They can also be used to link the content of the warning message with the predicted impact.

2.21 Bangladesh has a rich heritage of folk culture. Folk media, like ***Jatra***, ***Jari*** and other forms of folk culture have popular appeal among the peasantry, in particular. Dramatic performances and songs can incorporate themes about flood preparedness and warnings and thus provide information to rural people effectively.

2.22 Planning a programme of public education needs to draw upon the `community memory' of flooding to ensure that the ways in which flooding affects those at risk are effectively communicated. Planners must listen to those at risk as well as seeking to educate them (Australian Manual:6).

2.23 Warning messages will be most effective if they are preceded by a well coordinated and vigorous programme of public education. The winter is the best time for undertaking public education campaigns.

Agency Plans, Resources and Exercise

2.24 Flood forecasting, warning and response systems require planning, appropriate policies, organisational efficiency, inter agency cooperation and financial investment.

2.25 Both flood warning and flood related disaster management require substantial resources. This does not necessarily mean investment in expensive hardware or construction activities. Better use of existing facilities, technology and organisational capabilities and gradual investment in new technology can keep the level of financial investment low. For example, new schools can be constructed for use as flood shelters.

Reliable forecast and effective warnings help maximise the quality of the actions by response agencies when floods are rising. Standing Orders for Disasters require that all these agencies must prepare Action Plans to maximise their preparedness. They should also practice their roles during normal times.

2.26 The agencies involved in flood 'combat' activities must be ready for warning and emergency response activities to the disaster. A great deal of planning and co-ordination is necessary for this purpose. They should also conduct regular exercises in Winter or Spring to increase their state of preparedness.

2.27 As many agencies are involved in these activities, it is necessary to allocate proper roles and tasks to each agency. This is done by the Standing Orders for Disaster issued by the Government, which also requires relevant agencies to have Action Plans to provide flood warning and other services to vulnerable people and communities. Disasters often create unexpected situations and agencies should be organisationally flexible to cope with extraordinary situations.

Chapter Three

Flood Forecasting

3.1 Flood forecasting is a technical activity which estimates future river levels on the basis of analysis and simulation of current meteorological conditions, the flow and level of rivers or lakes and other hydrological characteristics. The flood forecasting element of a FFWRS comprises two main activities:

- Data Collection and Transmission
- River Modelling

How are forecasts made?

- by monitoring snow melt, rainfall, runoff and other factors in the upper catchment
- by measuring rainfall and river levels at important locations in the river systems of the country
- from forecasts of tides and tidal surges
- by using mathematical techniques and models to predict future river levels

Catchment Monitoring and Forecasting

3.2 The forecasting of floods depends upon regular monitoring of the actual and anticipated rainfall and river conditions and other changes in the environment of the catchment area. As Bangladesh comprises only 7.5 percent of the catchment area and data flow from countries of the upper catchment is intermittent, this makes it more difficult to carry out flood forecasting in Bangladesh.

What are the critical issues ?

- all stakeholders should recognize the value and importance of flood forecasts
- the stakeholders should understand that forecasts may occasionally be wrong

The Elements of Flood Forecasting

3.3 Information on rainfall and river flows is essential to know how much water is entering the country and flowing through it to the sea. Computer models, which represent the physical characteristics of the river network and the hydraulic process of water flow, can transform the data through successive intervals of time to predict levels in the major river channels of Bangladesh for up to 3 days. In this way it is possible to make forecasts of both future and downstream river conditions. Where the catchment is small and the river is steep, like many in the north east, rivers rise very quickly and forecasts will be limited to a few hours ahead.

Recent developments in satellite imaging provides an important database for early prediction of flooding in Bangladesh. Its use requires close coordination between Space Research and Remote Sensing Organisation (SPARRSO), Bangladesh Meteorological Department, Surface Water Modelling Centre(SWMC) and Flood Forecasting and Warning Centre.

3.4 The accuracy of floods forecasts depends upon a number of factors which include:

- data collection network
- data transmission arrangements
- meteorological forecasts
- flood prediction models

3.5 A full fledged Flood Forecasting and Warning Centre (FFWC) of Bangladesh Water Development Board (BWDB) was established in 1972. This centre is fully operative in the flood season, from 1 May to 30 September, as required by the Standing Orders for Disaster of the Government of Bangladesh.

3.6 Rainfall is measured by rain gauges and, when available, data may be obtained via SPARRSO from satellite and from weather radars operated by BMD. These can provide additional data covering a large area, including in the case of satellite, land beyond the national boundary. In 1997, a network of 48 rain gauges is operated by BWDB to support its flow forecasting.

3.7 River flow data are obtained from a network of 47 sites (in 1997) on the rivers of Bangladesh. Every three hours during daylight, measurements of the level of the river are made by staff of BWDB. Data from the 48 rain gauges and 47 river level stations are transmitted by radio to the FF&WC in Dhaka every morning and more often during periods of flooding.

3.8 The forecasting authorities must learn about users' requirements. If forecasting and warning agencies want a high degree of user and customer satisfaction, they must forge a communication bridge among themselves and with users. The 'combat' agencies may require an early warning, longer lead time and expected area of inundation. The Ministry of Communication may like to know more specifically the depth of inundation. The urban and rural users and users of different social classes may require different kind of information from the forecasting authorities. Users must also be advised of the limitations which restrict the range of information that can be provided and must understand the limitation of the products.

3.9 Feedback from the response agencies to the forecasting centre during a flood event is invaluable. Obvious forecast discrepancies can be quickly corrected, and useful information can be provided to improve the forecasting process. Awareness that there is good communication between local groups and the centralised forecasting agency improves the credibility of the official forecast and reduces the likelihood of competing local forecasts.

3.10 The time interval between forecasts can be adapted to provide the optimal frequency for the needs of the response agencies. Too much information can result in important warnings being overlooked.

Users of Flood Warnings

Users	Needs
Ministry of Disaster Management and Relief	rescue, relief and rehabilitation
Ministry of Water Resources	flood mitigation
Ministry of Information	dissemination of warnings
Ministry of Health and Family Welfare	combat health hazards
Ministry of Food	ensure food supply in the vulnerable areas
Ministry of Agriculture	agricultural rehabilitation
Ministry of Fisheries and Livestock	alleviation of damage to and rehabilitation of fisheries and livestock
Ministry of Defence (armed forces, when called upon)	rescue, relief and rehabilitation
Ministry of Home	rescue, relief and rehabilitation
Ministry of Communication	vigilance, maintenance of roads and highways
Ministry of Aviation	vigilance and flight operation
Ministry of Local Government Rural Development and Cooperatives	dissemination, vigilance, relief and rehabilitation
Ministry of Foreign Affairs	provide information to and explore sources of assistance from foreign countries and external agencies
Ministry of Post and Telecommunication	maintain communication system
Ministry of Power, Energy and Mineral Resources	protection of utilities
Bangladesh Red Crescent Society	dissemination, rescue, relief and rehabilitation
NGOs	dissemination, rescue, relief and rehabilitation
International Organisations and Agencies	information and communication support
Foreign Embassies/High Commissions	information and communication support
Urban Communities	protective measures
Rural Communities	protective measures and cultivation
Farmers	protective measures
Fishermen	protective measures
Boatmen	protective measures
Inhabitants of *chars, beels and haors*	special warning

Chapter Four

Interpretation and Design of Warning Messages

The Interpretation of Flood Forecasts

4.1 Basic flood forecasts only provide information about the peak ***height*** of water at river level forecast stations on the main rivers. To be meaningful, the forecast must be converted into a warning that says how far the water will spread overbank from the river (submerged area), and how much (depth) there will be in this area, and what is the likely duration.

Why do we need warning messages ?
Research findings indicate that messages providing advanced warning can significantly reduce loss of life, suffering from sickness and ill-health and damage to property, crops and other tangible resources.

4.2 Ideally the forecast message should be interpreted at the local level. The full operational procedures for interpretation of flood forecasts at the District and Thana level need to be developed. Recent developments in technology now make it possible to use inexpensive computers and software to prepare local level flood intelligence systems and maintain communication links between national and local levels.

Flood Marker Posts

4.3 Flood warnings without information on areas and likely depth of inundation loose some of their significance. The introduction of marker posts provides guidance locally on the likely level of flooding and helps villagers to interpret the warning messages. The marker posts are colour banded according to the severity of the flood and the warning messages advise to which colour band the flooding will rise. An illustrated pamphlet is available in Bengali.

The Design of Warning Messages

4.4 A warning message converts forecast flood levels, by using simple language, into terms easily understood by those at risk from flooding. It provides information about what is likely to happen when and in which specific areas. It also provides threatened people with advice on what to do before and during the flood.

What do we mean by a flood warning messages?
A flood warning message tells the public and particularly to people at risk:
When the flood is likely to occur,
What is the nature of the flood,
Where the likely impact of the flood will occur in a given locality, and
How people should respond to protect themselves from flood hazard.
It is **issued** by a credible and official source.

4.5 The message must be easily understood by the people at risk. It should be prepared in the context of the indigenous knowledge system of the people and their felt needs.

Sociological Issues

What are the critical issues ?

- Warnings messages must stand out and stand alone.
- Warning messages should reflect the felt needs of the people at risk.
- Particular care should be taken when warning of catastrophic floods.
- Warnings may occasionally over or under state the severity of flood.

4.6 A flood warning is intended for people at risk. It is extremely important that it is issued by the agency which has technical command over the data and its interpretation and is seen as the official source.

4.7 It is equally important that the warning is primarily for the benefit of people at risk. They have lived with flood for centuries. They have their indigenous warning system. A flood warning message should be founded on this indigenous knowledge system, with participation from the people. It may be refined, expanded and made technically sound by FF&WC. The message must reflect their `voice'. It must respond to their felt and changing needs. Development must be interactive.

4.8 The agencies issuing and communicating warnings might think that warnings could create panic among vulnerable people. Research on disaster has shown that this is largely a myth. Panic is mainly limited to a few cases of sudden disaster or to a few individuals. Fatalism remains a more challenging problem in order to get positive responses and affirmative actions.

4.9 In constructing warning message, it is necessary to remember that there are different flood types in Bangladesh. Each type requires different forms of response from the official agencies as well from the community at risk. The impact of the flood is also related to the local land use and to the natural physical and man made terrain.

4.10 The communities at risk are differentiated by class, occupation and by gender. Different social groups are likely to require slightly different information. If extensive flooding is anticipated, it may be necessary to request the female headed households or disabled people to move to a safer place earlier. The rich peasant may value information of depth of flooding in order to decide whether to stay at home and use a raised platform to cope with the flood or to take shelter with kinsmen in another locality. People living in ***Char***, ***beel*** and ***haor*** areas and along minor rivers may require different or additional information. People with regular flood experiences may respond well in most cases. But, they may ignore messages of unusual floods because of their confidence in their ability to cope.

4.11 The flood warning produces different responses within parts of a society. Any long term flood warning, if these were ever to be issued, may prompt some traders to hoard essential commodities and thereby provoke a rising price -spiral. It is, therefore, important to consider what secondary reactions may be created by warning messages. People show more solidarity during a time of crisis. As there might be some theft and looting, people may need to form vigilance teams.

4.12 The target audience includes 'combat' agencies who ideally require slightly more technical information than the general public to get prepared for rescue operation.

Message Construction

4.13 The construction of messages for flood warning appears simple. Production of an effective message requires collaboration among people with different skills - communication, psychology, sociology and artistic.

How do we construct Messages ?

- Flood warning messages must stand out and stand alone.
- They should be simple, clear and persuasive.
- They should convey all the essential information for people at risk.
- They should tell people what to do to protect themselves from flooding.

4.14 Messages must be presented in simple language and contain the appropriate information. They must be presented in a form which persuades people to act. They should contain words and images which are meaningful to people.

4.15 A crucial aspect of message construction is easy comprehension by the vulnerable people. In Bengali, for example, there are no standard terms which can distinguish between flash flood and monsoon flood. In a peasant society with a very low level of literacy, messages in standard Bengali may not be understood by even a majority of the audience. Thus, construction of messages requires a great deal of attention. Ideally they need to be constructed in as many dialects as possible.

Separating Flood Watches and Warnings from the routine daily forecasts and bulletins gives them a high profile. This elevates and establishes Watches and Warnings as important and highly significant messages requiring prompt action.

4.16 A standard (model) form of message may be helpful. But as the media use may be different and target groups or users are also dissimilar, a number of standard forms are likely to be more useful. These should be reviewed periodically to assess their relevance as the recipients provide feedback on their value, effectiveness and comprehensibility and in the context of changing nature of flood. Feedback from media reporting can be useful in improving the quality of message.

4.17 Messages are often effective through their latent content, the way they are presented or because of the medium used. Both apparent and latent messages and their presentation should stress action.

An effective flood warning should include the following:

- Header/Title to highlight flood location, date and time of issue.
- Name of Issuing Authority.
- Ordering information in terms of importance.
- Description of the areas likely to be flooded (include when possible probable depth).
- Time for next warning.
- Sources of advice and assistance.

4.18 The messages should include words as well as maps and visual images wherever possible. But at the same time they should be **simple** and **short**. For effective broadcast, messages need to be **short enough to be read aloud in no more than 45 seconds**. The form and content of messages should vary slightly from medium to medium. The level of uncertainty of the event or lack of information should be clearly indicated. A set of model messages appears in Appendix 3.

4.19 There should be proper prioritization of information in the message. Most important **items** must receive proper emphasis and appear early in the message.

Flood Warnings Phases

4.20 The three categories of flood intensity- Medium, Severe and Catastrophic- have increasingly severe impacts and require different forms of public advice. They, with the addition of the Flood Watch (alert) to agencies, form the basis for a series of phased flood warning messages. The system of phasing in Bangladesh has four elements.

A system of phased warnings has the following advantages:

- Agencies can be alerted before public warnings are issued allowing them time to make preparations to disseminate warnings and to respond to the warning.
- Warnings can be targeted to those most at risk. Those who will only be affected by a greater flood are warned in later phases.
- Advice in the messages can adapt to the changing impacts of a worsening flood as it affects more people and creates greater areas of inundation.

4.21 **Flood Watch** The first phase is an ***Alert*** called Flood Watch issued to 'combat' and other relevant agencies. It usually provides 24 hours earlier notice than a publicly issued flood warning and enables them to mobilise their resources and to make other preparations. It is particularly valuable to those organisations carrying out the dissemination process. No public warnings are issued or disseminated as the flood forecast is only provisional.

4.22 **General Flood Warning (for Medium Flood):** the first level of public warning. It corresponds to the ***Blue Band*** on village flood marker posts. Flooding would affect farmers and others living in low lying areas and on land adjacent to rivers. It would cause some economic loss and damage to property but would not be too extensive or serious. Loss of life is unlikely as the affected populations already have some flood response preparedness since they experience flooding on a regular basis , about every 3 years.

4.23 **Severe Flood Warning** would be issued as river levels continue to rise affecting larger areas and those parts of the population less familiar with flooding. It corresponds to the ***Red Band*** on village flood marker posts. It inundates some urban areas and some loss of life is likely to occur. Economic and property damages would be significant. This scale of flooding is likely to be experienced every 6 years on average. Warning messages contain guidance on flood response actions.

4.24 **Widespread Flood Warning (for Catastrophic Flood)** would be issued when an extremely serious flood, comparable to 1987 & 1988 impacts, is expected to occur. It corresponds to the ***top of the Red Band*** on village marker posts , which is close to the level of the maximum historic flood. Many parts of the population would be affected and significant damage caused. Many people, especially those living in urban areas, are unlikely to have recent experience in coping with a flood. Warning messages contain advice to those affected on what action they need to take. Warning messages are also addressed to those suffering flooding from earlier phases as they experience an extended period of flooding with increasing impacts.

4.25 **Stand Down:** this new message is issued to indicate that the immediate threat of flooding is over. It is based upon forecasts that rivers will fall below Danger Level and are not expected to rise above it again in the next few days.

Other Information Products

4.26 The separation of warnings from the other products requires a redesign of the existing information bulletins. These, which are based on a WMO guide form a suite of more functional and attractive products comprising a Daily Rainfall and River Digest, a Daily Flood Bulletin and a Weekly Flood Bulletin. Full details are given in Table 2 and Appendix 2.

TABLE 2 - DESCRIPTION OF PRODUCTS ISSUED FROM FF&WC

PRODUCT TITLE	TIME SCALE OF CONTENTS	URGENCY & TIME OF ISSUE	EXISTING PRODUCTS
Daily Rainfall & River Digest	IMMEDIATE PAST last 2-3 days, including current day's readings	PRIORITY issued during morning	Bulletins Summaries Forecasts
1. Daily Flood Bulletin **2. Weekly Flood Bulletin** **(provisional data)**	RECENT PAST includes Immediate Past extended to past week for Bulletin	PROMPTLY 1. issued during afternoon 2. issued within 24 hours of end of week	
1. River Forecasts **2. Watches & Warnings** **3. Stand-downs**	FUTURE up to 3 days ahead of day of issue	HIGHEST PRIORITY & RAPID (min delay) 1. issued during morning 2. immediate issue 3. immediate issue	
Flood Reports **- monthly** **- annual** **- special**	HISTORIC PAST Historical Record	LONG TERM -monthly issued within 4 weeks of month end; annual 2 months after end of monsoon	Flood Reports - weekly - monthly - annual - special

Chapter Five

Dissemination and Communication of Flood Warnings

5.1 Flood warnings are useless if they are not communicated to the people at risk with a sufficient lead time, in a manner in which they understand the message and in a way which persuades them to take appropriate action.

In Bangladesh dissemination of flood warnings is extremely difficult because a majority of the vulnerable people have no direct access to mass communication channels. Local government agencies have limited resources and facilities to pass on flood warnings to communities at the grassroots level. Thus it is necessary to deploy both traditional and modern channels of communication.

Communication

5.2 To be effective communication strategies must be persuasive. The communication process can be best described through Harold Lasswell's (1966:178) classic expression.

Who
says what
in which channel
to whom
with what effect?

5.3 A source or sender is a person (or agency) who has a need to communicate. Their message is encoded in the form of signs and symbols which can be understood by the receiving audience. The product of encoding is message construction. The means through which messages are conveyed from the source to the receiver are called channels.

5.4 When the message reaches the receiver, it must be interpreted to put meaning to it. The process is known as decoding. After decoding the message, the receiver may respond to the message.

5.5 Feed back is the final component of the communication process through which the source learns about the response of the receiver and, when necessary, adjusts his communicative behaviour to bring about desired changes in the response of the receiver.

5.6 The behaviour of users of flood warnings depends upon a large number of variables, including span of attention, focusing strategies, involvement and need. It also depends upon the way people perceive the usefulness of the information, their cognitive skills, past experiences, and their positions in the social hierarchy.

5.7 The complexity of the communication process illustrates the difficulties of disseminating flood warning messages to a large number of people at risk. In Bangladesh villages are dispersed, communication infrastructures are rudimentary, nearly two thirds of the population are illiterate, poverty is widespread and attitudes are mainly traditional. In this situation particular care has to be taken to construct credible messages and to use many channels of communication.

5.8 The selection of communication channels will depend upon the facilities available and the location and nature of the threatened communities. They must be able to reach the target users with adequate back up and feed back facilities. The choice of channels should match the urgency of the message and to the number of threatened people. Communication at an interpersonal level is important at the final stage of delivery: it is essential that the same message is communicated without distortion.

Dissemination Arrangements

5.9 Under the Standing Orders for Disasters the Bangladesh Water Development Board has the responsibility for preparing flood warnings and issuing these to the Disaster Management Bureau and the media. The FF&WC issues flood forecasts and warnings and disseminates them as shown in Figure 3. Through its field officers and local level administration it provides information about possible breaches in the embankments and flooding. Disaster Management Bureau has the responsibility for disseminating flood warnings to relevant authorities and agencies. The Ministry of Disaster Management and Relief informs Deputy Commissioners and TNOs of the relevant districts and thanas about flood-threats in their areas.

Modes of Dissemination

Dissemination channels can be of different categories. Successful dissemination of flood warnings depends upon the right mix of communication channels.

- Mass media- radio, TV & newspapers, can reach a large audience, but responses may often be limited and weak.
- Small scale channels - flood marker posts, posters, sirens, public address system, loud hailers, public meetings may be low in message content, but are high in terms of effectiveness.
- Technical - telephone, telegram, fax, wireless will be effective if person to person connections are achieved.
- Interpersonal - direct networking from union parishad to alert *para* through union parishad officials, school teachers, imams, house to house call, *VDP/Ansar.*

Roles of Specific Agencies in Warning and Dissemination

BWDB Field Staff	collection of rainfall and river data - local dissemination
BWDB FF&WC	forecasting and preparation of warnings - direct transmission to DMB, TV & Radio
Disaster Management Bureau	quick transmission through official channels - dissemination limited to relevant agencies
Ministry of Disaster Management & Relief	quick transmission through official channels - dissemination limited to relevant agencies
Police	quick transmission through administrative channels
Local Authorities	quick transmission by DCs to thanas - local dissemination by TNOs
NGOs	local dissemination of warnings

Media Dissemination

5.11 Radio which reaches the largest number of people in Bangladesh can be effective in disseminating flood warnings. The 1995 Media survey found that 18 percent of the rural people have working radios, but more importantly, nearly 44 percent have access to radio. The peak listening hours are 7am, 2pm and 8pm.

5.12 In recent years TV has spread to rural areas. Although only 3 percent own one, nearly 31 percent have access to it. The peak viewing hour is around 9pm.

Mass Media Channels for Disseminating Flood Warnings

Radio
- dissemination is quick.
- reaches the largest number of the audience.
- messages can be repeated and updated easily.
- special bulletins early in the morning, early afternoon, and late in the evening.
- interviews with specialist staff of the forecasting agencies.

Television
- quick transmission.
- more credible when use made of graphical displays (eg satellite images of clouds and rainfall)
- reaches a moderately large audience.
- message can be repeated and updated.
- animation and visual images can be presented.

Newspapers
- disadvantage: transmission time is limited

figure 2: BANCID CHART

Responses

5.13 The purpose of a flood warning is to get the recipients to take action which will reduce the damage caused by flooding. Even when it provides people with information and advice on actions to take, the warning may not induce positive responses as they might not be aware of the potential benefits of preparedness for floods. There are three major forms of responses from the people at risk.

Fatalism: People view floods as a kind of fate against which they can do little. They are likely to take protective action as a last resort when the disaster closes in upon them. They require strong community pressure to undertake positive action.
Scepticism: People do not take the warning seriously, particularly if they have experienced false warnings in the past. They may also feel they are capable of coping with the flood as well as they have done in the past. They require special persuasion when the flooding is more serious .
Activism: A smaller number of people receive and give more information than others and take initiative in embarking upon protective behaviour. They also help and support others to take protective measures.

Confirmation

5.14 A major difficulty with mass media is that there is no way of knowing how many may have missed the message or decided that it is not important. Thus mass media messages must be reinforced with word of mouth communication, specially through *para* leaders, school teachers and religious leaders.

5.15 The first aspect of confirmation is that those issuing warnings and passing them on should receive an acknowledgement from the recipient. The next task for the authorities is to establish that warnings have reached the target population at risk.

5.16 A further aspect is that people should be able to confirm what they have learnt from more than one source. People do not like to face a threatened situation or disaster and tend to ignore warnings unless they can find another source to confirm the message. This confirmation can be given when the flood warning broadcast on TV & radio, is also issued by the Deputy Comissioner and disseminated through TNOs and others locally.

5.17 It is extremely difficult to establish feed back mechanisms or assess the level of exposure to messages or their effectiveness. Field surveys are necessary to assess the effectiveness of messages and channels and research to devise proper feed back mechanisms.

Chapter Six

System Review and Improvement

System review is needed:
- to improve the reliability and performance of the Flood Forecasting, Warning and Response System
- to build upon actual operational experiences in Bangladesh
- to take into account changes in both natural and human environment
- to incorporate new forecasting and dissemination technologies

System review is:
- monitoring and critical review of some or all aspects of Flood Forecasting, Warning and Response system aimed at improving its performance in future

Review of flood warning system
- stakeholders of the Flood Forecasting, Warning Response System meet to discuss their experience and to suggest ways of improving it.
- regular workshops can also be an effective mechanism of review.
- the review process gives special emphasis to needs and suggestions from various users and, in particular, from people at the grass roots level.
- independent surveys may be needed to gather information at field level.

Critical issues
- review process must concentrate upon the identification of problem areas and their practical solutions
- review process must be constructive and not attempt to attribute blame
- review must underscore the measures for improving the performance of the system

6.1 The present Flood Forecasting Warning and Response System in Bangladesh is at best only approaching an intermediate stage of development (see Figure 4), based on the classification by Fordham et al. It will require many years of careful attention to achieve its full potential and enhance its performance. Independent evaluations, supported where necessary by field surveys and research, must also be an integral part of the review process. A good feedback mechanism is vital to enable development of the system.

6.2 The Flood Forecasting, Warning and Response System must be reviewed at least once per year. Regular reviews of the FFWRS are essential for the development of the system in the immediate short-term and for its continued maintenance and operational integrity in the longer term. Reviews should be carried out early in the winter of every year so that any revisions can be incorporated into the following year's procedures.

6.3 An annual review process should include long term strategic planning in addition to current development plans (eg FAP 10) for the shorter period. The inter-ministerial consultative committee, external support agencies and NGOs should participate in such planning with a view to achieving broad consensus.

6.4 Each agency involved in flood forecasting, warning and dissemination should participate in a review to identify constraints and problems and then undertake corrective measures. These operational reviews should be undertaken soon after each major flood or at the end of the monsoon season. This review process should focus on the performance of the system and implementation of policy at operational level, identify failures or weakness in each component, examine inter-agency co-ordination and patterns of responses by the users.

In order to ensure that the system can achieve positive responses from all the vulnerable people, these reviews should ask the following questions:

- how many of the target audience got the warnings in time?
- how many of them understood the warning message?
- how many of them took appropriate action?
- what were the causes which led to any failure to achieve an affirmative response?
- how adequate were the available data to answer these questions?

Review Process

6.5 The review should include technical aspects of flood forecasting to broaden the sources of data and improve the quality of modelling. It should look closely into the types of warnings, message content and their dissemination process in order to improve them. The pattern of users' responses should be investigated in terms of flood warning service, expected motivation, facilities and learning resulting from flood mitigation and developmental activities.

6.6 Both natural and man-made environments are changing fast in South Asia as a consequence of rapid increases in population and non-uniform development. As Bangladesh constitutes a small part of the catchments, the review process requires close cooperation among South Asian countries. Changes in natural environment include factors such as major environmental changes such as deforestation, or changes in rainfall or stream channel characteristics. An exchange of flood information among Asian countries would be extremely useful for the review process.

6.7 Reviews can easily turn into mere rituals when they have been performed over a number of years. This must be avoided if they are to remain effective. This can be achieved by changing the venue, introducing presentations from one of the participating organisations or obtaining the services of an independent chairman.

6.8 Finally, reviews must be held in a spirit of mutual cooperation and trust giving emphasis to objective unbiased and independent evaluation of past performance.

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Appendix 1

Terminology of flood types, intensities and warning phases

A1.1 Flood Types:

In Bangladesh, river flooding takes three main forms:

Monsoon Floods - Major rivers and their side channels overflow submerging extensive areas of land. The rivers rise slowly and with a slow recession may stay at high flows for extended periods of many weeks.

Flash Floods - Mainly in eastern and northern rivers where short duration heavy rainfall in the mountains causes a rapid runoff response and high flood waves with high consequential damage.

Rainfall Floods - High local rainfall intensities and long duration monsoon rainfall cause flooding due to inadequate local drainage. The flood waters spread rapidly, but may take many weeks to dissipate.

Tidal Surge Flood - The low-lying coastal area of Bangladesh has a complex network of estuaries and tidal floodplain. This area is frequently flooded by high sea levels and waves resulting from cyclonic storms in the Bay of Bengal.

A1.2 Flood Intensity

Three classifications of flood intensity are used to describe the impacts and level of damage.

Medium Flood - This scale of flooding affects mainly farmers and others living on low lying land and in areas adjacent to rivers. Some economic loss and damage to property occurs but is unlikely to be extensive or serious on a national scale. Loss of life is also likely to be small.

Severe Flood - As well as further flooding in rural areas some urban areas become affected, with significant economic and property damage and it is probable that loss of life would occur.

Catastrophic Flood - This extremely serious flood has impacts comparable to those of the 1987 & 1988 floods. It would be close to and may even exceed the level of the maximum historic flood. Many parts of the population would be affected and significant damage occur.

A1.3 Phases for Flood Warning

Flood Watch - The first phase is an *Alert* called 'Flood Watch' issued to 'combat' and other relevant agencies. It usually provides notice 24 hours earlier than a publicly issued flood warning and enables them to mobilise their resources and to make other preparations. No public warnings are issued.

General Flood Warning - This is the first level of public warning and is for a flood whose impacts are mainly rural as described for the Medium Flood. It corresponds to the *Blue Band* on village flood marker posts.

Severe Flood Warning - This would be issued as river levels continue to rise leading to impacts for Severe Flood. It corresponds to the *Red Band* on village flood marker posts. It affects some urban areas and some loss of life is likely to occur. Warning messages contain guidance on flood response actions.

Widespread and Very Severe Flood Warning - This would be issued when a very major and serious flood as described for the Catastrophic Flood is expected to occur. It corresponds to the *top of the Red Band* on village marker posts, which is close to the level of the maximum historic flood. Many parts of the population and large areas of the country, including many larger urban areas would be affected.

Appendix 2

Range of Flood Information Products

A2.1 The warning messages are designed to ensure that they communicate the essential information and advice in a way which encourages appropriate responses from those at risk of flooding. A set of phased warning messages has been introduced in order to increase the information content of warnings. They are separate from forecasts and routine information on the state of the rivers.

Preparation and Issue of Flood Information Products

A2.2 The range of products fulfills the criteria in WMO Technical Document No 598 "The Roles of Meteorologists and Hydrologists in Disaster Preparedness", tailored to meet the needs of Bangladesh. It strengthens the product range by:

- separating the information into a number of distinct products, which enables daily data to be issued promptly, ie by dividing forecasts from historical data and warnings from forecasts
- providing alerting messages in the form of Flood Watches
- increasing the profile of Flood Warning messages
- providing additional phased warnings for more severe forms of flooding
- providing daily and weekly resumes in the form of Flood Bulletins for distribution to organisations who need or would like to be briefed on current flooding
- offering a briefing service to organisations (external to Government) who do not receive information at present

A2.3 The suite of products has four main classes of publication:

(a) Daily Rainfall and River Digest
(b) River Forecasts
(c) Flood Watches & Flood Warnings
(d) Daily & Weekly Bulletins
(f) Flood Reports

A2.4 **Daily Rainfall and River Digest** replaces the former Bulletin and summarises information in the other more detailed products. It highlights significant events from the last 24 hours and provides a concise summary of overall conditions for rapid dissemination to key Government Agencies and Officials who need to see early in the day a short and highly explicit summary. The content focuses on key statistics and changes in order to draw attention to, for example, significant quantities of rainfall, new areas of flooding and rivers approaching Danger Levels.

A2.5 **River Forecasts** (quantifying future expectations of the state of the rivers) are primarily for use by technical departments who need a comprehensive set of data and can interpret basic facts for use in their own area of responsibility and activity and who do not need interpretations and guidance. This product is also for issue early in the day and is issued throughout the year to other agencies. It is not for general release to the media. In addition to forecasts of future river levels, even when flooding is not likely, it provides a fuller statistical summary (than the Digest) of recent river and rainfall conditions. The content would be similar to the current Statistical Statement.

A2.6 **Flood Watches** The first phase of warning is the Flood Watch, which informs other agencies that flooding is highly probable and to prepare for the Warning and Response phases. They typically provide 24 hours earlier notice than the Flood Warning. *In the case of those organisations with a role to play in the dissemination process they should automatically initiate their Action Plan standby/emergency procedures.*

Flood Warnings are issued when a flood event is forecast to occur or increase in severity, which will have a significant impact on the affected communities (see A1.3).

Stand Down message is issued to indicate that the immediate threat of flooding is over.

A2.7 Daily & Weekly Flood Bulletins meet a DMB requirement for information to issue to UN Agencies and Embassies. They are also for supply to those donor and commercial organisations that have indicted a willingness to pay for receipt of this information.

A2.8 **Daily Flood Bulletins** are issued throughout the monsoon season to advise on the state of the rivers. Weekly Bulletins are issued only during a flood event to provide information on the magnitude of the flood and its impact. They contain provisional and early estimates of impacts and are not therefore suitable as record documents.

The Daily Flood Bulletin interprets data from the field into readily assimilable form using maps of rainfall, thanas currently at warning stages or experiencing flooding (using colour to indicate severity).They also contain a general outlook for the next few days indicating whether flood conditions are likely to worsen or improve.

A2.9 **Weekly Flood Bulletin** replaces the current weekly flood report and provides a summary of key information and events for the past week, taken from the Daily Flood Bulletins. It also makes extensive use of graphical presentation techniques.

A2.10 **Flood Reports** describe the flood event "for the record" and are therefore prepared after the event only when more detailed and accurate information is available. They provide an authoritative record of the flood event and contain the same information as the current Monthly, Annual, Special Reports.

Appendix 3

Model Flood Warning Messages for Villages without Flood Marker Post

1. Medium Flood

2. Severe Flood

3. Widespread and Very Severe Flood Warning

2. Model Message for Severe Flood

FLOOD WARNING FOR IMMEDIATE BROADCAST

This Flood Warning is issued by Flood Forecasting and Warning Centre
Telephone (02) 955 3118; (02) 955 0755

DISASTER MANAGEMENT BUREAU should IMMEDIATELY transmit this message to DISTRICTS.

BANGLADESH RADIO and TV should broadcast this Flood Warning IMMEDIATELY after every news bulletin.

A Warning of Severe Flooding for <*list of districts*> was issued at <*time*> on <*day*> <*date*>.

The BWDB Flood Forecasting & Warning Centre reports that the River(s) <*river names*> are flowing well above Danger Level.

FF&WC forecasts predict that river levels will increase further over the next <...> hours. Severe Flooding will inundate large areas of all these Districts during the next <...> hours.

Flooding will occur in many rural areas and may affect some towns. Damage to property is expected. Roads, railways, embankments and bridges are likely to be submerged and damaged.

You should remain alert and listen to the radio bulletins for further information. This information will be updated following the next news bulletin.

A Warning of Severe Flooding has been issued for <*list of districts*>.

[Message ends] 24 May 1997

1. **Model Message for Medium Flood**

FLOOD WARNING FOR IMMEDIATE BROADCAST

This Flood Warning is issued by Flood Forecasting and Warning Centre Telephone xxxxxx

DISASTER MANAGEMENT BUREAU should IMMEDIATELY transmit this message to DISTRICTS.

BANGLADESH RADIO and TV should broadcast this Flood Warning IMMEDIATELY after every news bulletin.

A Warning of General Flooding for <*list of districts*> was issued at <*time*> on <*day*> <*date*>.

The BWDB Flood Forecasting & Warning Centre reports that the River(s) <*river names*> are rising and flowing close to or above Danger Level.

River levels will continue to rise and areas of all Thanas in particular <*thana names*> will experience general flooding. This will affect low lying villages and may cause some property damage and disruption to local communications.

Flood water will inundate low lying areas during the next 24 hours. Damage to crops and culture fisheries are expected.

You should listen to radio for further information. This information will be updated following the next news bulletin.

A Warning of General Flooding has been issued for <*list of districts*>

[Message ends] 20 May 1997

3. Model Message for Widespread and Very Severe Flood

FLOOD WARNING FOR IMMEDIATE BROADCAST

This Flood Warning is issued by Flood Forecasting and Warning Centre Telephone (02) 955 3118; (02) 955 0755

DISASTER MANAGEMENT BUREAU should IMMEDIATELY transmit this message to DISTRICTS.

BANGLADESH RADIO and TV should broadcast this Flood Warning IMMEDIATELY after every news bulletin.

A Warning of Widespread and Very Severe Flooding for <*list of districts*> was issued at <*time*> on <*day*> <*date*>.

The BWDB Flood Forecasting & Warning Centre forecasts that river levels will increase over the next <...> hours and will be close to highest recorded levels. There will be Catastrophic Flooding inundating large areas of all these districts during the next <...> hours.

Flooding in rural areas will worsen and will spread into many areas of the towns and cities. Water levels are expected to remain high for many days.

Serious damage to property will occur and all communications will be seriously disrupted. Further damage to roads, railways, embankments, bridges and other structures will occur. Watch and take care of flood embankments.

You should remain alert and listen to radio bulletins for further information. This information will be updated following the next news bulletin.

A Warning of General Flooding has been issued for <*list of districts*>.

[Message ends] 24 May 1997

Appendix 3 (cont)

Model Flood Warning Messages for Villages with Flood Marker Post

4. Medium Flood

5. Severe Flood

6. Widespread and Very Severe Flood Warning

4. Model Message for Medium Flood

FLOOD WARNING FOR IMMEDIATE BROADCAST

This Flood Warning is issued by Flood Forecasting and Warning Centre Telephone (02) 955 3118; (02) 955 0755

DISASTER MANAGEMENT BUREAU should IMMEDIATELY transmit this message to DISTRICTS.

BANGLADESH RADIO and TV should broadcast this Flood Warning IMMEDIATELY after every news bulletin.

A Warning of General Flooding for <*list of districts*> was issued at <*time*> on <*day*> <*date*>.

The BWDB Flood Forecasting & Warning Centre reports that the River(s) <*river names*> are rising and flowing close to or above Danger Level.

River levels will continue to rise and areas of all Thanas in particular <*thana names*> will experience general flooding. This will affect low lying villages and may cause some property damage and disruption to local communications.

Flood water will inundate low lying areas during the next 24 hours. It will rise into the BLUE zone in villages with a Flood Marker Post. Damage to crops and culture fisheries are expected.

You should listen to the radio for further information. This information will be updated following the next news bulletin.

A Warning of General Flooding has been issued for <*list of districts*>.

[Message ends] **24 May 1997**

5. Model Message for Severe Flood

FLOOD WARNING FOR IMMEDIATE BROADCAST

This Flood Warning is issued by Flood Forecasting and Warning Centre Telephone (02) 955 3118; (02) 955 0755

DISASTER MANAGEMENT BUREAU should IMMEDIATELY transmit this message to DISTRICTS.

BANGLADESH RADIO and TV should broadcast this Flood Warning IMMEDIATELY after every news bulletin.

A Warning of Severe Flooding for <*list of districts*> was issued at <*time*> on <*day*> <*date*>.

The BWDB Flood Forecasting & Warning Centre reports that the River(s) <*river names*> are flowing well above Danger Level.

FF&WC forecasts predict that river levels will increase further over the next <...> hours. Flood water will rise above the BLUE zone in villages with a Flood Marker Post. Severe Flooding will inundate large areas of all these Districts during the next <...> hours.

Flooding will occur in many rural areas and may affect some towns. Damage to property is expected. Roads, railways, embankments and bridges are likely to be submerged and damaged.

You should remain alert and listen to the radio bulletins for further information. This information will be updated following the next news bulletin.

A Warning of Severe Flooding has been issued for <*list of districts*>.

[Message ends] **24 May 1997**

6. Model Message for Widespread and Very Severe Flood

FLOOD WARNING FOR IMMEDIATE BROADCAST

This Flood Warning is issued by Flood Forecasting and Warning Centre Telephone (02) 955 3118; (02) 955 0755

DISASTER MANAGEMENT BUREAU should IMMEDIATELY transmit this message to DISTRICTS.

BANGLADESH RADIO and TV should broadcast this Flood Warning IMMEDIATELY after every news bulletin.

A Warning of Widespread and Very Severe Flooding for <*list of districts*> was issued at <*time*> on <*day*> <*date*>.

The BWDB Flood Forecasting & Warning Centre forecasts that river levels will increase over the next <...> hours and will be close to highest recorded levels. Flood water will rise into the RED zone in villages with Flood Marker Posts. There will be Catastrophic Flooding inundating large areas of all these districts during the next <...> hours.

Flooding in rural areas will worsen and will spread into many areas of the towns and cities. Water levels are expected to remain high for many days.

Serious damage to property will occur and all communications will be seriously disrupted. Further damage to roads, railways, embankments, bridges and other structures will occur. Watch and take care of flood embankments.

You should remain alert and listen to radio bulletins for further information. This information will be updated following the next news bulletin.

A Warning of General Flooding has been issued for <*list of districts*>.

[Message ends] 24 May 1997

Appendix 4

Acronyms

BMD	Bangladesh Meteorological Department
BWDB	Bangladesh Water Development Board
DANIDA	Danish International Development Agency
DL	Danger Level
DMB	Disaster Management Bureau
FAP	Flood Action Plan
FF&WC	Flood Forecasting and Warning Centre
FFWRS	Flood Forecasting Warning and Response System
FIC	Flood Information Centre
GIS	Geographical Information Systems
ISPAN	Irrigation Support Project for Asia and the Near East.
NGO	Non-Government Organisation
NOAA	National Oceanic and Atmospheric Administration (of United States)
NORAD	Norwegian Agency for International Developments
NWMP	National Water Management Plan
NWP	National Water Plan
SOD	Standing Orders for Disasters
SPARRSO	Space Research and Remote Sensing Organisation
SWMC	Surface Water Modelling Centre
WARPO	Water Resources Planning Organisation

add:
combat agency

Glossary

beel	a low area in the flood plain normally flooded throughout the year
catchment	the area of land draining into a stream at a given location
char	accreted land within the river channel
danger level	the water level of a river above which the flooding may cause damage to crops and homesteads
delta	the land formed at the mouth of a river by the deposit of sediment
disaster	an event in time and space which disrupts normal activities of a community and causes such great loss that external assistance is required
floodplain	the normally dry land area adjoining rivers, lakes or bays that is inundated during flood
geomorphology	the branch of geology which is concerned with the structure, origin, and development of the topographical features of the earth's crust
haor	a tectonic depression found mainly in the north east of the country which forms permanent water body
hazards	events which pose danger to a community
hydrograph	a graph which shows the flow rate or river level at a given location in the stream with respect to time
hydrology	the study of circulation of water in and on the earth and in its atmosphere.
inundation	rise and spread of water over land
meteorology	the study of earth's atmosphere and is particularly concerned with weather forming process and weather forecasting
monsoon	the name of the wind that changes direction with the seasons. In south Asia it blows from the southwest in summer and brings heavy rains
para	neighbourhood
rainguage	an instrument placed in an unsheltered place which measures how much water has fallen
river gauges	instruments which measure elevation of water surface against a fixed level, such as, mean sea level
runoff	the flow of precipitation from catchment area through a stream
thana	a subdivision of a district
union	an administrative unit consisting of a number of villages
watershed	the area of land draining into a stream at a given location
weather	the heat, coldness, wetness and other day-to-day meteorological conditions that affect a place