A GIS-BASED SYSTEM FOR ESTIMATING EMERGENCY RELIEF REQUIREMENTS FOR FLOOD VICTIMS

By

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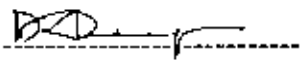
Candidate's Declaration

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.



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Abbreviations and Acronyms

AVHRR	Advanced Very High Resolution Radiometer
BBS	Bangladesh Bureau of Statistics
BDPC	Bangladesh Disaster Preparedness Centre
BDRCS	Bangladesh Red Crescent Society
BIDS	Bangladesh Institute of Development Studies
BMD	Bangladesh Meteorological Department
BUET	Bangladesh University of Engineering & Technology
BWDB	Bangladesh Water Development Board
CARE	Cooperative Assistance for Relief Everywhere
CDMP	Comprehensive Disaster Management Program
CI	Corrugated Iron
cm	Centimeter
CPP	Compartmentalization Pilot Project
CPP	Cyclone Preparedness Program
DC	Deputy Commissioner
DDMC	District Disaster Management Committee
DEM	Digital Elevation Model
DFO	Dartmouth Flood Observatory
DL	Danger Level
DMB	Disaster Management Bureau
DMP	Disaster Management Project
DMU	Disaster Management Unit
DPP	Disaster Preparedness Program
DRRO	District Relief and Rehabilitation Officer
EDM	Enfants Du Monde
EGIS	Environment and Geographic Information System
EOC	Emergency Operation Center
ESCAP	Economic and Social Commission for Asia and the Pacific
EPWAPDA	East Pakistan Water and Power Development Authority
FAP	Flood Action Plan
FAO	Food and Agricultural Organization
FIC	Flood Information Centre
FFW	Food For Work
FCD/FCDI	Flood Control, Drainage/ and Irrigation
FFWC	Flood Forecasting and Warning Center
FPCO	Flood Plan Coordination Organization
GDM	Ganges, Brahmaputra and Meghna
GDIN	Global Disaster Information Network
GDP	Gross Domestic Product
GIS	Geographic Information System
GOB	Government of Bangladesh

GUI	Graphical User Interface
HF	High Frequency
HH	Household
HQ	Headquarter
IEB	Institution of Engineers, Bangladesh
IFFD	Integrated Food For Development
IFSP	Integrated Food Security Program
IMDMCC	Inter-Ministerial Disaster Management Coordination Committee
In	Inch
ISPAN	Irrigation Support Project for Asia and the Near East
IWFM	Institute of Water and Flood Management
Kg	Kilogram
Km	Kilometer
LGED	Local Government Engineering Department
LIDAR	Light Detection and Ranging
m	Meter
mm	Millimeter
MCSP	Multipurpose Cyclone Shelter Program
MPO	Master Plan Organization
MSL	Mean Sea Level
MSS	Multispectral Scanner
NDMC	National Disaster Management Council
NDMAC	National Disaster Management Advisory Committee
NE	North East
NGO	Non-Government Organization
NIRAPAD	Network for Information, Response and Preparedness Activities on Disaster
NOAA	National Oceanographic and Atmospheric Administration
NWP	National Water Plan
NWMP	National Water Management Plan
NWRD	National Water Resource Database
PACT	Private Agencies Collaborating Together
PIO	Project Implementation Officer
PNGOs	Partner NGOs
PRIP	Private Rural Initiatives Project
PWD	Public Works Department
RSI	Radarsat Satellite Inc.
SAR	Synthetic Aperture Radar
SOB	Survey Of Bangladesh
SPARRSO	Space Research and Remote Sensing Organization
SRDI	Soil Resources Development Institute
SWMC	Surface Water Modeling Centre
Sq. ft	Square Foot
Sq. km	Square Kilometer
SQL	Structured Query Language

Sq. m	Square Meter
SW	South West
UDMC	Upazilla Disaster Management Committee
TM	Thematic Mapper
UDMC	Union Disaster Management Committee
UNCRD	United Nations Centre for Regional Development
UNDP	United Nations Development Program
UNDRO	United Nations Disaster Relief Coordinator
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific & Cultural Organization
UNHCR	United Nations High Commissioner for Refugees
UNO	Upazilla Nirbahi Officer
UP	Union Parishad
WARPO	Water Resources Planning Organization
WB	World Bank
WL	Water Level
WMO	World Meteorological Organization

Glossary of Terms

Amon	A variety of rice sown in July-September and harvested in November-January.
Aus	A variety of rice sown in March-May and harvested in July-August.
Bazar	Market
Bil	Marshy land
Boro	A variety of rice sown in November-December and harvested in April-May.
Char	Newly formed or reformed lands on the river bed.
Chira	Flattened rice used as a cereal
Ghat	Terminal / Landing place for watercrafts
Growth Center	Important market place identified by the government
Gur	Molasses
Hat	Village markets that operate only on specific days of the week
Killa	Earthen mound built for providing shelter, primarily for livestock, during cyclonic period.
Kutcha	Earthen; temporary (house)
Kutcha Road	Unpaved road
Madrasha	Educational institution with emphasis on Muslim religious education.
Mauza	Smallest revenue unit in Bangladesh. A mauza may be equal to a village or larger since a mauza may consist of one or more villages.
Muri	Puffed rice
Parishad	Council

Pucca	Permanent construction of brick and/or concrete
Pucca Road	Paved road
Relief	Attention to immediate and basic needs of disaster survivors. These needs include food, clothing, shelter and medical or emotional care. In the case of fast-impact disasters such as floods, earthquakes or cyclones, this process is directed at saving lives and alleviating further suffering.
Upazilla	Administrative unit above union and below zilla
Union	Lowest administrative unit in Bangladesh which comprises of several villages. It is the basic local government unit in the rural areas. An average union has an area of about 31 square kms and population of about 20 thousands. It consists of few wards defined to include some mauzas/villages
Union Parishad	Union Council (Lowest tier of local body)
Ward	Municipal or city administrative unit headed by the elected Commissioner
Zilla	District

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Abstract

Bangladesh is one of the most disaster prone nations of the world. During and after a disaster, many government, non-government, international and private organizations are involved with the functions of warning dissemination, evacuation, emergency relief and rehabilitation programs In the emergency relief operation, they face different problems especially in the estimation of relief materials and distribution of such material in an efficient manner among the affected population In most cases, it is not possible for the involved organizations to carry the required amount of relief in the relief centres of the affected areas in due time for want of proper estimation of relief requirements. In some places relief material is supplied in excess of requirement In this regard, a proper and need oriented information system may solve the problems encountered in the emergency relief and rehabilitation program

The present study has developed a GIS-based model and information system for estimating emergency relief requirements for flood victims. With the model, it will be possible to estimate the affected population and relief requirements for the relief centres. The model includes different phases such as identification of the affected areas, demarcation of the catchment areas of the identified relief centres, estimation of the affected population and assessment of relief requirements for the relief centres.

The model developed in this study has been applied on the study area of two upazillas, namely Keshabpur and Manirampur, of Jessore district. The probable affected areas of the study area have been identified using Digital Elevation Model (DEM) and certain measured water level. The flood depth of the particular areas has been calculated from the measured water level and the elevation of the areas. The flood has been categorized into different flood types based on the flood depth. Then the affected population has been estimated and relief requirements have been assessed for the catchment areas of the relief centres under different flood categories.

In the disaster prone countries like Bangladesh, this model can play an important role for estimating emergency relief requirements for flood victims. The model may be updated regularly with necessary modifications

Chapter 1

Introduction

1.1 Background of the study

Bangladesh is a nation of over 135 million people with a geographical area of 1,47,570 sq. km located on the Ganges, Brahmaputra and Meghna delta (BBS, 1997). The country is one of the most disaster prone nations in the world. The country is located in an incompatible geographical position making her vulnerable to extreme climatic events. The country is also beset with a host of other serious problems including overpopulation, poverty, resource constraints, lack of appropriate infrastructure and institutional facilities, low human resource development, lack of technological innovation, various environmental problems etc. These problems are complicated and compounded with the occurrences of regular and frequent disasters impeding the overall socio-economic development efforts of the country.

The country has experienced flooding from time immemorial It is almost a regular event resulting in loss of human lives and livestock, widespread damage to property, physical infrastructure, crops etc This has brought forth tremendous human sufferings and misery. The immediate effect of a disastrous flood is a situation where vast areas of land are inundated. As a result, standing crops are damaged, roads, highways and railway tracks are submerged, houses are damaged and in some cases washed away, shops and market places are forced to shut down, offices and service centers are closed down and almost all normal activities come to a standstill.

During and after a disaster, materials and human assistance are urgently needed from different sources. In Bangladesh, many government, non-government, international, private and volunteer organizations are involved with the emergency functions of warning dissemination, evacuation and emergency relief operation among the flood affected people. In the emergency relief operation, they face different problems especially in the proper estimation of relief materials and distribution of such material in an efficient manner among the affected population. In most cases of emergency relief and rehabilitation programs, the required amount of relief do not reach the affected areas in due

time for lack of proper estimation of relief required for the affected people. In some places relief materials are supplied in excess of requirement.

In this regard, a proper and need oriented information system may solve the problems encountered in the emergency relief and rehabilitation program. Information itself does not solve disaster management problems; but management problems cannot be properly addressed and solved without adequate information Information is thus central to the concept of integrated flood management and improving flood disaster management. It is an important tool to reduce damage to flood affected people and economic activities. As a management tool, information has been seriously under-used and neglected earlier in different strategic issues like disaster management in Bangladesh At this age of science and technological advancement, useful and urgently required tools should be developed with new and advanced technology and applied to face different management problems like emergency relief operation An appropriate information system can be developed for managing emergency relief operation. It will provide necessary information during and after the flood and help take the decisions for emergency relief operation. In this regard, Geographical Information System (GIS) is a very important tool providing necessary information in different decision making situations.

The present study has been undertaken to develop a model for estimating emergency relief requirements for flood victims The information system developed in this study may be applicable to the flood hit regions over the country for effective relief operation

1.2 Objectives of the study

The study has been conducted to achieve the following objectives:

i) To develop a model for estimating emergency relief requirements for flood victims

ii) To develop an information system for managing emergency relief operation over a flood hit region.

1.3 The importance of information in flood management

Disaster management and corresponding decision-making should be based on current, accessible and reliable information This holds true in particular for rational decisions in integrated flood management, where compromises and balances among many different impacts and interests are explicitly considered

In Bangladesh, some organizations in the public and private sectors use geo-spatial information and analyses. Flood management in the broad context is not institutionalized in our country. Information provision has so far been focused too much on disasters, especially during and immediately after an excessive flood. Effective information provision would focus on the following tasks of flood management.

- Reduction of disaster impact
- Managing emergency relief operation

Lack of information is a serious bottleneck for effective flood management in Bangladesh Despite the fact that Bangladesh is in one of the most flood-prone regions of the world, comprehensive flood inundation/risk maps are essentially non-existent Consistent monitoring and data collection on the extent, depth and duration of floods is substantially lacking for supporting flood management in Bangladesh. Data are collected on an ad-hoc basis, while their reliability and access is of major concern. Much of the available information is derived from descriptive attributes attached to mapping units of historic reconnaissance resource inventories, such as water resource management plans and soil surveys

Proper information provision that includes the use of appropriate, analytical and predictive tools is also lacking For example, the prediction of floods is limited to river water levels, which is of little use to direct users and managers. Similarly, damage functions are not well defined. In addition to these data collection and processing problems, the available information is not properly disseminated and potential users are not aware of how to get the information

New technological developments and proper institutional arrangements are able to improve flood monitoring and predictions and can facilitate access and dissemination of the generated information. For example, recent developments have made Synthetic Aperture Radar (SAR) data globally available through satellite remote sensing technology. This technology can provide crucial information for assessing floods in cloud-covered, monsoon environments

In the existing flood management in Bangladesh, the information base is not strong enough to support disaster management strategies including estimation of emergency relief requirements. The different public and private organizations are involved in emergency relief operation It is difficult to manage the emergency relief operations properly without adequate information.

1.4 Flood Information available in Bangladesh

Flood disaster management and monitoring in Bangladesh suffer from a lack of data and information on the conditions of and changes in the extremely dynamic physical and socio-economic environment. Flood information that is available in the country is incomplete and inconsistent in some cases. This is because of a number of reasons

First, although flooding is a regular phenomenon in Bangladesh, it was not annually assessed until 1988 in a systematic way Only big floods like those of 1987 and 1988 were assessed in a systematic way with help and cooperation from both national and international organizations (Chowdhury & Sato, 1996). However, these sources of information are not complete and there exist data inconsistencies.

Secondly, there sometimes seems to be a tendency to overestimate the flood-affected area That is because floods are generally assessed by a number of institutions and this sector wise assessment tends to aggravate the tendency to overestimate flood affected areas due to various socio-political reasons Therefore, flood affected area data are inconsistent and sometime misleading.

Recent flood policy strategy in Bangladesh has made it clear that an effective monitoring system is needed to identify flood affected areas and perhaps it is

the basic tool for any kind of study related to flood mitigation in Bangladesh In the past, floods were estimated in Bangladesh by ground observations. The introduction of satellite remote sensing technology, with the establishment of the Bangladesh Space Research and Remote Sensing Organization (SPARRSO) in the early 1980s, has provided a more reliable tool for flood monitoring in Bangladesh Among the available satellite imagery, the NOAA-AVHRR (National Oceanographic and Atmospheric Administration-Advanced Very High Resolution Radiometer) has been used in Bangladesh to identify aerial coverage of flood vulnerable land.

Since 1986, satellite imagery NOAA-AVHRR has been used extensively for flood monitoring in Bangladesh Flooding conditions can also be studied with LANDSAT imagery, which has much higher spatial resolution than the AVHRR (80m for Multispectral Scanner, MSS and 30m for Thematic Mapper, TM versus 1.1 km for AVHRR) (EGIS, 1998) But less frequent coverage (every 16 days) by LANDSAT greatly limits its usefulness for studies of the dynamic processes of the hydrosphere and atmosphere. Furthermore, the high incidence of cloud cover increases the interval between passes, severely limiting its responsiveness to regional needs. On the other hand, relatively less expensive, higher repetition rate (twice/day coverage per satellite) and night-time infrared make AVHRR one of the most useful operational remote sensing systems for flood monitoring presently available (EGIS, 1998).

Under the Flood Action Plan (FAP) efforts were made to co-ordinate project mapping through FAP19 "Geographical Information system" (FAP, 1995). Afterwards the EGIS project was started to continue the work of FAP19 and also of the FAP16 "Environmental Study". An important objective of this project was to support WARPO (Water Resources Planning Organization) in water sector planning. WARPO has developed NWRD (National Water Resources Database) which provides data with reasonable accuracy from a single database of a single organization (WARPO, 1999). The work was started by a joint team comprising staff of EGIS (Environment and GIS support Project for water sector modeling), SWMC (Surface Water Modeling Center) and NWMP under the direction of WARPO

1.5 Scope of the study

The present study with a view to develop a model and an information system for estimating emergency relief requirements for flood victims has been undertaken to cope with the difficult task of emergency relief operation after the occurrence of a devastating flood. In a developing country like Bangladesh, disaster management, especially flood disaster management, is not adequately organized due to lack of a proper system for assessing and managing flood information An information system should provide necessary information regarding the physical, socio-economic characteristics and infrastrutural facilities available in the affected areas, population statistics etc. to support decisions in emergency relief operation without any delay after a disaster.

In Bangladesh, many public and private organizations such as the Ministry of Disaster Management and Relief, Disaster Management Bureau, Directorate of Relief and Rehabilitation, District Disaster Management Committees, Upazilla Disaster Management Committees and Union Disaster Management Committees etc. and different national and international humanitarian development organizations conduct the emergency response including relief operation simultaneously. In this regard, they need adequate information about the clear picture of the affected areas and the affected population including the required relief requirements. At present, the organizations involved face tremendous problems in conducting relief operations due to lack of adequate and proper information at proper time.

In this situation, the present study has been undertaken with the objectives of developing a model for estimating emergency relief requirements for flood victims In the study, the different aspects of estimation of emergency relief requirements such as estimation of the affected area, identification of the relief centers, estimation of the relief materials etc. has been taken into consideration. Here, a model has been developed with which it will be possible to estimate the relief requirements for the relief centers. In this regard, the database has been developed with necessary data collected from different relevant organizations i.e , WARPO (Water Resources Planning Organization), Bangladesh Water Development Board, Surface Water Modeling Center, EGIS (Environment and

GIS Support Project for water sector modeling), Local Government Engineering Department etc.

In the model developed, some analyses including affected area estimation, estimation of number of affected people and finally estimation of relief requirement have been included. The model is implemented using GIS (Geographic Information System) software PC Arc/Info, ArcView and other software In the present study, the data and information required have been identified and collected from different sources to develop the model In disaster prone countries like Bangladesh, developing a model and information system for estimating emergency relief requirements for flood victims is a new effort towards developing an efficient and modern disaster management system The present model should be updated regularly with necessary modification removing the drawbacks and inconsistency detected

1.6 Methodology of the study

The present study for developing a model for estimating emergency relief requirements for flood victims is one of the essential efforts being made recently towards effective disaster management in Bangladesh. The present study was initiated from the realization of the urgent need for an information system that may help assess and manage the emergency relief operation. The study is based mainly on the data collected from the different secondary sources and necessary discussions with various officials who are experienced and involved in different disaster management projects. In the present study, the methodology followed is briefly discussed below

1.6.1 Review of related literature

Relevant literature like published and unpublished thesis, journals, books, newspapers, web address etc. were reviewed with a view to understand the existing relief and rehabilitation system and emergency disaster measures undertaken by different government, non-government and international organizations.

1.6.2 Finding out existing emergency relief operation

Visiting the different organizations involved in emergency relief operation and consulting with different officials, the existing procedures of emergency relief operation and the roles of different organizations have been identified Knowledge of existing system of emergency relief operation is necessary to develop the model for estimating emergency relief requirements for flood victims. Different organizations related to disaster management consulted and different officials discussed under the present study are described below:

Consultations with different organizations related to disaster management

In the present study, various government, non-government, autonomous, international and private organizations including different research and educational institutions were contacted and visited to learn about their duties and participation in the emergency relief and rehabilitation activities Efforts were made to find out the shortcomings and problems in emergency relief operation. The following organizations were visited:

- Flood Forecasting and Warning Center (FFWC), BWDB
- Ministry of Disaster Management and Relief
- Disaster Management Bureau (DMB)
- Directorate of Relief and Rehabilitation (DRR)
- Water Resources Planning Organization (WARPO)
- Environment and GIS Support Project for Water Sector Modeling (EGIS)
- Surface Water Modeling Center (SWMC)
- Institute of Water and Flood Management (IWFM), BUET
- Disaster Management Project, CARE Bangladesh
- Bangladesh Meteorological Department (BMD)
- Bangladesh Space Research and Remote Sensing Organization (SPARRSO)
- Local Government Engineering Department (LGED)
- Soil Resources Development Institute (SRDI)

During the visits of the above organizations, efforts were made to find out the existing procedures of emergency relief operation and the experience that the organizations gathered in different times especially in emergency relief and rehabilitation activities.

Discussions with the different officials

To develop a model for estimating emergency relief requirements for flood victims, a number of specialized and experienced officials from different organizations were contacted. In this regard, the experts of the following organizations were contacted a number of times and interviewed to know their opinions and experience in the present disaster management framework including emergency relief operation Their views and suggestions were taken regarding the proposed model and different aspects of emergency relief operation. The officials from the following organizations were contacted:

- Surface Water Modeling Center (SWMC)
- Flood Forecasting and Warning Center (FFWC), BWDB
- Disaster Management Bureau (DMB)
- EGIS
- WARPO
- Institute of Water and Flood Management (IWFM), BUET
- Local Government Engineering Department
- CARE Bangladesh

1.6.3 Selection of the study area

Selection of the study area is one of the important parts of any study. The present study aims at developing a model for estimating emergency relief requirements for flood victims in Bangladesh. The proposed model will be applicable to any disaster prone area of Bangladesh. For the present study, two upazillas, namely Keshabpur and Manirampur, under Jessore district have been selected. These areas were selected for the following reasons:

1. The southwest region of Bangladesh has been greatly affected by the devastating flood of 2000. The southwest region of the country is not normally flood prone. It was an odd phenomenon from a historical

perspective The satellite images of that region during Flood 2000 are available to EGIS, SPARRSO and other organizations. As part of the required data of this present study, the images of the affected areas of southwest region were required So the two upazillas were selected for using the Satellite images of that region during the flood 2000

2. Different government, non-government, international and private organizations were involved in emergency relief operation in the southwest regions of the country. As the main concern of the present study is estimation of emergency relief requirements, so the experience they gathered and the activities they performed could be taken into consideration in this study.

3. Many reports on the flood of 2000 of southwest region have been prepared and published by different organizations. The reports on emergency relief and rehabilitation program of southwest region could be used in the present study.

4 In the study, Digital Elevation Model (DEM) is one of the important elements used. The two upazillas selected have more variation in elevation in comparison to the other areas within the region So these two upazillas have been selected for the present study

1.6.4 Collection of necessary data and information

The proposed system would require considerable amount of data such as Digital Elevation Model (DEM), study area information, population statistics, shelter and relief centre information, relief requirement standard etc., that need to be collected from different sources

Table 1.1: Purpose and source of data required for the study

Data/Information	Source	Purpose
Digital Elevation Model (DEM)	WARPO	To find out the areas to be affected by flood
Relief requirement Standard	PACT/PRIP	To estimate the amount of relief required per head
Population data	BBS	To find out the number of population to be affected in a

		disaster hit region
Shelter information	LGED Upazilla Base map	To identify the location of shelters and affected areas
Relief centre information	LGED Upazilla Base map	To identify the location of relief centres
Settlement data	LGED Upazilla Base map	To show the location of settlements in maps
Location of 1. Schools 2 Colleges 3. Growth centres 4 Godowns 5. Health centres 6 Govt. offices	LGED Upazilla Base map	To prepare base map of study area
Location of 1. Administrative boundary up to mauza level 2 Upazilla headquarter 3 Union headquarter 4. Roads 5. Rivers 6. Water Body	WARPO/EGIS	To prepare base map of study area

1.6.5 Development of the model

In this study, a model for estimating emergency relief requirements has been developed. The important phases of the model are

a) Identification of the flood affected areas
b) Calculation of flood depths and flood types
c) Identification of the relief centres
d) Demarcation of the catchment areas of the relief centres
e) Estimation of the affected population
f) Assessment of the relief requirements

The model has been developed based on the data and information collected from different organizations. The present model is based on GIS (Geographic Information System) using PC ARC/INFO, ArcView and other software.

The methods followed in this study are presented in Figure 1.1:

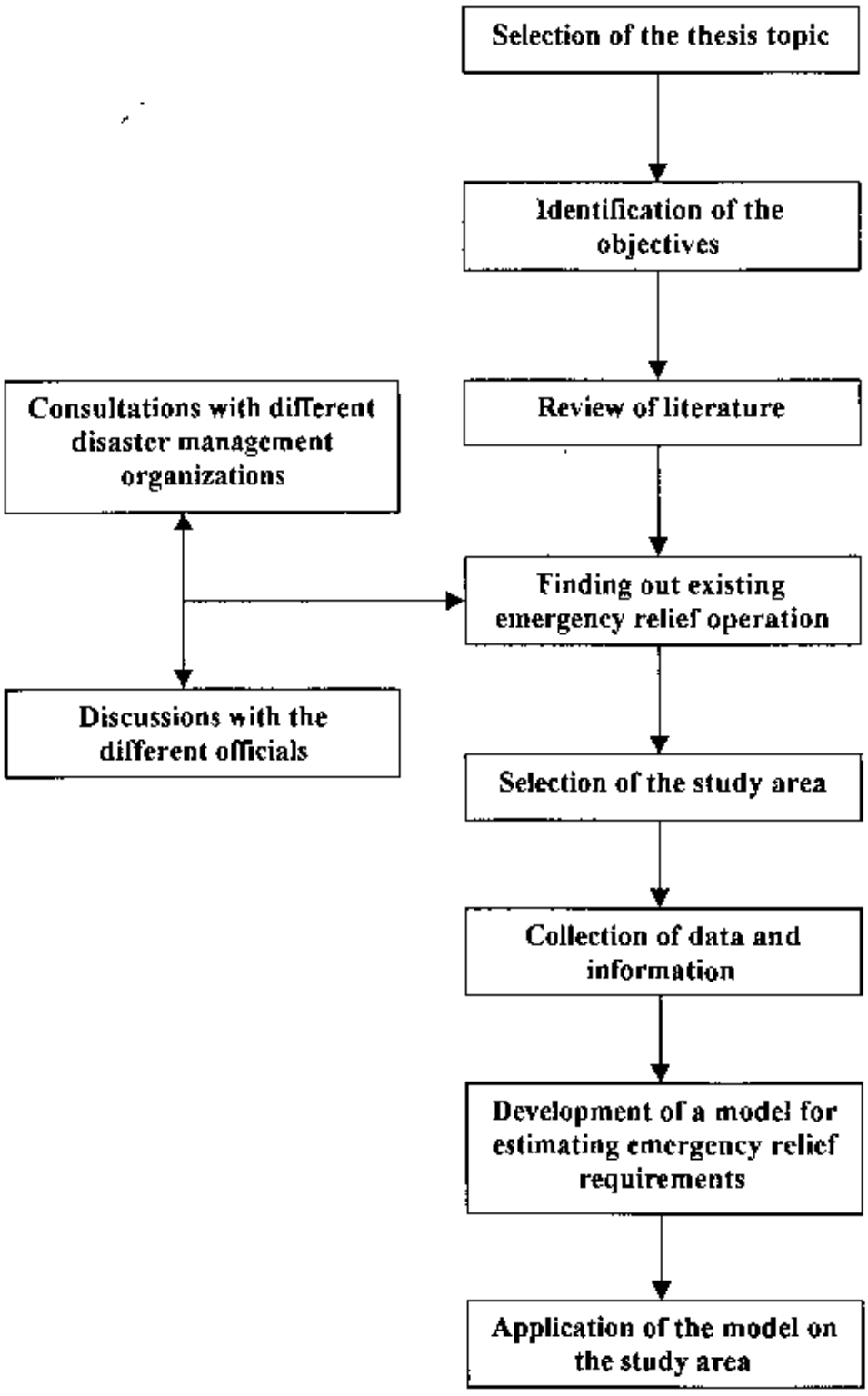


Figure 1.1: Flow chart of the methodology

1.7 Limitations of the study

The present study for developing a model for estimating emergency relief requirements has some limitations. The limitations are described below:

1. The flood forecasting models, hydrological models, other related models and data from different sources have been used in developing the model.

2 The Digital Elevation Model (DEM) used in this study is of 300 m resolution. It has been used to identify the flood affected areas under different flood depth or different water level in the rivers during flooding period .It is not updated. The flood affected areas could be identified properly and perfectly if the DEM of better resolution is available

3. The elements like shelter information, settlement, schools, colleges, growth centers, madrasa etc. shown in the study area have been taken and digitized from the LGED upazilla base map. Detailed field survey was not possible to collect information regarding the different features available in the study area.

1.8 Organization of the study

The present study has been divided into seven chapters Chapter-1 presents background of the study, objectives and scope of the study along with the importance of information in flood management and flood information available in Bangladesh. The methodology and limitations of the study are also discussed in this chapter

Chapter-2 deals with the concepts and issues related to disaster management strategies. Geographic Information System (GIS) and its possible uses in flood management are also discussed in this chapter.

Chapter-3 presents review of related literature such as books, journals, reports, thesis and other materials The application of GIS in disaster management strategies in different countries is discussed in this chapter.

Chapter-4 discusses types, characteristics, sources and causes of floods in Bangladesh along with some major flood damages

Chapter-5 deals with present institutional framework and emergency relief activities in Bangladesh.

Chapter-6 has developed a model for estimating emergency relief requirements This chapter discusses different phases of the model such as identification of the affected areas, identification of the affected population, selection of relief centres and their catchment areas, assessment of relief requirements etc

Chapter-7 presents a number of recommendations and concludes the study.

Chapter 2

Concepts and Issues

2.1 Introduction

Disaster, catastrophe, calamity, debacle or act of God-whatever one calls it, the incidents associated with such expressions are generally physical phenomena. They were the concern of interest of physical scientists. But, nowadays it has become a major concern of policy makers and planners The growing awareness about the environmental issues and their influence on national development has made consideration for such events an integral part of development plan and policies. A clear understanding of various aspects related with disaster management is therefore necessary in order to shape up the plans which are associated with or influenced by environmental issues.

2.2 Definition of a Disaster

A disaster has been defined as "an event, natural or man-made, sudden or progressive that seriously disrupts the functioning of a society, causing human, material or environmental losses of such severity that the affected community has to respond by taking exceptional measures" (Carter, 1992).

The League of Red Cross and Red Crescent Societies has defined the term "Disaster" in the following way

> "A disaster is a catastrophic situation, in which the day-to-day patterns of life are –in many instances-suddenly disrupted and, as a result, people need protection, food, clothing, shelter, medical and social care, and other necessities of life."

A more specific definition, which is restricted to more sudden events, is in use in the United Kingdom:

> "A major incident is a serious disruption to life, arising with little or no warning, causing or threatening death or serious injury to, or rendering homeless, such numbers of persons in excess of those which can be dealt with by the public services operating under normal procedures, and which calls for the special mobilization and organization of those services".

The concept of disaster can be defined in various ways with regard to the point of view they are dealt with, but in general, all disaster have some common characteristics They are as follows.

- They cause disruption of regular mode of life. The effects of such disruptions can be very sudden and widespread.

- They can have extensive negative impacts on living beings They can result large death of human beings and animals and plants. Apart from this, there can also be some negative effects on the living beings who survive, after the end of a catastrophic disaster

- Disasters are accompanied by damage to the social infrastructure The extent of damage depends on the severity of disaster. Disruption of communication and transportation network is also common.

- There is an immediate need of institutional and social assistance to the victims. The need for shelter, food, clothing and medical care would depend upon the nature and severity of disaster.

2.3 Disaster management

Disaster management is a continuous process A formal definition of disaster management is given below.

> "An applied science which seeks, by the systematic observation and analysis of disaster, to improve measures, relating to prevention, mitigation, preparedness, emergency response and recovery" (Carter, 1992).

Disaster Management is a cyclic process-which means the fluctuations related with it do not start and stop with each occurrence of disaster, rather it continues with gradual adjustments and improvements (Figure 2.1). There are various components of disaster management and each component incorporate different types of activities (Figure 2.2).

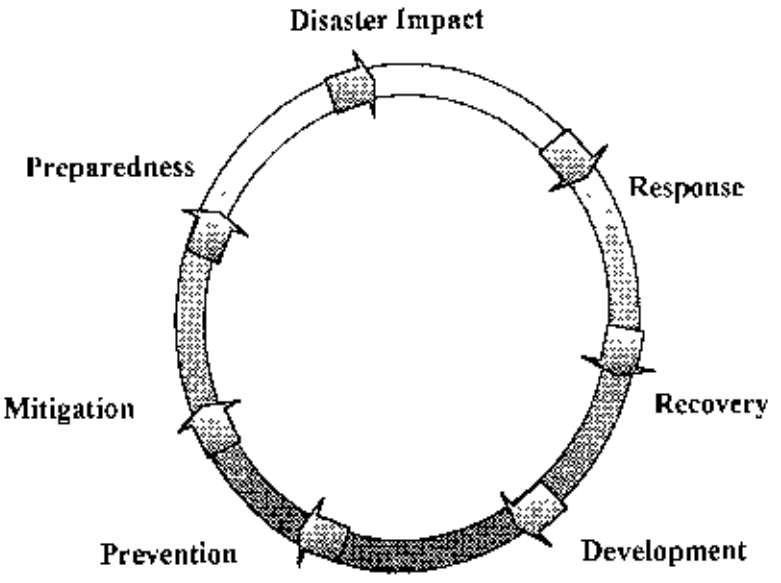


Figure 2.1: Basic Format of the Disaster Management Cycle

Source: Carter (1992)

2.3.1 Preparedness

The term "Preparedness" can be defined in the following way:

> "Measures which enable governments, organizations, communities and individuals to take steps rapidly and effectively to disaster situations Preparedness measures include the formulation of viable disaster plans, the maintenance of resources and training of personnel." (Carter, 1992).

Preparedness measures comprise national disaster management policy, disaster legislation, appropriate organizational structure, national disaster management authority, coordination among the organizations, training programs, forecasting, public warnings, standing arrangements for evacuation and organization of rescue etc National disaster management policy provides guidelines about actions that have to be taken for the preparation and other activities of successive stages. Legislative support is also required to strengthen the policy framework Participation of individuals or organizations can be ensured through disaster legislation.

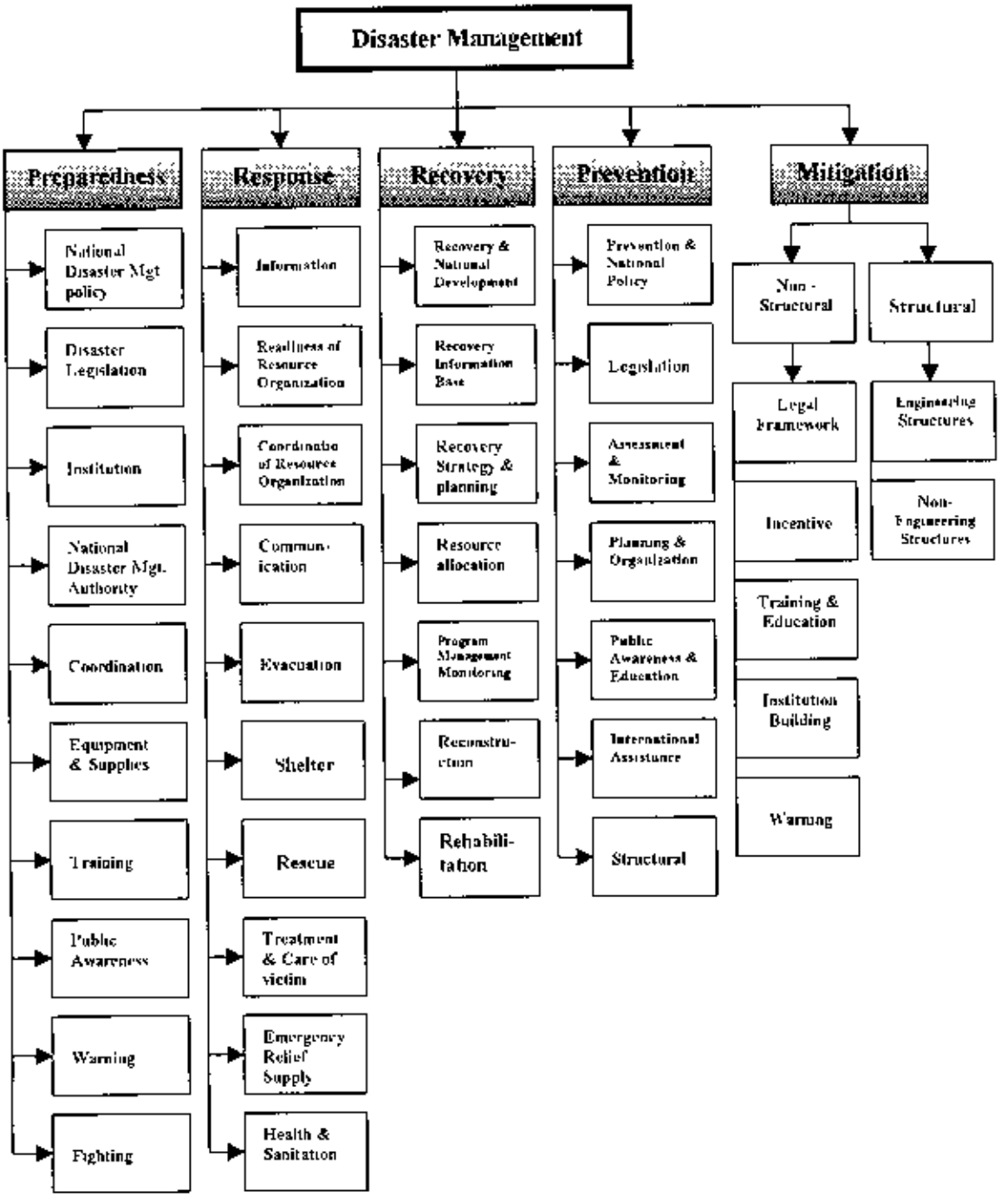


Figure 2.2: Stages related with Disaster Management

Source: Carter, 1992

2.3.2 Response

Response to natural disaster can be defined in the following way:

> "Response measures are those which are taken immediately, prior to and following a disaster Such measures are directed towards saving life and protecting property and to dealing with the immediate damage caused by the disaster" (Carter, 1992).

The nature of response depends upon the type of disaster and intensity of threat Response measures include information, readiness of resource organizations, coordination of response operation, communications, evacuation, shelter, rescue, treatment and care of victims, emergency relief supply, restoration of transportation, water and power supply facility, health and sanitation, reconstruction etc.

Information on disaster impact is the preliminary step towards response Extent and speed of resource mobilization would depend upon the information about nature of destruction in the affected areas. Various government and non-government organizations should be ready to respond to disaster situation. Disaster management committees are necessary at different administrative levels to ensure overall coordination in decision making and allocation of tasks. Communication facility must be developed to ensure adequate response under severe situation.

Evacuation is very important step in disaster management Shelter facility can be provided by constructing formal shelters or by turning public or institutional buildings into emergency shelters. Rescue operations should be conducted immediately after the disaster for reducing casualties and further damage to personal wealth Rescue operation depends upon communication, transportation and man-power.

Food supply for victims and emergency field workers will have to be ensured Estimation of food reserves and assessment of food requirement during emergency period would determine the extent of assistance required from

international and local organizations Apart from emergency food, people may require clothing, cooking utensils, plastic sheets etc.

Sometimes the affected area may be cut off from the rest of the country if the entire transportation network and national communication facilities collapses Similar things may happen in water and power supply system Under such situation temporary re-establishment and quick repairing and reconstruction of these sectors are necessary.

Reconstruction of buildings and other facilities should begin before further deterioration However, it largely depends upon resource mobilization Resources should be mobilized from internal and external sources for reconstruction of infrastructural facilities on priority basis

2.3.3 Recovery

Recovery can be defined in the following way:

> "Recovery is the process by which communities and the nation are assisted in returning to their normal life and functions following a disaster" (Carter, 1992)

Recovery measures include recovery information base, recovery strategy and programs, resource allocations, programs management and monitoring etc. Information on response operations, development programmes, post disaster review by special teams and comparative analysis of previous disastrous situation is useful for preparation of recovery strategy.

A technical advisory team can be created to evaluate post disaster requirements. Basing upon their suggestions, a strategy should be formulated indicating major areas of recovery, envisaged time frame for recovery, interlinking recovery with national development programmes, assessment of resource availability, major responsibility and programmes for recovery action and system of monitoring.

The size and shape of total recovery programme depends upon the availability of resources Usually third world countries rely upon international assistance which may come as donations, grants, credits, equipments and materials etc

A good number of projects may be initiated in recovery stage, therefore proper management and monitoring facility may become crucial. Sometimes special offices are entrusted with this responsibility

2.3.4 Prevention

Prevention of occurrence of natural disaster is practically impossible, but it can include some measures which can reduce the intensity of devastation. Prevention can be defined in the following way:

> "Prevention covers those measures which are aimed at reducing the occurrence of a sudden event and/or preventing such an occurrence having harmful effects on communities" (Carter, 1992).

Construction of dam to control floods or tidal upsurge or construction of houses above the normal flood level or surge height are examples of preventive measures. Preventive measures will have to be designed in the context of National Development Plan, National Disaster Management Policy, Disaster Legislation, Country Disaster Plan etc. On the other hand people may become hostile about preventive measures if they do not match with traditional norms and values or not properly designed and have negative impacts. Cost of implementation and other national priorities can also influence such issues Sometimes government or state authority may fail to take effective preventive measures out of fear of loosing popularity and public support.

A comprehensive national disaster management policy should outline the preventive measures including the authority who would execute the implementation process Legal support is required to backup the implementation process Mandatory building codes can be cited as an example which can enhance the preventive measures taken against flood or cyclone

Cost-benefit analysis of preventive measures and continuous monitoring of disaster hazards and vulnerabilities are required to formulate well-judged preventive measures. Public awareness and education programmes can improve preparedness programmes and at the same time can associate people with preventive measures.

2.3.5 Mitigation

The concept of prevention and mitigation are somewhat confusing. Prevention implies that the occurrence of certain disastrous phenomena can be controlled while there are still some events which can not be controlled but their impact can be minimized. Thus mitigation can be defined in the following way:

> "Measures aimed at reducing the impact of a natural or man-made disaster on a nation or economy" (Carter, 1992).

Like any other stage of disaster management, this stage needs initiation, management, prioritization, monitoring, evaluation and institutionalization. Mitigation can be done in two ways.

a) Non-structural mitigation

Non-structural mitigation measures include legal framework, incentive, training and education, institutional building and warning system etc If existing legislation can not provide enough support to the implementation of mitigation measures, then special legal framework may be introduced Incentive can be offered to fill up the gaps which can not be covered by legal framework Special tax evasions or reduced insurance premium or grants and subsidies can be effective where adoption of mitigation measures can not be forced

In order to make mitigation programmes successful, special training programmes for officials or construction specialists and education and awareness generation programmes for general population can become useful. Four groups are important for this purpose (i) the public officials, (ii) technical students whose professional education should include disaster

mitigation courses, (iii) the small builders and (iv) craftsmen and general students

Disaster mitigation capacity of a nation depends upon the social structure and organizational capacity to deal with the aspects related with disaster management Planned initiatives can be taken to strengthen the organizations to develop mechanisms and increase their institutional capacity and skills.

Better warning system can effectively improve disaster management and mitigation system. Evacuation and mobilization of emergency services and resources can be done appropriately if timely warning of impending disaster is received by the community and organizations involved

b) Structural Mitigation

Structural mitigation involves construction of specially planned and designed structures. It can be accomplished by adopting engineered structures and non-engineered structures.

Engineered structures are specially planned, designed and constructed with the help of engineers, planners and architects They may include simple dwellings or multi story office blocks, dams, embankments, transportation facilities etc For this, the aspects such as site planning, assessment of forces created by the natural phenomena, the planning and analysis of structural measures to resist such forces, the design and proper detailing of structural components, construction with suitable materials, good workmanship etc will have to be considered.

The general code of construction and technique existent in the country can never be elaborate enough to cope with the requirements of disaster mitigation Therefore, a new set of codes and techniques would be needed if engineered structures are to be constructed.

Non-engineered structures are also useful in many cases. Majority of building in a community or country are built by local contractor. Only a few

can afford to engage engineers and architects and even if they do, can hardly comply with the requirements of disaster mitigation codes and techniques. But such structures can increase the threat of danger For such cases incentives or new building coded can be introduced.

2.4 Definition of flood

Flood can be defined as "the rise of waters of a natural stream above a level associated with the beginning of damage Damage stage is usually reached when the stream is bankful; that is when the channel is completely occupied Beyond this, overflow of the flood plain is reached. Flood plain ranges from a narrow marginal width in confined, steeply sloped valley of mountainous country to one extending many miles from the river channel" (SWMC & BWDB, 2000).

2.5 Geographic Information System (GIS)

Geographic information systems are computer-based systems that are used to store and manipulate geographic information (Aronoff, 1993). A GIS is designed for the collection, storage and analysis of objects and phenomena where geographic location is an important characteristic or critical to the analysis.

GIS is a system that contains spatially referenced data that can be analyzed and converted to information for a specific set of purpose, or application. The key feature of a GIS is the analysis of data to produce new information. A GIS is a system of computer hardware, software, and procedures designed to support the capture, management, manipulation, analysis, and display of spatially referenced data for solving complex planning and management problems.

The Components of a GIS

A GIS provides the flowing four sets of capabilities to handle georeferenced data (Aronoff, 1993).

1. Input
2. Data management (data storage and retrieval)
3 Manipulation and analysis
4. Output

The above components of a GIS are illustrated below:

Input: The data input component converts data from their existing form into one that can be used by the GIS. Georeferenced data are commonly provided as paper maps, tables of attributes, electronics files of maps and associated attribute data, air photos and even satellite imagery. The data input procedure can be as straightforward as a file conversion from one electronic format to another, or it can be complex.

Data management: The data management component of the GIS includes those functions needed to store and retrieve data from the data base. The methods used to implement these functions affect how efficiently the system performs all operations with the data. There are a variety of methods used to organize the data into computer readable files. The way the data are structured (data structure) and the way files can be related to each other (the organization of the data base) place constraints on the way in which data can be retrieved and the speed of the retrieval operation

Data manipulation and analysis: The data manipulation and analysis functions determine the information that can be generated by the GIS. A list of required capabilities should be defined as part of the system requirements What is often not anticipated is that the introduction of a GIS will not only automate certain activities, it will also change the way the organization works.

Data output: The output or reporting functions of GIS vary more in quality, accuracy and ease of use than in the capabilities available The functions needed are determined by the users needs and so user involvement is important in specifying the output requirements

The fundamental components of a GIS and its environment are illustrated in Figure 2.3.

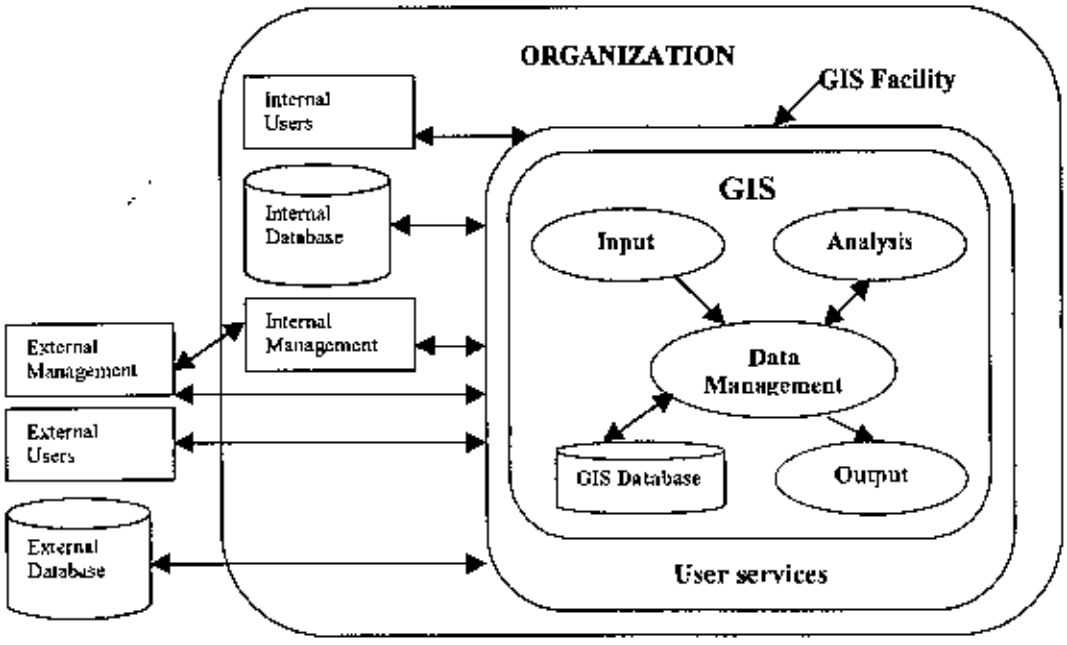


Figure 2.3: The Management Context in which a GIS facility exist
Source: Aronoff (1993)

The Nature of Geographic Data

In a computer based GIS, geographic data are represented as points, lines and areas The information for a geographic feature has four major components:

i) its geographic position
ii) its attributes
iii) its spatial relationship and
iv) time

More simply, the four components are. where it is, what it is, what is its relationship to other spatial features and when the condition did or feature exist

2.6 Spatial Data Models

There are two fundamental approaches to the representation of the spatial component of geographic information.

1. The Raster Data Model
2. The Vector Data Model

The Raster Data Model

In its simplest form, the raster data model consists of a regular grid of square or rectangular cells The location of each cell or pixel (for picture element) is defined by its row and column numbers. The value assigned to the cell indicates the value of the attribute it represents. Each cell in a raster file is assigned only one value In the raster data model, each cell represents an area of the land surface. Since the attribute of each cell is stored as a unique value, the total number of values to be stored is the product of the number of columns times the number of rows. The smaller the area of land that each cell represents, the higher the resolution of the data and the larger the file needed to store the data.

The Vector Data Model

The vector data model provides for the precise positioning of features in space. The approach used in the vector model is to precisely specify the position of the points, lines and polygons used to represent features of interest The map area is assumed to be a continuous coordinate space where a position can be defined as precisely as desired The vector model assumes that position coordinates are mathematically exact In fact, the level of precision is limited by the number of bits used to represent a single value within the computer, although it is a very fine resolution compared with the cell sizes generally used in raster systems

The Figure 2 4 shows the comparison of the Raster and Vector Models The landscape in (A) is shown in a raster representation (B) and vector representation (C) The pine forest stand (P) and spruce forest stand (S) are area features. The river (R) is a line feature and the house (H) is a point feature.

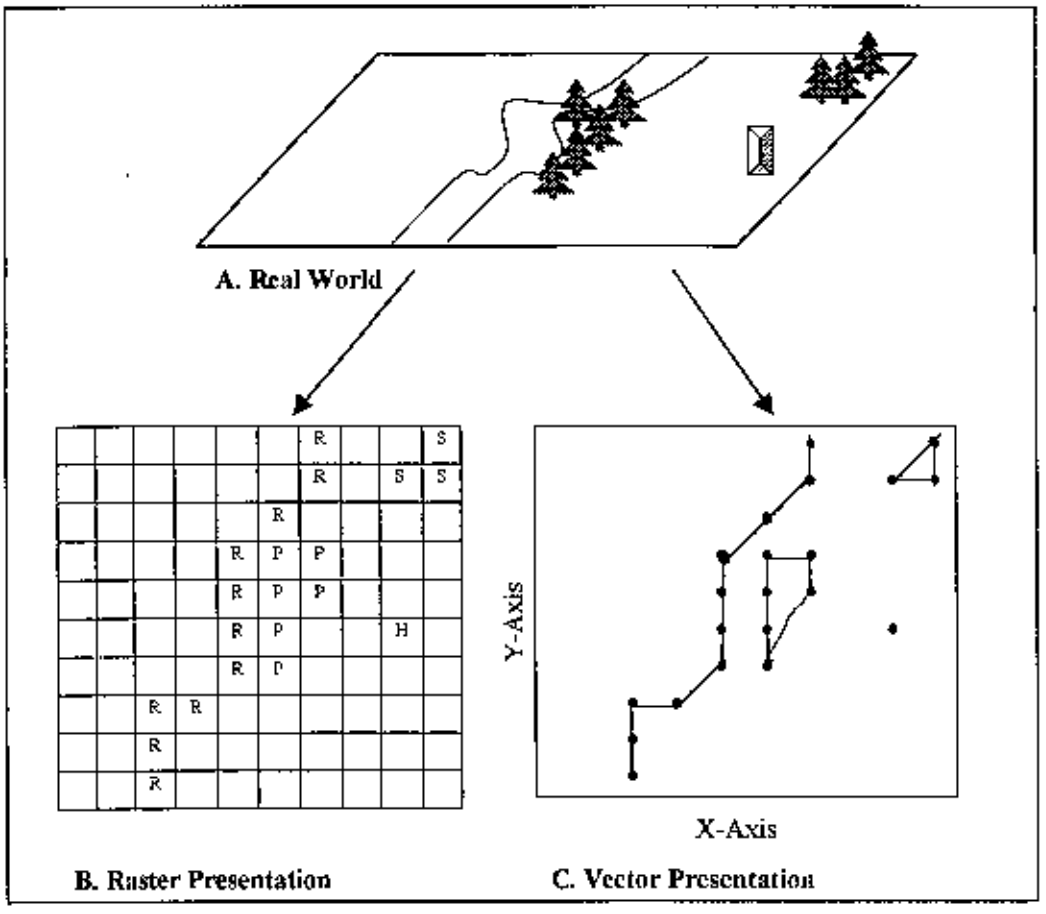


Figure 2.4: Comparison of the Raster and Vector Models
Source: Aronoff, 1993

Thiessen or Voronoi polygons

Thiessen or Voronoi polygons define individual areas of influence around each of a sets of points. It is an approach to extending point information which assumes that the "best" information for locations with no observations is the value at the closest point with a known value (Aronoff, 1993).

Thiessen polygons are constructed around a set of Points in such a way that the polygon boundaries are equidistant from the neighboring points. In other words, each location within a polygon is closer to its contained point than to any other point.

2.7 Design and implementation of a GIS based system

GIS is an automated system It has a sophisticated ability to store non-graphic attributes or geographically referenced data and link them with the graphic map features so that a wide range of information processing and display operations, including map production, can be accomplished. The focus is on geographic analysis rather than mere display of graphics.

The application of GIS varies widely. It can produce maps and information accurately and efficiently showing particular combinations of graphic and non-graphic data This is one of the most valuable features of GIS Together with its other features, such as its data management and analytical capabilities, GIS gives managers an enhanced ability to manipulate and use data more efficiently.

The design philosophy of a GIS based system can be simply stated as "application must drive system design" (Pan and Koh, 1999). In the design of an information system, the requirements and resources available must first be defined before establishing the applications and processes that may be possible Then, the system function and database content are determined and designed to meet the requirements. The design process is interactive, moving from the abstract, through a concept, preliminary design and detailed design, then to specification. Database is the foundation needed to perform any application. Its content and accuracy are essential to the success of a GIS based system. Figure 2.5 shows the flow of the design philosophy of a GIS based system

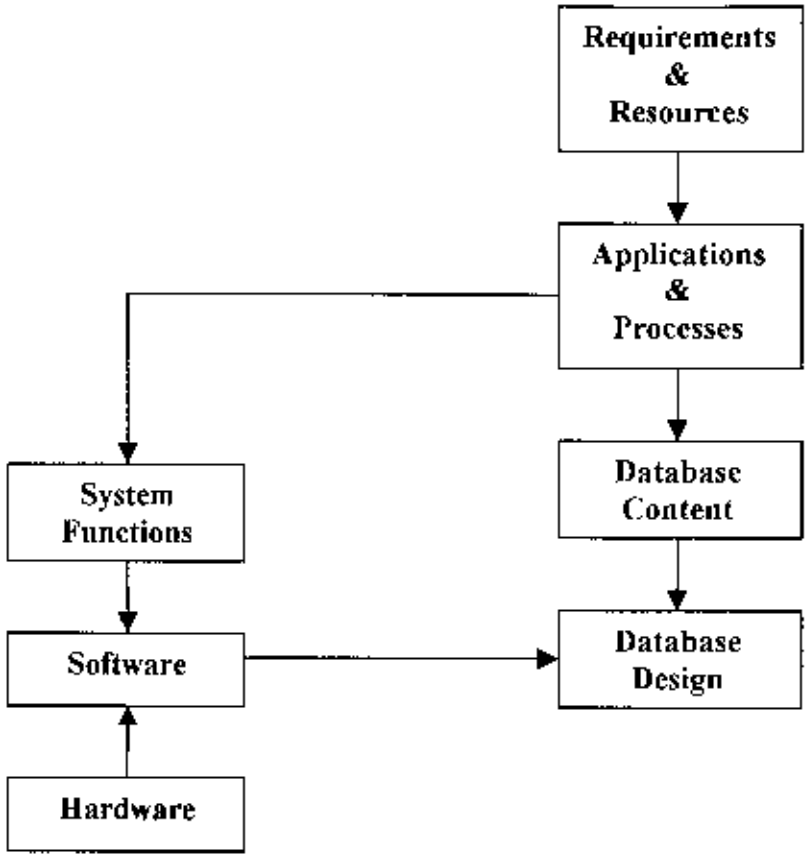


Figure 2.5: Design philosophy of a GIS based system

Source Pan and Koh (1999)

The implementation of a GIS based system may be classified broadly into five stages (Figure 2.6). The first stage, concept, is to define the user needs, available resources, feasibility assessment and system requirements. Second, the design stage, the system functions and databases are developed. In the development stage, an organization acquires the software, hardware and data conversion services, and develops procedures to operate the system.

After having acquired all the necessary items for the automated system, the phasing from manual to automated activities is carried out in the operation stage. Finally, an evaluation of the installed system and the planning for improvements and expansion may be performed. This is known as the audit stage.

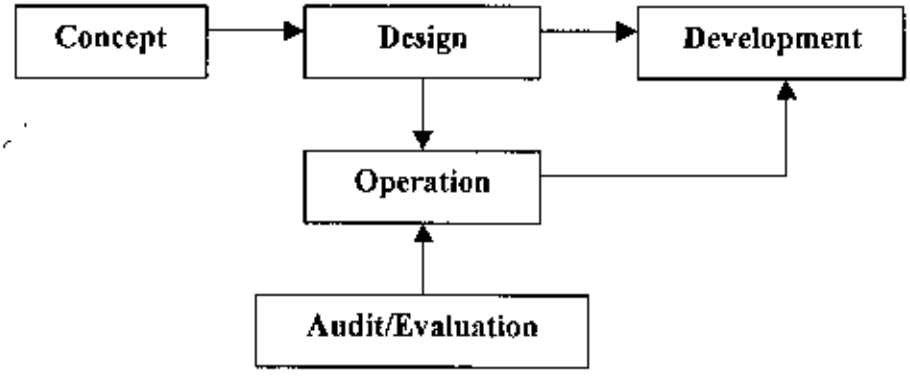


Figure 2.6: Stages of implementation of a GIS based system
Source Pan and Koh (1999)

2.8 Geographic Information System (GIS) in flood management strategies

GIS facilitates the researchers, authorities and relief organizations to efficiently plan, implement and monitor the natural disaster preparedness and mitigation activities such as predictions, preventive actions, relief operations, rehabilitation, reconstruction, awareness creation and public education

At present, Geographic Information System (GIS) based tools and models are being developed and used for flood management in many countries of the world In Bangladesh, GIS have not been frequently used in flood management strategies. Some organizations like EGIS, SWMC, BWDB and others are using GIS technologies to a very small extent for flood prediction, monitoring and management. In some cases, initiatives were taken to develop the updated database for making flood management strategies Bangladesh Water Development Board (BWDB) has established a flood information center for providing the flood information to the people and relevant organizations during monsoon season and flooding period. They use a number of hydrological and flood forecasting models provided by SWMC and EGIS EGIS is involved in developing water sector modeling and in some cases flood management strategies in cooperation with other relevant organizations. WARPO (Water Resources Planning Organization) of Ministry of Water Resources has developed a National Water Resources Database (NWRD) in association with EGIS, SWMC and BWDB. Bangladesh has scopes to utilize GIS and other advanced technologies to a large extent for flood management and other disaster management strategies.

Space based observation of the earth is advancing at a very rapid space. A series of earth observation satellites has been successfully launched and operated over the past three decades to support scientific and commercial objectives for global environmental monitoring and resource management. Among the earth observation satellites, some are being used for supporting flood management tasks and strategies in the world including Bangladesh. The most recent generation of earth observation satellite sensors can provide new information for flood monitoring and flood management in Bangladesh.

The following figure describes an advanced disaster management system determining pre and post disaster strategies utilizing Geographic Information System (GIS) and remote sensing technologies

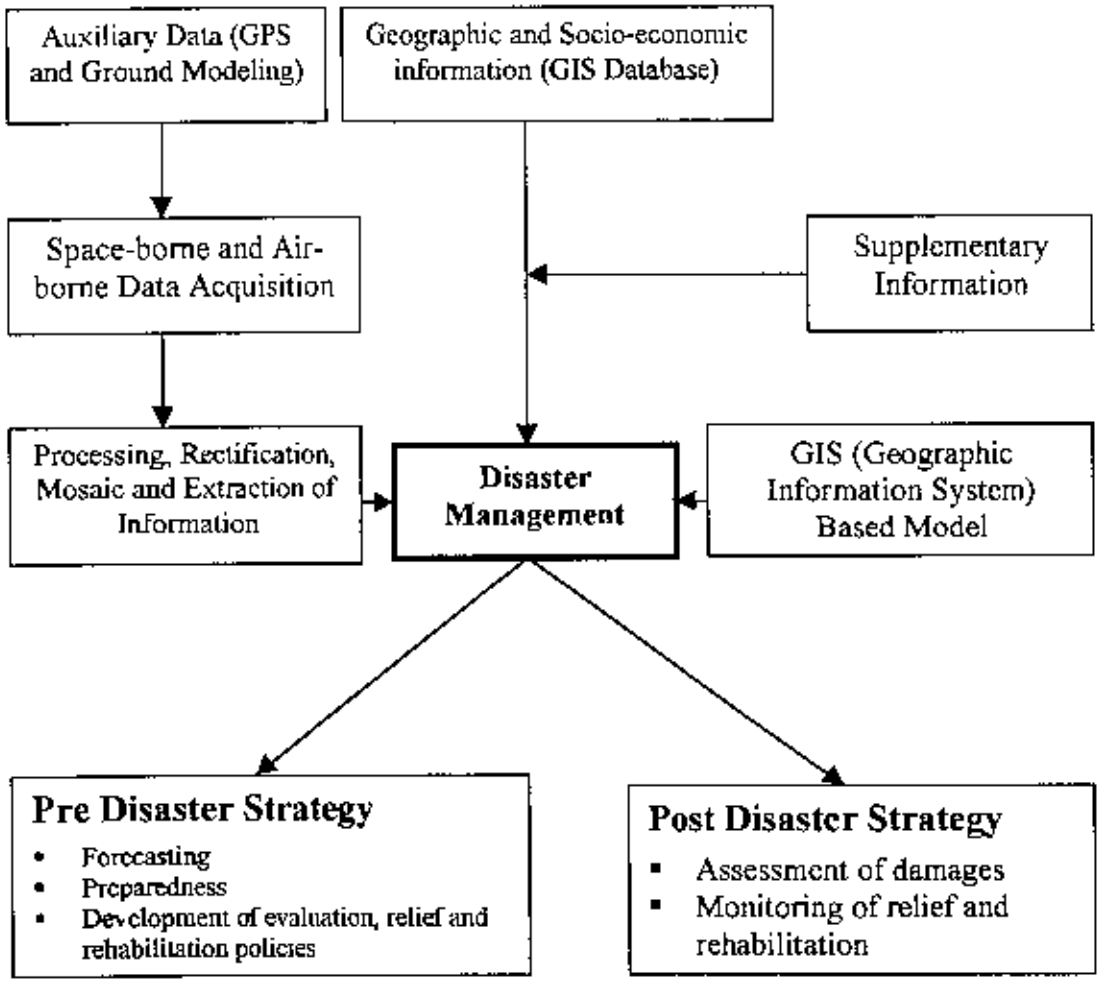


Figure 2.7: Effective disaster management system using Geographic Information System (GIS) and Remote Sensing technology
(Source: Alam and Habib, 2000)

In the most disaster prone and least developed countries like Bangladesh, information system can play an important role especially in post flood emergency response including relief distribution among the flood-affected people

2.9 Relief Approaches

In the existing relief and rehabilitation programs, there is no systematic and computerized way of estimating relief requirements and distributing relief among the affected people (Pramanik, 1995). It is a very difficult task for the local people of the affected areas to estimate the number of affected people who need relief materials within a very short time. In recent days, the conceptual approaches of relief have changed significantly. Many new aspects of disaster management have been taken into consideration in the present coordinated emergency relief operation In the traditional relief approach, capacity of the local people is not considered along with the need assessment and involvement of them in the relief operation is not ensured. On the other hand, Development Relief Approaches ensure both needs and capacity assessment and encourage the local people in the relief activities Assessment of relief requirement is also done by an information system and a model in the development relief approach Differences between the conceptual approaches of Traditional Relief Approach and Development Relief Approach are shown in Table 2 1:

Table 2.1: Difference between the Traditional Relief Approach and Development Relief Approach

Traditional Relief Approach	Development Relief Approach
Victims are helpless and need things	"Victims" are active people with capacities
Must do rapid needs assessment	Must do both a needs and a capacities assessment
The urgency of needs dictates that speed and efficiency are paramount Organizations can not afford to take the time to consult or involve local people	It is never seen to consider the long term impacts of outside assistance: from the very beginning, Organizations must respect the ideas and capabilities of local people
Physical and material things are the focus	Even if the organizations supply some physical things that people need, they must be sure to rely on,

	and encourage local peoples capacities
The goal is to meet emergency needs and to get things back to normal	The goal is to reduce long term vulnerabilities and to support the increase in capacities
Estimation of affected population and damages is not systematic	Estimation of affected population and damages is made by a model
Assessing relief requirement is not scientific	Assessing relief requirement is based on a model and information system

Source: Holloway and Huq (1994)

In the existing relief operation, the involved organization has to face a great problem in estimating relief materials and distributing these among the affected people. In these cases, the computerized information system may help estimate the emergency relief requirements for flood victims including the relief operation among the affected population

2.10 Information for post disaster assessment and emergency response

Proper and adequate information can help the relevant organizations and decision makers to make emergency response including identification of relief centres and estimation of relief materials The following table describes detailed information collection procedures including priority areas, nature of the assessment techniques and needs assessment

Table 2.2: Information collection for post-disaster assessment and emergency response

Priority areas for data collection	Nature of the Assessment Techniques	Assessment of Needs
Extent of impact on geographical area	▪ Existing thematic maps ▪ Aerial Photography ▪ Ground-level photography ▪ Ground-level reconnaissance -Team observation ▪ Surveys ▪ Interpersonal Communication -Telephone -Radio	
Demographic data	▪ Existing baseline information ▪ Census data	

	▪ Thematic maps ▪ Aerial Photography ▪ Ground-level reconnaissance -Surveys -Population and Demographics -Team observation ▪ Interpersonal Communication -Telephone -Radio	
Housing	▪ Census data ▪ Aerial Photography ▪ Ground level photography ▪ Ground-level reconnaissance ▪ Surveys -Thematic maps -Team observation -Interpersonal Communication	▪ Alternative shelter (Public buildings, hotels, schools) ▪ Available/extended family ▪ Location of refugees ▪ Relationship between shelter needs/climate ▪ Priority areas for reconstruction ▪ Number of housing units needed ▪ Cooking facilities ▪ Areas of limited suitability for residential development
Transportation Systems	▪ Census data ▪ Thematic maps ▪ Aerial Photography ▪ Ground level photography ▪ Ground-level reconnaissance -Surveys -Team observation	▪ Essential transport systems ▪ Access to all affected areas ▪ Vehicle resources (buses. trucks, vans) ▪ Specialized vehicles
Communication Systems	▪ Census data ▪ Ground-level reconnaissance ▪ Surveys ▪ Interpersonal communications	▪ Reestablishment of International Communication ▪ Communication with remote and isolated areas
Nutrition and Food System	▪ Census data ▪ Thematic maps ▪ Ground-level reconnaissance -Surveys -Team observation -Interpersonal communications	▪ Food available ▪ Food patterns ▪ Agricultural production Cycles ▪ Food distribution System ▪ Shortage Facilities ▪ Special Food Needs

Source: UNDRO (1984)

Chapter 3

Review of Literature

3.1 Introduction

Review of the related research and literature is necessary to provide ideas, theories, explanations or hypothesis valuable in formulating the problem, to suggest methods of research appropriate to the problem, to locate comparative data useful in the interpretation of results and to contribute to the general scholarship of the investigator (Carter, 1992). Therefore, for the present study an extensive literature survey was done on books, reports, thesis, journals, booklets, websites etc. related to disaster management including emergency relief operation. The materials related to the advanced disaster management strategies, information systems etc. have also been reviewed to be familiar with the disaster management strategies and technologies used by the international organizations in the different countries

3.2 Some websites related to disaster Management

Some websites of the national and international organizations regarding the disaster management strategies have been visited Some of them are described below

3.2.1 National Information Networks

Through partnerships, both local and international, RSI (Radarsat Satellite Inc.) is integrating remote sensing technology into derived information solutions that are accessible through national information networks to all levels of government and the private sector. The following Figure 3.1 depicts the National Information Network concept:

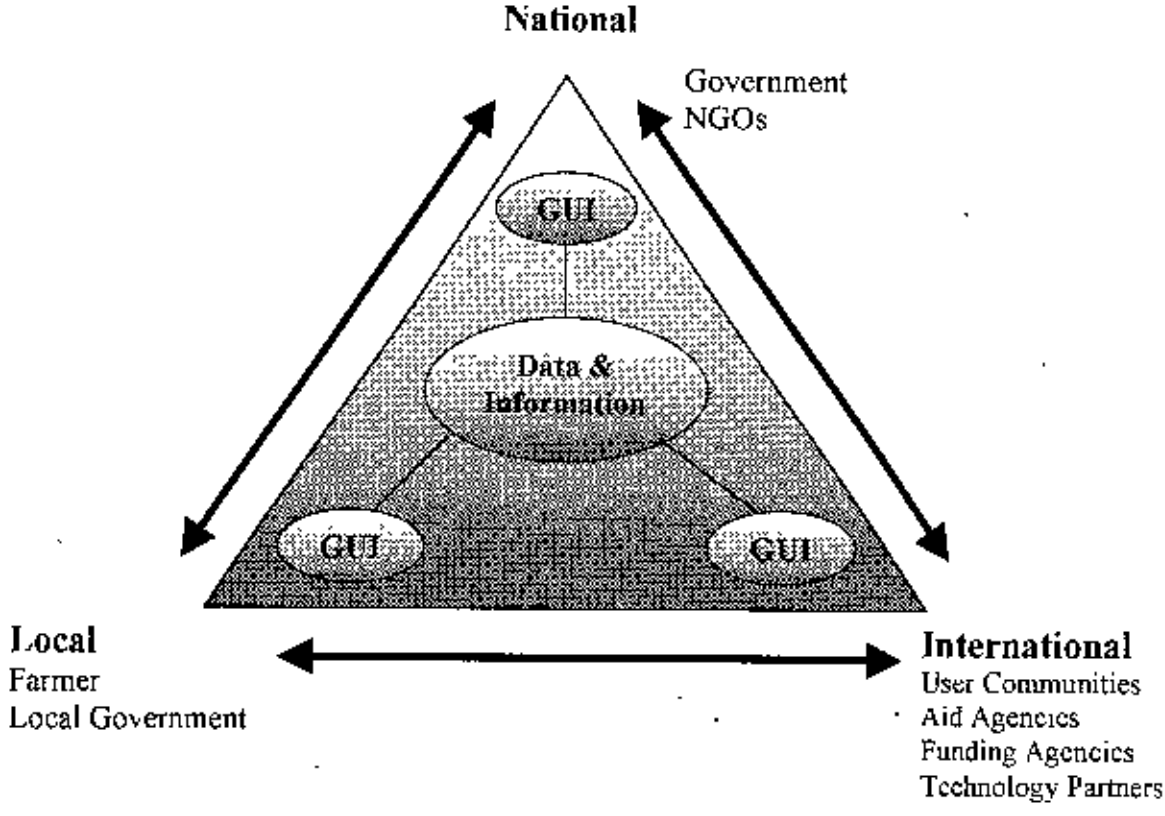


Figure 3.1: National Information Network connectivity

Source. Riverside Technology, Inc. and EGIS (2000)

The flood management component of the Vietnam project, described above, provides an example of how the National Information Network concept is being implemented for disaster management. The example is smaller in scope than what could be accomplished in Bangladesh, but the model is applicable in any country. The system under development is represented in Figure 3.2. It relies on the internet to bring together various sources of data, component integration, and flood related information display through a series of applications modules. Each module addresses a specific need in the flood information and management. The system will make available information bulletins from the Vietnam Disaster Center to a wide range of users, including the media, research organizations, embassies and others.

The system components are modular, allowing for integration with other Web environments with a similar applications focus. Some of the applications tools include

- Links from flood warning system to RSI's emergency programming service to ensure Radarsat is tasked to acquire images at critical times.
- A response system to ensure NRT information delivery to the Vietnam Disaster Center.
- A flood monitoring system to track the development of a flood through time. This includes continued satellite data collection and the generation of information products to support decision making
- A damage assessment tool to provide maps, tables and reports.

In the future, a Flood Information and Management Interface modules will be used to distribute information and help coordinate integration of data and information from the other modules. The overall system provides the infrastructure to support a web-enabled IT approach, beginning with data acquisition through to the sharing of critical information with a multidisciplinary group of users. The system will be implemented within an international framework to enable a large number of stakeholders access to time-critical information.

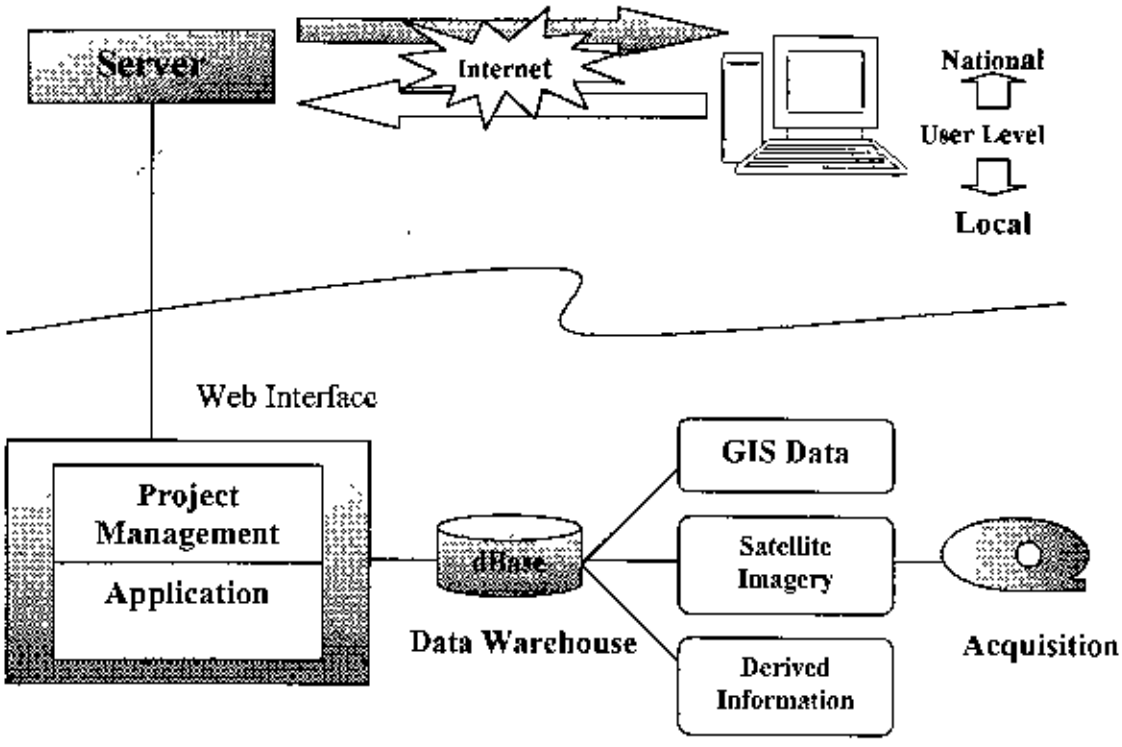


Figure 3.2: Flood disaster management system

Source: Riverside Technology, Inc. and EGIS (2000)

The commercial RADARSAT distributor RSI has placed considerable emphasis on the development of Internet-enabled information products Many of these examples are relevant to the Bangladesh case and demonstrate an increasing degree of sophistication in the generation of products. This may range from using single image acquisitions, to image pairs for change detention, to multi-temporal sets for long-term monitoring. Also, project management tools can be established so that the Internet can be used for internal project management and for process-tracking. The use of information technology enhances communications between various stakeholders in the project. Its use can be easily extended to a multi-agency approach. Its use can be easily extended to a multi-agency approach, as would be the requirement in Bangladesh.

3.2.2 Asian Disaster Preparedness Center (ADPC)

The Asian Disaster Preparedness Center (www.adpc.ait.ac.th/) already has a number of active programs in Bangladesh and it is well known as an important

resource In addition to Bangladesh, ADPC serves most countries of the region in formulating national disaster management policy, building capacity for disaster management and designing programs for comprehensive disaster management This includes services for a variety of activities including post-disaster assessment, civil engineering and mitigation practice. Also, ADPC is involved in planning of immediate relief response and subsequent rehabilitation activities.

ADPC acts as an information clearing house for disaster management policies and practices in Asia Their resources include a specialized library database and they publish a quarterly newsletter. ADPC manages regional programs in disaster management, operated in close collaboration with national institutions. These programs emphasize capacity development, research, networking and technical assistance One such program is the Asian Urban Disaster Mitigation Program (AUDMP) which aims to reduce the natural disaster vulnerability of urban population, infrastructure, lifeline facilities and shelter in targeted cities in Asia.

3.2.3 ReliefWeb

ReliefWeb is a project of the United Nations Office for the Coordination of Humanitarian Affairs Its mandate is to strengthen the response capacity of the humanitarian relief community through the timely dissemination of reliable information on response, preparedness and disaster prevention (www.reliefweb.int). According to ReliefWeb, its 50,000 documents make it the largest source for humanitarian response information on the Web. It provides access to information on current natural disasters as well as past events, dating back to 1981. It is therefore a point of departure for accessing lessons leaned from floods in other countries. It also maintains an online library of disaster relevant materials, provides extensive links to other relevant web pages and tracks funding requirements and donor contributions for complex emergencies and natural disasters. Amongst the information accessible from ReliefWeb are generalized maps showing flooding in Bangladesh and of cyclones in the Bay of Bengal. ReliefWeb's website also contains a section with "lessons learned" for constructing a collaborative, publicly accessible, disaster management information access point.

Should a publicly accessible website be established that is specific to flooding or disaster management in Bangladesh, ReliefWeb's "lessons learned" section should be considered Amongst ReliefWeb's goals are the following

1 To act as a main source of time critical and reliable information for global humanitarian assistance.

2 To provide updated information on unfolding emergencies and natural in order to support decision making on relief, logistics, funding and contingency planning.

3. To encourage information sharing, coordination and standardization among the humanitarian community's information partners both at headquarters and the field level.

4. To strengthen the capacity of users, especially in disaster and emergency prone countries, to receive, share and utilize information more effectively for humanitarian relief.

5. To pioneer the use of Geographic Information Systems (GIS) and other new technologies for humanitarian purposes

3.3 Studies related to flood disaster management in Bangladesh

Different local and international experts have conducted several investigations and studies over the years to discover the causes and effects of flood, its behavior and mitigation, and to suggest solutions for flood management.

3.3.1 Flood Action Plan (FAP) study, 1989-95

Following the disastrous flood in 1987 and 1988 the ministry of water resources, along with the donor community, prepared a report titled 'National Flood Protection Program'. The Government of Bangladesh and the UNDP set eleven guiding principles for future flood management studies. Ultimately, an action plan was undertaken by the World Bank in 1989, which included 26 studies covering a 5 year period of 1990 to 1995, coordinated by the Flood Plan Coordination Organization (FPCO). FAP

studies had a target to achieve a permanent and comprehensive solution to the flood problem and to create an environment for sustained economic growth and social improvement. It also introduced a concept of compartmentalization of controlled flooding and drainage within a protected area. The FAP studies have followed a multi-criterion analysis which has brought costs, benefits, social and environmental impacts in a single framework. Initially, FAP was focused on flood mitigation, gradually paying more attention to the complete hydrological cycle and developing an integrated water resources management plan that covers the issues relevant not only to floods but also to drainage, irrigation, navigation, environment and socio-economics.

3.3.2 Water and Flood management strategy, 1995

A framework for development and implementation of a strategic National Water Management Plan (NWMP) for Bangladesh presented by FPCO has been approved by GOB. It builds on the studies conducted under the FAP and NWMP. Its recommends a 5 year (1995-2000) program involving (a) preparation of a national water management plan, (b) strengthening the water sector organizations responsible for planning, construction, operation and maintenance and (c) implementation of a compact portfolio of high priority projects. The water management plan will examine the supply of water in the context of international rivers and ground water and the demand from irrigation, fisheries, navigation, drinking and municipal needs and other important areas. It will provide an institutional framework for developing and managing water resources.

3.4 National Water Resources Database (NWRD) of WARPO

Information has become essential for planners at all levels as complexities related to management decisions continue to grow. The support is urgently required by the Water Resources Management Plan for Bangladesh in meeting the great challenge of resolving diverse problems and issues in water sector planning. Although there have been past initiatives to establish a methodical and consolidated system to provide data or information related to the sector, the process has proved to be more complex than anticipated as the data are

collected by different organizations in different formats and are difficult to access. But for National or regional level planning and management all data should be authentic or reliable, compatible and readily accessible.

Under the Flood Action Plan (FAP), efforts were made to co-ordinate project mapping through FAP 19 "Geographical Information system". Afterwards the EGIS project was started to continue the work of FAP19 and also of the FAP16 "Environmental Study". An important objective of this project was to support WARPO, among others through the development of a database for water sector planning NWRD is therefore to makeup a huge leeway between the demands the constraints of the planners, providing data with reasonable accuracy from a single database of a single organization. The work was started with a joint team comprising staff of EGIS, SWMC and NWMP under the direction of WARPO to develop NWRD

Development of Tools at NWRD

During the development of NWRD, a number of application tools were developed to facilitate different types of activities. These application tools are simple to use and through a single interface, a number of events can be performed by these tools. For example, with the Statistical Tool simple statistical parameters can be computed, analyzed results can be displayed in graphical, chart or tabular format and stored as well as exported in different formats. The Tools also facilitate the analysis of time series data of any year or period Other than the Statistical Tool, ArcView and SQL server based tools and applications were developed for the front-end user for searching, exporting, editing, viewing and representing data The Advanced Analysis Tool will help planners to generate useful information.

Geokey is a metadata software developed by Geodan BV, Amsterdam. This software has been used for developing a metadatabase by integrating with NWRD

Generic Query and Display Tools

This ArcView application is the front-end to the user querying for data in the NWRD database. By using this tool one can display data as theme

for shapefile, Grid and image and other information in the tabular format. Tabular data can be linked to shape files by using 'Spatial Link'. This tool can query the data layers on the basis of three hierarchical orders as designed for the NWRD database

Advanced Query Tools

Spatial Data Conversion tool converts spatial data between different themes already loaded into ArcView using generic query tool Available conversion types are:

1. Point-to-Polygon
2. Polygon-to-Polygon
3. Polygon-to-Point

Point to Polygon conversion type can be used with one of the three methods:

1 Simple
2. Thiessen and
3. Interpolation

Time Series Viewer Tools

This user-friendly tool is developed in a Visual Basic environment to display, edit and export the time dependent data, which are defined as time series data. There are also some facilities for selecting multiple years and type and superimpose the daa. This tool can display data as chart for a single or multiple stations for any specified time intervals by retrieving data from the SQL server.

Export Tools

A user-friendly generic export tool has been developed for easy exporting of data from the NWRD. This Tool is developed to export data in different formats in the Visual Basic environment for the potential users. The subset of tabular data kept into the SQL Server can be selected and exported at any location Time series data can be selected by the station name or identification number Desired start and

end time of data retrieved can also be specified. As users have opportunity to extend the functionality of the system with their own desktop tools and analysis, a facility is provided to export data out of the system into standard formats

Statistical Tools

This Tool performs simple statistical analysis on time-series data and represents the output as graph Simple statistical analysis (i.e. Sum, Average, Min, Max) can be done on time-series data. Data can be summarized yearly (dry, wet and full), monthly, decadal and daily basis

3.5 Studies related to disaster management using GIS

Some studies related to disaster management using GIS in the different countries reviewed are described below:

3.5.1 Methodology for Flood Damage Assessment using GIS and distributed Hydrologic Model

In this study, a flood damage assessment methodology was proposed by Dutta and Herath which is a combination of flood and damage assessment models. The methodology can be used for quick assessment of damage after a flood event for forecasted flood events The methodology is being applied in one Japanese catchment Some aspects of the methodology are described below

Flood Damage Assessment Methodology

The methodology discussed many aspects of flood damages. Estimation of flood damages is a very complex process. It needs consideration of many factors both quantitative as well as qualitative. Damage can be grouped into two major categories namely, economic damage or tangible damage and societal damage or intangible damage. In this study only economic damage due to floods were considered. Dimension of economic damage due to any flood disasters is governed by the factors like Land use pattern of the flood affected area, Depth and Duration of Flooding and Spatial distribution of Flood.

In the proposed methodology, there are three distinct components of the methodology, first is the damage assessment model, second is the flood model and third is GIS database of spatial data.

GIS Database

GIS is very much required for both damage assessment model and distributed hydrologic modeling for pre and post processing of the large amount of input and output spatial data. GIS helps process the raw spatial data efficiently and store the processed data systematically to input in the model. Required spatial data for different components of the hydrologic model and available input raw data format are needed.

The conceptual scheme of the flood damage assessment methodology described in the study is shown in Figure 3.3:

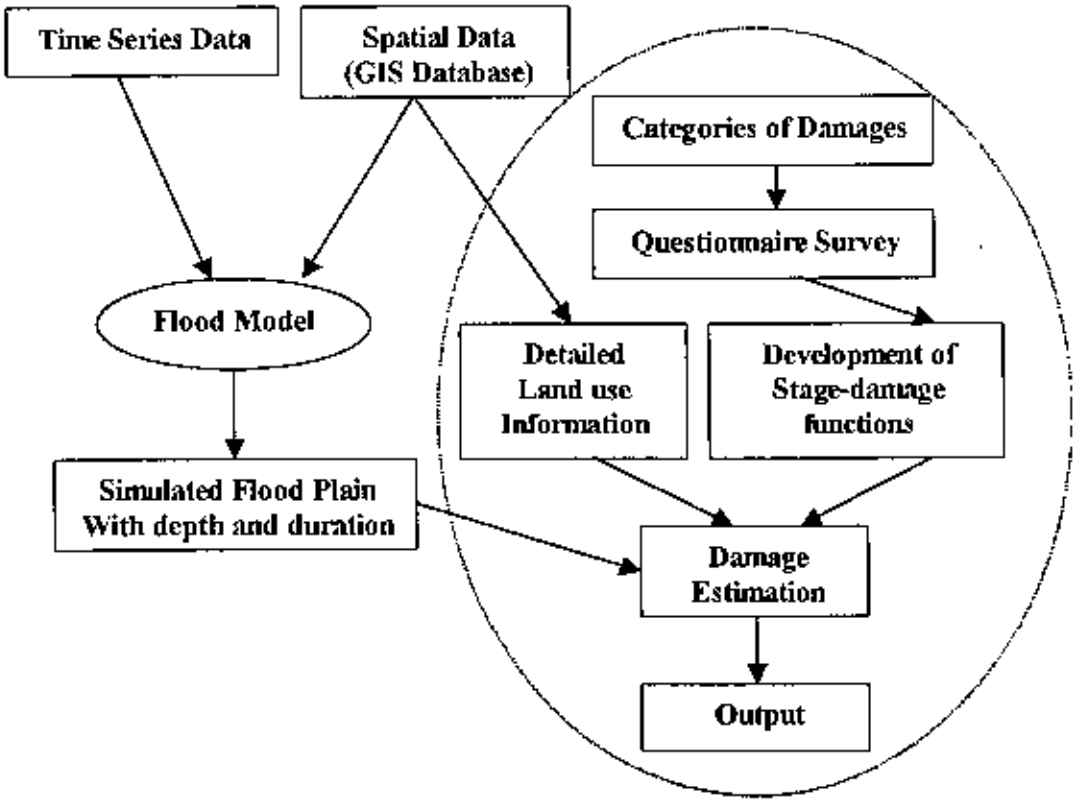


Figure 3.3: Conceptual scheme of the flood damage assessment methodology
Source: Dutta and Herath (1999)

3.5.2 GIS for efficient Natural Disaster Preparedness and Mitigation in Srilanka

Use of Geographical Information System (GIS) for efficient planning and implementation of the natural disaster risk reductions in Srilanka was studied by Weerakoon. GIS facilitates the researchers, authorities and relief organizations to efficiently plan, implement and monitor the natural disaster preparedness and mitigation activities such as predictions, preventive actions, relief operations, rehabilitation, reconstruction, awareness creation and public education. Flow chart of operations are proposed to objectively analyze the data in different layers coupled with the specialized software programs to spatially model the risk of different types of natural disasters and to minimize the damage.

Disastrous floods are usually caused by a storm or by an accidental release of water from a water retaining structure Physical factors influential for floods are the rainfall intensity, conveyance of the drainage network, land use and topography of the drainage basin Thus, data from GIS can be extracted as input for a separate Surface Water Model (SWM), e g HEC models, developed on the principles of hydrology and hydraulics to estimate the flood levels under different land use patterns and rainfall of different return periods. The output of SWM can then be an input to the database to compute the flood prone regions. The flood disaster counter measures can be adopted with land use changes Also, when the upstream catchments are experiencing a storm the flood levels and the potentiality dangerous zones in the downstream could be identified for evacuation and relief operations. Flow chart of the operations in GIS to estimate the areas of potential flood risk coupled with a SWM is given in Figure 3.4

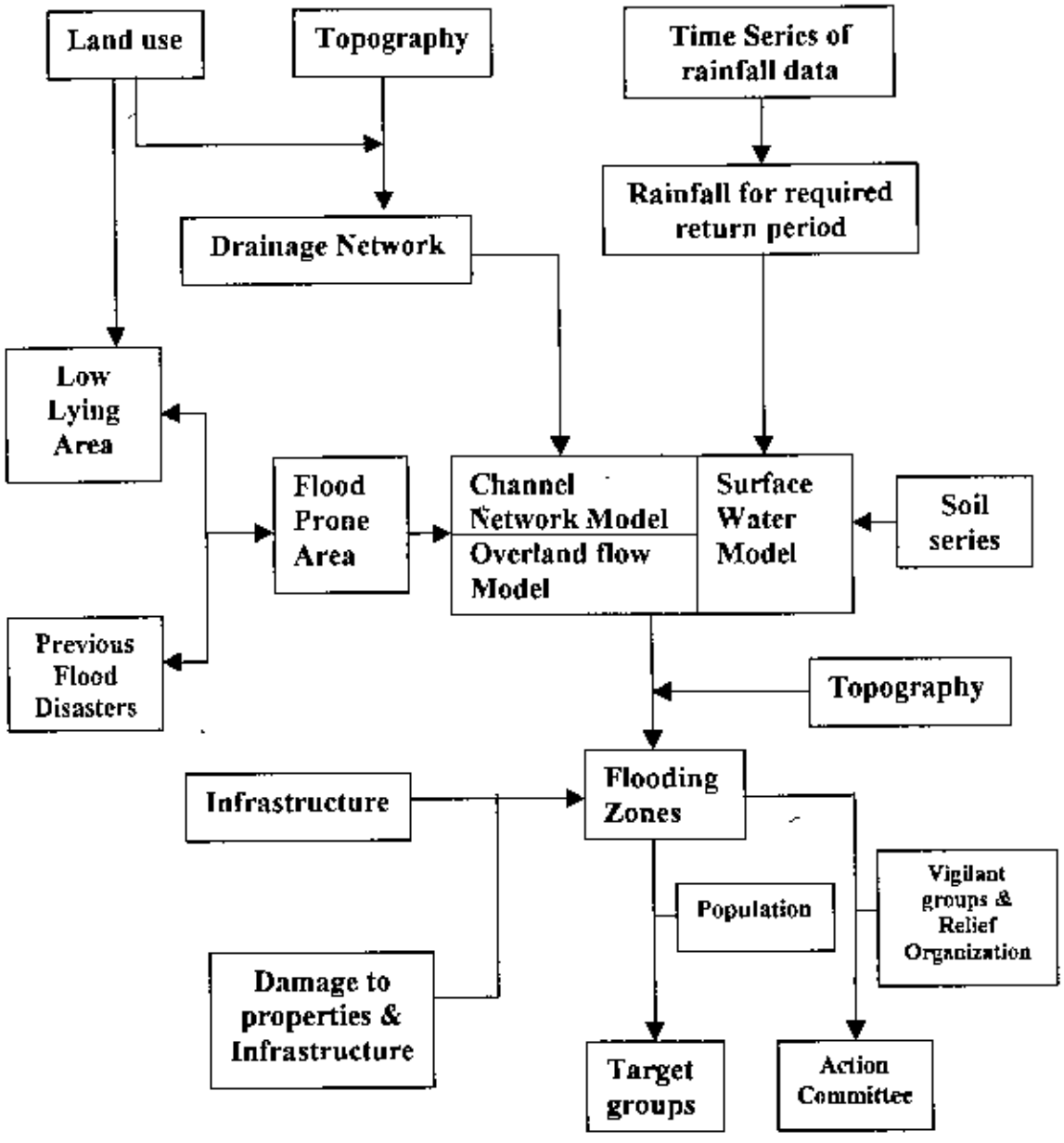


Figure 3.4: **Flow chart of operation for the preparedness and mitigation of flood disasters**

Source: Weerakoon (1999)

Chapter 4

Flood Disaster in Bangladesh

4.1 Introduction

Floods are among the most severe natural hazards in terms of human sufferings and economic losses in Bangladesh The country experiences normal annual flooding while the historical catastrophic floods inundated a large portion of the country's total area The recent flood in 1998 has been found to be more severe than all previous floods (Chowdhury and Sato, 1999).

The catastrophic flood of 1998 lasted from the first week of July to the third week of September and characterized one of the most severe flooding both in terms of depth and duration in the history of Bangladesh (CARE, 1999) It inundated more than 70% of the total land and caused severe damage to lives and properties

4.2 Types and characteristics of floods in Bangladesh

While the monsoon dominates the rainfall pattern in Bangladesh, the flooding is a result of a series of factors These factors include the rapid rate of runoff, the location and effect of the confluences of the major rivers inside the country, the extremely flat topography of the area and the influence of the tides and surges in the Bay of Bengal.

In Bangladesh, the following types of floods are normally encountered.

a) Flash floods in the eastern and northern rivers

These are characterized by a sharp rise followed by a relatively rapid recession in a few days, causing high water flow velocities that damage to crop and properties In the northeastern region, the main problems is flash flooding during the pre-monsoon months which causes damage to dry-season boro rice and also to towns and other infrastructure.

b) Rain flood due to high intensity rainfalls

It appears all over the country due to high intensity rainfall. The very high local rainfall intensities in the monsoon season often generate volumes in excess of the local drainage capacity, causing local floods.

c) Monsoon floods from the major rivers

It appears along the bank of the major rivers due to over spilling of water generally rise slowly over a period of time. Water spilling over the banks of these rivers and their tributaries causes the most extensive flood damage, particularly when all the major rivers rise simultaneously

d) Floods due to storm surges in the coastal area

The coastal area of Bangladesh consists of large estuaries, extensive tidal flats and low-lying islands. Storm surges generated by tropical cyclones cause widespread damages to life and property. Cyclones are most common during the pre-monsoon and post-monsoon periods (April-May and October-November respectively), and have not been known to coincide with monsoon flood peaks (Rashid, 1991).

In recent years, as a result of unplanned construction of rural roads and flood embankments, drainage has often been impeded which has aggravated the flooding conditions.

The normal sequence of floods starts with flash floods in the eastern hill streams during the pre-monsoon period in the months of April and May. Heavy flooding occurs if the peaks of the Ganges and the Brahmaputra coincide, this may happen during August-September.

4.3 Sources and causes of floods

Bangladesh contains the flood plains of three great rivers (the Ganges, the Brahmaputra and the Meghna), their tributaries and distributaries. The three

rivers drain a total catchment area of about 1.5 million square kilometers, of which 7% lies within Bangladesh These three great rivers of the sub-continent join in Bangladesh before entering the Bay of Bengal. At the monsoon period, the combined annual flood flow from these rivers and their tributaries passes through the single outlet of lower Meghna into the Bay of Bengal. The south-west monsoon wind raises the mean tide levels in the bay reducing the slope and discharge capacity of the lower Meghna. As such, high water levels extend over most of the country

In summer, the warm, moist air of the monsoon sweeps up the Bay of Bengal from the Indian Ocean producing some of the highest recorded rainfalls in the world over Bangladesh and the upstream catchments of the major rivers, particularly in the Indian states of Meghalaya and Assam as well as over north-eastern Bangladesh.

The annual rainfall over the area varies greatly in both time and location Seventy to eighty five percent of the annual rainfall is concentrated in the monsoon season from May to September. Average total annual runoffs from the Ganges, Brahmaputra and Meghna catchments are approximately 400 mm, 1200 mm and 1500 mm respectively The Brahmaputra starts rising in March due to snow-melt on 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. Six to ten days will elapse from a rain fall in the upper catchments until the corresponding peak is felt within Bangladesh

Recent climatological research has produced models showing possible consequences of the greenhouse effect, the gradual rise in global temperature resulting from an increasing concentration of carbon dioxide and other gases in the atmosphere, which decrease outward radiation from the earth. The existing climatic models are very crude and the predictions made from them are still highly speculative. So far as the Ganges, Brahmaputra and Meghna catchments are concerned, the possibility exists that gradually increasing global temperatures (variously estimated between 0.8^0C and 5.4^0C by 2030) will increase the rate of snow-melt in the Himalayas. Such changes, if they came about, could increase monsoon season flood flow into Bangladesh, impede

drainage from the lower river reaches and increase the frequency of storm surges in coastal areas (SWMC & BWDB, 2000).

Deforestation in upper catchment areas may influence the total volume of water available for runoff, modifying the time distribution of runoff and contribute increased sediment input to the rivers The consequences are reduced rainfall nfiltration, evapotranspiration and increased exposure of soils to erosion Soil erosion rates in the Himalayas are naturally very high and landslides caused by earthquakes and heavy rainfall are the dominant contributions. Data on the effects of deforestation in the Himalayas are scarce and there is an urgent need to investigate the extent to which possible changes in climate and vegetation cover in the upper catchments have led to increased total runoff and in the anual distribution of discharges and sediment transport in the downstream river reaches

4.4 Floodplains

Floodplains serve as flood storage in the monsoon season and help in contributing water to the soil and groundwater aquifer to support the eco-system and maintain habitats

In absence of floodwater storage and corresponding sedimentation in the floodplain, siltation may occur in the river system itself. Another function of floodplain is augmentation of the post-monsoon river flows through the gradually release of stored flood waters.

Floodplains and deltas provide grazing land for cattle and wildlife and spawning ground for many fish species. Inundation of floodplains triggers off migration and breeding for beel dominated fish species. There is approximately 8,500 sq km of active floodplains which is almost 6 percent of the country as interpreted from 1992 and 1993 Landsat image (Riverside Technology, Inc. & EGIS, 2000). Out of the total active floodplains within the riverbanks, nearly 40 percent island chars is along the Brahmaputra-Jamuna Rivers.

Non-active floodplain in the form of haors located in the NE region and in the southern part of the NW region as well as oxbow lakes are the abandoned

reaches of meandering rivers known as baors, mostly located in the SW and SC regions. Bangladesh has more than 16,000 sq km of wetlands (including lakes, ponds, rivers and estuaries), which is approximately 11 percent of the country (Riverside Technology, Inc. & EGIS, 2000)

4.5 Major flood damage caused in the history of Bangladesh

Historical records describe that five major floods occurred in the 19th century (1842, 1858, 1871, 1885 and 1892) and 16 such floods occurred in this century (1900, 1902, 1907, 1918, 1922, 1954, 1955, 1956, 1962, 1968, 1970, 1974, 1984, 1987, 1988 and 1998). In the 1950s, severe floods occurred in 1954, 1955 and 1956, when a large portion of the country was inundated. Devastating floods were also frequent throughout the 1960s and early 1970s, engulfing an area ranging between 35,000 and 52,000 km^2 Two very exceptional years were 1987 and 1988 when more than 40% of the country was devastated by consecutive floods (Chowdhury & Sato, 1999). The damages and effects caused in the major floods during the past two decades are shown in Table 4.1:

Table 4.1: Damages and effects caused in the major floods

Year	No. of affected districts	No. of affected Upazilas	No. of affected persons	Affected Houses		No. of Death	Affected Embankment in Km
				Complete	Partial		
1986	19	175	6715734	196803	279212	454	165
1987	50	347	24823376	71572	169104	2583	1272
1988	23	165	8937724	124530	270632	1100	67
1988	52	346	35732336	1030659	2265776	6506	1651
1989	27	70	1848389	3203	16096	689	-
1990	17	58	1383360	14101	58418	387	125
1991	07	35	2239445	33961	80994	1196	339
1991	23	97	3410404	73449	121518	1999	186
1991	28	170	5582355	232633	370934	1199	186
1993	23	224	11559586	234393	615336	2608	1093
1994	15	40	553467	19177	31005	103	18
1995	40	259	16382922	344276	1087409	5882	2398
1995	22	88	5806950	79725	355386	1744	211
1995	14	100	4007310	474707	571222	1431	267
1996	48	222	8106988	218275	598818	2968	448
1998	53	370	31000000	980000	2460000	918	3430

Source: Chowdhury and Sato (1999)

4.5.1 The Flood of 1987

The serious 1987 floods resulted from very heavy rainfall in the period of July to September over northwest Bangladesh and the area of West Bengal immediately to the north This heavy local rainfall caused severe flooding in the many minor rivers in the northwest region. These effects were further aggravated by the highest flood peak ever recorded on the Ganges, an exceptionally high flood on the Teesta and despite a Brahmaputra flood only slightly above average, breaches in the Brahmaputra right embankment

The effects of this severe event were reflected in particular in the serious flooding in the Atrai, Bangali, Ghagot, Karatoya and Jamuna rivers. The exceptionally high river levels caused a number of embankments to be overtopped, eroded and breached and drainage regulator design capacities in empoldered areas were greatly exceeded As a result of design drainage capacities being totally inadequate for this very exceptional local runoff, public cuts of embankments were necessary to relieve the internal flooding. Widespread destruction occurred to embankments, regulators, roads, railways, schools, houses, offices and commercial properties and livestock perished in massive numbers. Vast areas of crops were entirely lost and elsewhere yields were seriously reduced.

4.5.2 The Flood of 1988

In contrast to the largely internally generated floods of 1987, the severe 1988 floods were generated by intensive rainfall that extended over North and North East Bangladesh, India, Nepal and Bhutan, the most intense local concentrations being in Assam, Meghalaya, Bhutan and Arunachal Pradesh. The flood peak of the Brahmaputra was the highest ever recorded. The flood peak of the Ganges was also high, but most significantly the two peaks unusually coincided, with devastating effects on the Padma downstream of the Brahmaputra/Ganges confluence. Very large over bank areas along the Brahmaputra, Ganges and Padma were flooded to an unprecedented extent and Dhaka was seriously affected for the first time.

The floods of 1988 started with some of the rivers in the rivers in the south-eastern hill basins crossing danger levels in early May. Subsequently, another wave of flash floods occurred in June peaking around 27th. Flood levels, however, were lower than the flood in early July to heavy rainfall in the Meghalaya. The flood was of a very high intensity and exceeded the peak levels of 1974 and 1987. The storm crossed over the Meghalaya, entered the Assam valley and caused flooding in the rivers of the Brahmaputra basin with the result that the Teesta, Dharla and Brahmaputra crossed their danger levels

Out of 34 water level stations monitored, the highest recorded flood levels were exceeded at 10 stations The 1987 peak levels were exceeded at 22 stations The entire flood plain of the Ganges, Brahmaputra and Meghna river systems of the country, including Dhaka, Narayanganj and Tongi, was inundated. Most cities in the flood plains were affected to varying degrees, depending on local conditions

4.5.3 The Flood of 1998

The 1998 flood of Bangladesh has been termed as the flood of the century The fury of the flood by its magnitude and duration, by its devastation and human suffering is unparalleled. Starting from 8th July when the Brahmaputra-Jamuna crossed the danger level for the first time The country was in the grip of flood for about 79 days until the last river the Meghna at Bhairab Bazar dropped below danger level on 25th September, 1998

The most important factor that contributed to the flooding of 1998 was the four flood waves in succession propagating through the Brahmaputra, each one coming before the river level could drop down sufficiently to accommodate the next flood. It may be noted that the flood peaks of the four flood waves were increasing and the river at this point was for 57 days above danger level and for another nine days very near to danger level (FFWC, 1999).

Table 4.2: Damages caused in devastating flood of 1998

Description	Effects
Number of affected Districts	: 53 (out of 64)
Number of affected Upazillas	: 370 (out of 461)
Number of affected People	: 3,10,00,000
Dead people	: 918
Affected Houses:	
▪ Completely damaged	: 9,80,000
▪ Partially damaged	: 24,60,000
Number of Affected Educational Institutions	: 26,935
Affected Roads:	
▪ Completely damaged	: 1090 km
▪ Partially damaged	: 5975 km
Number of affected Bridges	: 2178
Affected Rural Infrastructure:	
▪ Kutcha Roads	: 22,590 km
▪ Pucca Roads	: 6,565 km
▪ Bridges/Culverts	: 2283 km
Number of affected Hat-Bazaar	: 155
Number of affected Deep Tube well/Tube well	: 3,00,000
Affected Rail Line	: 500 km

Source: EGIS (1999)

4.5.4 The Flood of 2000

Bangladesh experienced a very unusual late monsoon flood in the year 2000 in the western part of the south west region. The flood was very unusual in nature because the area in the last 50 years or so did not experience a flood of such a magnitude. Occasionally, the area is subjected to drainage congestion during heavy rainfall particularly within the coastal polder areas. This year, the main

cause of flooding was attributed to the tremendous flood inflow from West Bengal in India

Extensive areas of Meherpur, Chudanga, Kushtia, Jhenaidah, Jessore and Satkhira districts were inundated About 2.5 million people were affected. Most of the homesteads in the flood affected areas were damaged Vegetables gardens, aman crop and fisheries were mostly damaged in the flood hit areas Thousands of people were rendered homeless Immense loss occurred to the forestry and plantation in the area. As one of the major national highways was inundated by flood water, exports and imports were interrupted for several weeks. The resulting socio-economic and environmental impacts are yet to be ascertained

The late monsoon flood of September and October of 2000 was an unusual extreme event. The flood was characterized by a huge volume of flood flow from West Bengal in India. The flood occurred in three stages. In the beginning flood spill from the Ganges occurred during the period September 17-20. Flood water spilled into Kumar-Nabaganga, Begabati-Bhadra and Kobadak system The second spill came from the overflowing Kodla and Ichamati rivers which began on September 22. Flood spill then entered to the Kobadak and Betna rivers in the Meherpur, Mahespur and Sarsa areas The third flood infiltration from the Sonai river occurred by breaching the Polder 1 embankment in Satkhira near Baikari. Another source of spill was at Keragachi just north of Polder 1. The flood spill that occurred was due to both natural and manmade causes.

More than 3 million people were affected by the flood in Kushtia, Chudanga, Meherpur, Jessore, Khulna and Satkhira districts. Among the affected upazilas, Sharsa, Koloroa and Satkhira were the worst affected. People had to live in temporary makeshift shelters for a long time without having proper sanitation and water supply facilities. During the early days of flood, most of the people had to live on supply from the gravel kitchen and women and children were most vulnerable group affected by the flood. Due to stagnated water many types of timber and fruit trees started dying causing immense loss to the forestry and plantation in the area. As one of the major national highways was inundated by flood water, export and import interrupted for some weeks Further due to large

scale inundation, all the rural roads were submerged. As a result, no vehicular traffic could move

A preliminary damage assessment was carried out in 17 Upazillas in the South West region by EGIS based on the information extracted from satellite images of September 30 and October 14, 2000. Field information and published newspaper articles were used to support the image processing outputs. Output from EGIS analysis of damage is given in Table 4.3:

Table 4.3: Estimated damage of flood affected 17 Upazillas

Upazilla Name	Severely affected settlements (In Hectares)	Damaged Aman under flood water (In Hectares)	Apparently undamaged Aman (In Hectares)	Rivers, Beels and Shrimp Ghers (In Hectares)	Total Upazilla area (In Hectares)
Gangni	258	4899	16623	570	33694
Meherpur Sadar	482	11465	14917	1341	39054
Damurhuda	710	13619	11581	1895	32422
Jiban Nagar	281	7037	8018	361	20479
Maheshpur	640	24668	8910	1395	42761
Chaugachha	284	9875	8693	671	26372
Sharsa	1072	23903	4356	2530	33479
Jhikargachha	312	8791	15970	635	30724
Kalaroa	1069	5120	8695	2258	24535
Satkhira Sadar	2713	8745	9210	8558	36970
Tala	342	2570	14325	5040	33695
Debhata	785	1187	2300	10125	17032
Assasuni	1341	2643	10698	8390	28324
Paikgachha	2103	4743	7995	17305	38701
Kaliganj	1461	5281	12667	17444	45210
Shyamnagar	3359	11972	17866	18131	73465
Koyra	2021	6845	20662	6031	61999

Source: SWMC and BWDB (2000)

Chapter 5

Existing Institutional Framework and Emergency Relief Operation in Bangladesh

5.1 Introduction

In disaster management including emergency relief operation in Bangladesh, different government, non-government, international, private and volunteer organizations participate. The present institutional framework of disaster management in Bangladesh and existing emergency relief operation has been discussed in this chapter. The existing framework does not ensure well arrangement of emergency relief operation among the involved organizations. The existing emergency relief operation in Bangladesh is not very organized The organizations involved in disaster response follow their respective policies and guidelines. There is little coordination among the different organizations who are involved in emergency relief operation.

5.2 Existing institutional framework in disaster management

The different organizations from government, non-government, international and volunteer organizations are involved in disaster management especially in flood management and emergency relief operation. There are some committees or councils who are responsible for making decisions and policies at the national level. The different organizations with their activities and area of interest are described in Table 5.1.

Table 5.1: Organizations involved in disaster management and their area of interest

Name of Ministry	Line organizations	Area of interest
Ministry of Water Resources	WARPO	Macro level water resources planning and maintain water resource database.
	BWDB	Micro level water resources planning and implementation of water resource development projects and operations and maintenance of existing projects Monitoring and maintaining hydrological data base
	FFWC	Flood forecasting, warning and dissemination for flood management.

	EGIS	Advise the WARPO and MOWR on the strategy water resource planning and assist WARPO in the screening the water resource project in the light of EIA/SIA with RS and GIS techniques and technology.
	SWMC	Provide surface water modeling services to Government and other national institutes
Ministry of Disaster Management & Relief	DMB	Provide services such as awareness, collecting, preserving and disseminating management and geographical information for managing disaster caused by floods, cyclones, draught and earthquake.
Ministry of Defense	SPARRSO	Provide the information about crop production the land use/land cover and flood extent in the flood plain using RS and GIS technology to the agriculture ministry and others. Forecast qualitative long-term prediction of floods based on climatic and oceanographic data Also monitor and, predict cyclone and storm surge with BMD.
	Armed Forces	Help the nation in rescuing the flood victims, facilitate the relief operation and construction of emergency infrastructures for flood management.
	BMD	Responsible for monitoring and forecasting of climatic information including storm surge and cyclone. Country representative for obtaining WMO's information through GTS connection.
	SOB	Conducting surveys on land cover and topographic information and maintains benchmarks. Conduct Aerial surveys and maintain Aerial Photos and Base maps for the country.
Ministry of Local Government, Rural Development and Cooperatives (MOLGRDC)	LGED	Responsible for rural infrastructure development and maintenance with local participation. Implementation of small scale (less 1000 ha.) water resource development sectoral projects. Maintain GIS database on Infrastructure, utilities and Upazilla attribute database
Other institutions	IWFM	Carry out research on flood management and provide advisory services to WARPO, SWMC, other govt. and NGOs in relation to water resource and flood management
	Red Cross/ Red Crescent	Participate in relief operation

5.3 Disaster Management Committee at the national level

At the national and local level, different organizations participate in relief and rehabilitation program and decision making process.

The following Councils/Committees are responsible for decision making and coordination at the national level in disaster management:

a) National Disaster Management Council (NDMC)
b) Inter-Ministerial Disaster Management Coordination Committee (IMDMCC)
c) National Disaster Management Advisory Committee (NDMAC)

The activities of the different disaster management councils or committees at the national level are described below.

5.3.1 Activities of the National Disaster Management Council (NDMC)

The National Disaster Management Council chaired by the prime minister is responsible for taking decisions regarding disaster management and formulating necessary guidelines at the national level. The council takes neeessary actions for discussion and implementation of the suggestions given by the National Disaster Management Advisory Committee and the Inter-Ministerial Disaster Management Coordination Committee

The council approves Standing Orders on Disaster, a handbook published by the Disaster Management Bureau, and the National Disaster Management Plan. It ensures coordination among the civil administration, defense services and NGOs in disaster management. The council takes initiatives to enact necessary laws for disaster prevention, mitigation and response

5.3.2 Activities of Inter-Ministerial Disaster Management Coordination Committee (IMDMCC)

The Inter-Ministerial Disaster Management Coordination Committee is constituted with representatives from different ministries related to disaster management in Bangladesh. The committee implements the policies and

decisions given by the National Disaster Management Council. It coordinates the actions taken by all government agencies It will also direct the activities of Disaster Management Bureau.

The committee is responsible for major operational decisions during the emergency period It makes decisions on allocation of relief resources through its sub-committee, the Executive Emergency Relief Management Committee.

5.3.3 Activities of National Disaster Management Advisory Committee (NDMAC)

The National Disaster Management Advisory Committee comprises representatives from government institutions, universities, NGOs, different financial institutions, experienced persons in different areas etc. The committee advises the National Disaster Management Council, the Ministry of Disaster Management & Relief and the Disaster Management Bureau regarding technical, management and socio-economic aspects of disaster management including vulnerability analysis

5.4 The Role of the Ministry of Disaster Management and Relief

The Ministry of Disaster Management and Relief is the focal point in the different areas of disaster management. The Disaster Management Bureau assists this Ministry in normal situations, warning and signaling period, during disaster and after disaster period with necessary information The Ministry helps the National Disaster Management Council and Inter-ministerial Disaster Management Coordination Committee by providing necessary information for decision making. The activities of the Ministry during disaster and rehabilitation period are illustrated below:

During disaster period

The Ministry requests for damage assessment and ships of the Naval and Air Forces. It asks the defense authority for relief and rescue operation considering emergency situation. It also coordinates the relief and rescue operations in association with NGOs

The Ministry arranges the meeting of the National Disaster Management Council and the Inter-ministerial Disaster Management Coordination Committee. It collects detailed information regarding the damage of the affected area and determines the necessary material in relief and rehabilitation program It also collects the aid and other relief materials from individuals and different national and international sources.

During rehabilitation

The Ministry of Disaster Management & Relief arranges house building grants, test relief and Food for Works Program (FWP) It continues emergency relief and rehabilitation works until the situation of the affected areas is normal. It also coordinates the relief and rehabilitation programs

5.5 The Role of the Disaster Management Bureau

The Disaster Management Bureau under the Ministry of Disaster Management & Relief was established in 1992. Its major responsibilities include different activities for growing people's awareness, making necessary policies and guidelines, different prevention and mitigation activities etc. The activities of the Bureau in different situation are described below:

Common responsibility

The Disaster Management Bureau provides necessary consultancy services regarding all the aspects of disaster management. It communicates with different government organizations, donor agencies, NGOs and volunteer organizations and ensures maximum possible cooperation and assistance among the relevant organizations regarding all the aspects of disaster management.

Responsibilities during normal period

The Bureau undertakes different programs to increase awareness for reducing disaster risk among the people in the disaster prone areas,

government employees and the people of different occupations. It performs secretarial duties of the national advisory committee on disaster.

It makes policies for reducing disaster in association with the Planning Commission and other organizations to ensure necessary steps for reducing disaster risk. It makes necessary arrangements for publication and distribution of Standing Orders on Disaster, National Disaster Management Plan and other related manuals It makes guidelines for Disaster Management Action Plan for different districts, Upazillas and unions of the Government and provides assistance in implementing them It offers training on disaster management for different ministries, local authorities, training organizations, government officers and employees, elected representatives and others.

It sets up and operates an Emergency Operation Center (EOC) at the national level with improved communication facilities and distributes necessary data and information regarding disaster to the government and NGOs. It supplies booklets, maps and other material to those who are involved in disaster management

It monitors possible risks of disaster on the lives and property, preparedness situation and obstacles in implementing the programs and projects undertaken in disaster prevention and mitigation. It collects and preserves necessary information i e list, address, condition and ownership of shelters, killas, embankments, platforms higher than flood level etc

It coordinates the activities of NGOs. It raises awareness among the people about weather signaling. It makes arrangements to propagate different public awareness programs on radio and television. It organizes different meetings, seminars, workshops at the national, district, upazilla and union levels for increasing awareness regarding disaster. It communicates with the Ministry of Education to incorporate the subject of disaster management in academic syllabus. It also arranges for conducting research activities in disaster management.

Warning and signaling period

The Disaster Management Bureau ensures that all involved officials, organizations and public media receive the warning signals of an anticipated disaster. It assists the Ministry of Disaster Management & Relief in undertaking programs, which are needed immediately for the people and different organizations of affected areas. It activates the Emergency Operation Center (EOC) and maintains communication with other organizations to activate their action plan and control room

It publishes daily bulletins during disaster period for the foreign embassies and missions of the United Nations. It also gives guidelines to the local authorities in determining the requirements for relief materials and assessing the loss and damage

During disaster period

The Bureau operates the Emergency Operation Center. It assists the Ministry of Disaster Management & Relief to form the preliminary damage assessment teams It assists the Inter-Ministerial Disaster Management Coordination Committee to ensure coordination among the government, NGOs and different organizations in relief and rehabilitation.

It draws the attention of the concerned authority in monitoring the progress of the rescue, relief and rehabilitation programs and identifying the problems. It also assists the Ministry of Disaster Management & Relief for providing information to the Economic Relations Division, Ministry of Information, foreign agencies, NGOs etc.

During rehabilitation

It provides data/information to the concerned authority in making rehabilitation programs. It ensures the inclusion of steps in reducing risks of future disaster in rehabilitation programs.

It analyses the steps undertaken in overall disaster management and publishes reports on the basis of learned experiences/education. It also brings necessary changes in future policies and training on the light of that experience.

5.6 The Activities of the Directorate of Relief and Rehabilitation (DRR)

The directorate plays a vital role in relief and rehabilitation program. It stores the necessary relief material in the disaster prone areas and ensures security and maintenance of them. It uses the fund under the Food for Work Programme (FWP) for construction of roads to communicate with Killas and Shelters and tree plantation etc It performs the following additional activities along with its normal activities.

Warning and signaling period

It sets up the Control Room in the premises of the directorate and communicates with the Control Room of the Ministry It suggests all the officials to be aware of the disaster

It informs the ministry about the preparedness situation in the affected areas. It sends the Daily Situation Report to the Ministry. It maintains the financial records about the amount of the relief materials and food items in the LSD and CSD in the affected areas

During the disaster period

It sends relief material rapidly to the affected areas. It suggests the field level officials to help the local administration in evacuation and rescue operations It uses river transport for transportation and movement of the relief material and rescue operation.

It informs the ministry by assessing the necessity of the relief materials. It informs the ministry immediately for special assistance. It ensures the keeping of correct records about uses of the allocated relief material.

During rehabilitation

It assesses the demands for different relief materials and recommends their allocation It visits the affected areas and informs the Ministry of Disaster Management & Relief.

It supplies the house building grants, food aid and other material as early as possible within its own power Beyond its power, it recommends the ministry for house building grants, test relief, food aid, and other materials It implements necessary government orders regarding disasters It submits the estimated cost for relief and rehabilitation programs to the Government.

5.7 Activities of Flood Forecasting and Warning Center (FFWC)

The Flood Forecasting and Warning Center (FFWC) of the Bangladesh Water Development Board (BWDB) is responsible for monitoring flooding of the country

As a nonstructural measure, timely flood forecasting and warning are identified as the key elements to reduce flood damages and human sufferings significantly; they are also highly cost effective. Therefore, in 1972, a full-fledged Flood Forecasting and Warning Center was established under the administrative control of BWDB to aid national preparedness for floods. Over the years, the system of flood forecasting and warning has substantially improved.

During the flooding season of 1998, FFWC prepared daily flood bulletins and incorporated information about rainfall, rise/fall of river water, flood forecasting for 24 and 48 hr in advance and warning messages (if any). The FFWC attempted to provide adequate services to the local and national level decision making process. The forecasting procedure adopted by the FFWC was based on hydrological information, forecaster's experience and model simulation.

The forecasting procedure in 1998 was comprised of several stages, these include

- real-time rainfall and water level data collection
- meteorological forecasting and boundary estimation
- flood forecasting by numerical modeling
- flood warning dissemination by daily bulletin

When the flood situation was severe a Flood Map, upon availability, was incorporated to the daily bulletin This Flood Map was prepared during the flooding season on some specific dates describing flood inundation on that day, which kept national level policy makers informed about the extent of flooding in the country After the flood season, a Total Flood Map was prepared that served as an important policy document for an integrated flood hazard mitigation strategy. The flood forecasting and warning procedure of FFWC is summarized in Figure 5 2.

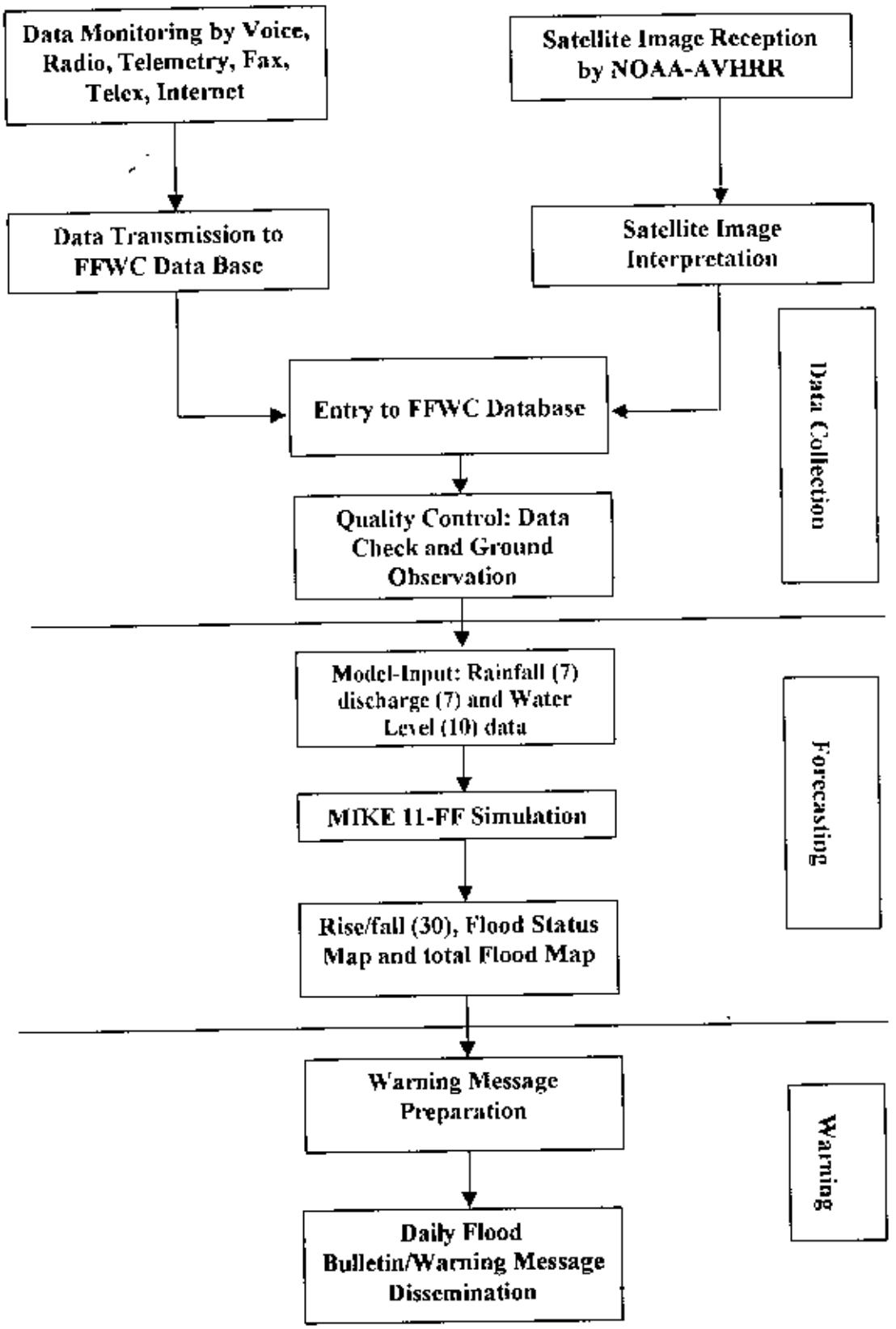


Figure 5.1: Flood forecasting and warning procedure of FFWC

5.8 Responsibilities of the relief and rehabilitation officers at the district and Upazilla level

District Relief and Rehabilitation Officers (DRRO) and Project Implementation Officers (PIO) under the supervision of Deputy Commissioners and Upazilla Nirbahi Officers (UNOs) perform the following activities in the affected areas.

During normal period

They maintain relief material and equipment They ensure the formation of Upazilla Disaster Management Committees and Union Disaster Management Committees and arrange training for them.

During warning and signaling period

They open the Control Room in the offices of the Deputy Commissioners and Upazilla Nirbahi Officers (UNOs) They inform the Deputy Commissioners and Upazilla Nirbahi Officers (UNOs) about the disaster condition of the areas.

They submit proposals to the Directorate of Relief and Rehabilitation for increasing the allocation of relief material. They propose moving relief material from the possible affected Godowns to secured places with the approval of the Deputy Commissioners. They help coordinate among the volunteers and other organizations at the District and Upazilla levels.

They ensure the security of river transports involved in relief operation. They visit the identified relief centers and submit repons to the Disaster Management Bureau and Directorate of Relief and Rehabilitation.

During the disaster period

They finalize the process of sending relief material at the affected area. They help in rescue operation

They submit the reports to the Deputy Commissioners and the Upazilla Nirbahi Officers (UNOs) assessing primary damage to lives and property They arrange the sending of relief material They supervise and monitor relief distribution undertaken by Union authority.

During rehabilitation

They provide detailed information regarding damage and effects to the Deputy Commissioners, Directorate of Relief and Rehabilitation and Disaster Management Bureau

They arrange for reaching the house building grants, food aids and other relief material to the affected people within a short period They send the reports of relief and rehabilitation programs to the Directorate of Relief and Rehabilitation.

5.9 Responsibility of the District Disaster Management Committee

The District Disaster Management Committee is constituted with the Deputy Commissioner as its Chairman and the District Relief and Rehabilitation Officer as its member secretary. The committee also includes representatives from the armed forces, NGOs and other officials. It ensures that Upazilla Disaster Management Committees are formed and function effectively. It also ensures that issues related to disaster management are considered in the district level planning and during implementation of the development projects It prepares a Disaster Action Plan. The plan ensures that cyclone and flood warnings are properly disseminated and shelter facilities are identified at the Upazilla level. It ensures the provision of potable water supply and other services to the Upazilla level shelters when and if necessary.

It prepares a contingency plan for ensuring proper rescue and relief operations and communication facility with the Upazilla and national Emergency Operation Center (EOC) of the Disaster Management Bureau It operates an EOC to coordinate evacuation, rescue, relief and initial rehabilitation operations throughout the district and supervise and mobilize these activities.

It arranges surveys to assess post disaster needs and priorities. It follows the guidelines provided by the Disaster Management Bureau and other national authorities and informs the national Emergency Operation Center

It prepares the post disaster rehabilitation plans. It allocates and arranges the delivery of available resources for rescue, relief and rehabilitation to the affected Upazilla on the basis of assessment of needs in line with the general guidelines provided by the DMB and district authority. It supervises the distribution and use of relief goods and provides information to the national authorities and contributing agencies

5.10 Responsibilities of the Upazilla Disaster Management Committee

The Upazilla Disaster Management Committee is formed with the Upazilla Nirbahi Officer as its Chairman and the Upazilla Project Implementation Officer as its member secretary Representatives from concerned divisions, NGOs, the armed forces and other organizations are involved with the committee. It ensures that Union District Management Committees are formed and function effectively.

It prepares a Disaster Action Plan and a contingency plan for ensuring proper rescue and relief operations and communication facility with the District and Union level authority. The committee operates an EOC to coordinate relief and rehabilitation operations throughout the Upazilla.

It conducts surveys to assess post disaster needs and priorities according to the directions provided by the Disaster Management Bureau and district authorities. It supervises the distribution and use of relief material. Some other functions performed by the Upazilla Disaster Management Committee are similar to the District Disaster Management Committee but at the Upazilla level.

5.11 Responsibilities of the Union Disaster Management Committee

The Union Disaster Management Committee is formed with the Chairman of the Union Council as its Chairman and the Secretary of the Union Council as its

Member Secretary The committee includes members of the Union Council, representatives from the teachers, women representatives, NGOs etc

It ensures that local committees are formed about the necessary preparedness measures. It prepares a Disaster Action Plan for the union to ensure the ability and the readiness of the local communities, union authorities and local organizations

It ensures that cyclone and flood warnings are properly disseminated locally It identifies shelter facilities to which people move Individuals are responsible for organizing particular services to those shelters It ensures provision of potable water supply and other services to the shelters when and if necessary It organizes periodic information campaigns and practice drills for warning dissemination, evacuation, rescue and initial relief operations.

It prepares also a contingency plan like the DDMC and the UDMC for ensuring proper rescue and relief operations and communication facility with the Upazilla headquarters and for local actions to help the worst affected families to recover

It organizes initial rescue activities using locally available means, when required and collaborates with other rescue services, when assigned. It collects the data on the impact of disaster and forwards it to the Upazilla authorities following the guidelines provided by the DMB and the Upazilla authority. It also organizes the distribution and use of relief and rehabilitation assistance

5.12 Participation of NGOs in Disaster Management

There are many Non-Government Organizations who participate in emergency relief and rehabilitation activities. The NGOs participate in relief activities in association with different government organizations

Different local, national and international organizations take part in disaster management individually and collectively. Disaster Management Project of CARE Bangladesh and its partner NGOs formed a new national network called NIRAPAD (Network for Information, Response and Preparedness activities on Disaster).

5.13 Existing emergency relief operation by the government

When a certain region is hard hit by floods, steps are taken to activate the "Control Room" of the Ministry of Disaster Management and Relief During Flood, the meeting of the Inter Ministerial Disaster Management Coordination Committee, chaired by the Minister of Disaster Management and Relief, is held to fix up the activities of different ministries or line organizations In the meeting, decisions are made about the possible actions of all concerned organizations.

During flood, the meeting of the National Disaster Management Council, chaired by the Prime Minister, is also held to direct the concerned authority to assist the affected people and strengthen relief activities During the relief and rehabilitation period, the meeting of the Inter Ministerial Disaster Management Coordination Committee and the National Disaster Management Council are held a number of times.

The meeting of the District Disaster Management Committees, Upazilla Disaster Management Committees and Union Disaster Management Committees are also held along with the regular meeting of National Disaster Management Council and Inter Ministerial Disaster Management Coordination Committee. The concerned Deputy Commissioners place demand for the relief materials to the Ministry of Disaster Management and Relief after collecting the assessment of flood damage prepared by the concerned District Disaster Management Committees, Upazilla Disaster Management Committees and Union Disaster Management Committees. The relief materials are allocated from the Ministry of Disaster Management and Relief under the directives of the Prime Minister as per the demand of the Deputy Commissioners

The different aspects of emergency relief and rehabilitation programs are described below

5.13.1 The damage assessment forms to be filled up by the concerned authority

After a devastating flood in any region of the country, the extent of damage is assessed by the concerned authority. In the Government set up of Bangladesh,

the damage assessment is made through the assessment forms and certain set formats by the local authority. The assessment is sent to the higher authority for emergency relief and rehabilitation programs.

Assessment of approximate damage and emergency need

Within one hour of a disaster striking an area or as early as possible, the Union Disaster Management Committee is instructed to send the particular form regarding assessment of approximate damage and emergency need as a primary report to the Upazilla Nirbahi Officer, District Administration and the control room of the Ministry of Disaster Management and Relief by telephone or any other means

Upazilla Nirbahi Officer (UNO) will send this form to the Control Room of the Ministry of Disaster Management and Relief through concerned Deputy Commissioner by collecting information from the officers of different Departments at Union Council and Upazilla level

5.13.2 Plans regarding relief distribution in Model Union/Pourashava Disaster Action Plan

Certain rules and regulations are followed by the Government in Model Union/Pourashava Disaster Action Plan. In the Model Union/Pourashava Disaster Action Plan, the following regulations are followed.

- After disaster, a list will have to be prepared for those families who will need relief. The most distressed families i.e, families headed by unemployed women or landless families will be enlisted. After disaster has occurred, the limited amount of relief will be distributed among the neediest families according to the priority list.
- A place will be identified for collection and aggregating of relief materials
- Some possible distributing place within the union will be registered for distributing relief.

- Relief materials may be collected from Upazilla Headquarters, NGOs, well-to-do people etc Those who will coordinate the distribution of these materials will be determined so that these could be distributed with justice and maintaining law

- The Union Disaster Management Committee reports to Upazilla Nirbahi Officer (UNO) regarding how much relief materials the union had received from various sources and how these had been distributed.

5.13.3 Opening relief centres and conducting relief operation

The Disaster Management Committee, Upazilla Nirbahi Officer, or District Administration takes steps to open shelters or relief centres to protect the people's life and valuable property.

The Chairman of Union Council as the Chairman of Union Disaster Management Committee organizes and opens the relief centres in the chosen places such as cyclone shelters, educational institutions, community centers and other government buildings and other suitable places

The concerned member of the union council will be responsible for each centre and at least ten local volunteers will help him in coordinating the arrangement

Good arrangement for necessary spaces, health facility, water supply and light in the relief centres will be made. As per the requirements, Shallow tube wells will be installed as early as possible with assistance from the Department of Public Health Engineering for ensuring availability of pure drinking water.

In every center, master roll of the beneficiaries and deposit and cost statements of the relief material will be maintained.

5.13.4 Emergency reserve of relief materials

During disaster period, food and emergency building materials are reserved in the disaster prone district headquarters with a view to supply food rapidly and construct the shelters. The District Relief and Rehabilitation Officer maintains these materials and ensures their use These relief materials are sent to the relief

centre under the directives of Deputy Commissioners or District Disaster Management Committee.

The following materials are supplied as relief materials

1. Rice/Flour
2. Sugar
3. Biscuits
4. Dal
5. Chira/Gur
6. Salt
7. Edible oil

In the CSD and LSD under the distribution system of food supply, a significant amount of wheat and rice is reserved for ensuring food supply across the country. Chira, gur, muri etc are easily available and accessible to the people. These materials need not be stored because of their availability. If required, the District Disaster Management Committee can purchase these from the local market. The different building materials are reserved in the district level.

5.14 Relief activities undertaken by the government during the flood of 1998

Since the first week of July, 1998, there were indications that the water of some rivers was rising and flood was forecast if that condition continued In this situation, steps were taken to open the Control Room of the Ministry of Disaster Management and Relief from 10th July 1998 to face any situation created by flood.

During the flood, the first meeting of the Inter Ministerial Disaster Management Coordination Committee chaired by the Minister of the Ministry of Disaster Management and Relief was held to determine the activities of different Ministries or organizations In the meeting, guidelines were given about the possible actions of all concerned organizations and overall flood situation.

On 24 July, 1998, the first meeting of the National Disaster Management Council chaired by the Prime Minister was held. In the meeting, directives were given to stand beside the affected people and strengthen relief activities.

On 13 August, 1998 and 1 September, 1998, the second meeting of the Inter Ministerial Disaster Management Coordination Committee and the second meeting of the National Disaster Management Council were held respectively

The meetings of the District Disaster Management Committees, Upazilla Disaster Management Committees and Union Disaster Management Committees were also held along with the regular meetings of National Disaster Management Council and Inter- Ministerial Disaster Management Coordination Committee The concerned Deputy Commissioners sent their demands for relief materials to the Ministry of Disaster Management and Relief after collecting the assessment of flood damage by the respective District, Upazilla and Union Disaster Management Committees The relief materials were allocated from the Ministry of Disaster Management and Relief under the directives of the Prime Minister as per the demands of the Deputy Commissioners

Chapter 6

A Model for estimating Emergency Relief Requirements for Flood Victims

6.1 Introduction

Disaster management should aim for, among other things, efficient and cost-effective ways of managing disaster response and reducing causalities and damages caused by natural disasters. Highly sophisticated and effective disaster management systems can be developed by utilizing Geographic Information System (GIS), remote sensing and other advanced technologies Many organizations of different countries like the U.S. Federal Emergency Management Agency (FEMA), Asian Disaster Preparedness Center (ADPC), Global Disaster Information Network (GDIN), U.S. Geological Survey (USGS), USGS Center for Integration of National Disaster Information (CINDI) etc. are developing and using flood management tools and models incorporating GIS and remote sensing technologies.

In Bangladesh, GIS based tools and models can be developed and used for flood management strategies including estimation of emergency relief requirements. A number of organizations like EGIS, SWMC, BWDB are using GIS at a small scale for flood prediction, monitoring and flood management. Some of them have taken initiatives to develop an updated database like National Water Resources Database (NWRD) for making effective flood management policies and strategies BWDB has set up a flood information center for providing the flood information to the general people and relevant organizations during the monsoon season and flooding period EGIS and SWMC are involved in developing water sector models and flood management strategies in collaboration with other relevant organizations. In Bangladesh, GIS based models can play a vital role for making flood management strategies and managing emergency relief and rehabilitation activities. In this present study, a model has been developed for estimating emergency relief requirements for flood victims

6.2 Intended output from the model

The model will provide different information for estimating emergency relief requirements efficiently A variety of information is needed regarding the affected population, the possible relief centres, relief requirements for planning

the distribution of relief material among the affected people. In the existing relief and rehabilitation system, there is no objective method of estimating relief requirements and distributing relief among the affected people It is a very difficult task for the local people of the affected areas to estimate the number of affected population who need relief materials within a very short time. In most cases, relief operation is not conducted after assessing relief requirements based on a model and information system Sometimes, the coordination among the organizations involved in emergency response is not ensured. In recent times, the concept of relief has changed significantly Now relief approach ensures both needs and capacity assessment and encourages the local people in the relief activities Assessment of relief requirements can he done with an information system With the present model, different organizations involved in relief operation will be able to estimate the relief requirements of the relief centres in the affected areas

The organizations involved can be informed about the flood effects and relief requirements from the model. In Bangladesh, the concerned Ministries, associated Directorates/Divisions, autonomous bodies, various local government organizations, NGOs, private, international and volunteer organizations are involved in relief operation There are also a number of committees and councils for making emergency decisions and policies at the national level Among them, the National Disaster Management Council chaired by the Prime Minister, the Inter-Ministerial Disaster Management Coordination Committee and the National Disaster Management Advisory Committee are responsible for making emergency decisions. In the government sector, the Ministry of Disaster Management and Relief, the Disaster Management Bureau, the Directorate of Relief and Rehabilitation, concerned Deputy Commissioners, District Relief and Rehabilitation Officers and other officials undertake different steps for relief and rehabilitation programs. At the local level, Union Disaster Management Committees, Upazilla Disaster Management Committees, District Disaster Management Committees, Upazilla Project Implementation Officers, different volunteer organizations and individuals also take part in relief operation in cooperation with NGOs and various national and international humanitarian organizations The model can provide the following information to the aforesaid organizations for estimating emergency relief requirements

1. The probable affected areas and intensity of floods

The areas which will be affected can be identified from the model. The different flood depth of the particular areas can be estimated. Based on the flood depth, the intensity of floods i.e. the effects under different category of floods such as shallow floods, medium floods, deep floods and very deep floods can also be found out from the model

2. The physical infrastructure of the affected areas

The location and other information of various physical infrastructure i e roads, shelters, schools, colleges, buildings, settlements etc of the affected areas can be found out from the model. During flood, the organizations can be informed about the location and capacities of shelters, godowns, transportation routes, the locations of government buildings and NGOs etc

3. The location of relief centres and their catchment areas

The location of relief centres and their catchment areas can be identified from the model. The relief centres have been selected from the available shelters, schools, colleges, madrasas, government buildings etc considering the different aspects.

4. Estimation of population for the catchment areas of the relief centres

The total population under different catchment areas of the relief centres can be estimated from the model. The affected population who need emergency relief assistance can also be estimated.

5. Assessment of relief requirements for the relief centres

When the affected population is estimated, the relief materials required for emergency relief operation can be estimated from the model. The concerned organizations will be able to conduct emergency relief operation from estimation of relief requirements.

6.3 Development of the database for the model

The database or base information is a very important component in the information system for flood management especially in emergency relief operation Base information contains layers of information which are static in nature but are required for supporting the monitoring and prediction of floods, assessing damage and planning for relief operations. Base information has to be updated regularly The socio-economic, infrastructure, physical, geographical and environmental aspects of the country are changing very rapidly To obtain accurate information for the decision making process, updated database is very essential. For effective and efficient flood management, a strong system of base information is a pre-requisite, which would greatly facilitate emergency response including relief and rehabilitation activities

Proper base information is not a mere compilation of existing information from elsewhere, but would need processing and analysis. In Bangladesh, WARPO has developed an NWRD assembling data from different relevant organizations such as EGIS, SWMC, BWDB, LGED etc. The data are accessible to the concerned organizations, research institutions and other beneficiaries. During flooding, the database may help the relevant organizations to make emergency response including identification of proper locations for shelter and relief centres and suitable transportation routes for dispatching relief material to the affected area. The base information may also help assess the flood effects and estimate the relief requirements.

As part of the model for estimating emergency relief requirements, an adequate and enhanced database containing different physical, economic, infrastructure and demographic data of the flood-prone areas and other related information should be developed and updated regularly. The database will include detailed information about different infrastructure and natural factors like roads, rivers, school, college, shelters, elevation and other important characteristics of the area such as demographic statistics During flooding, some data like flood depth, flood extent, duration etc can be collected from relevant flood monitoring organizations. After flood, the concerned organizations can obtain their required information for necessary decision making in emergency relief

operation by using the database and applying the guidelines described in the model.

In the model, data and information required have to be collected from different relevant organizations. The necessary data required, their sources and purposes are illustrated in Table 6.1

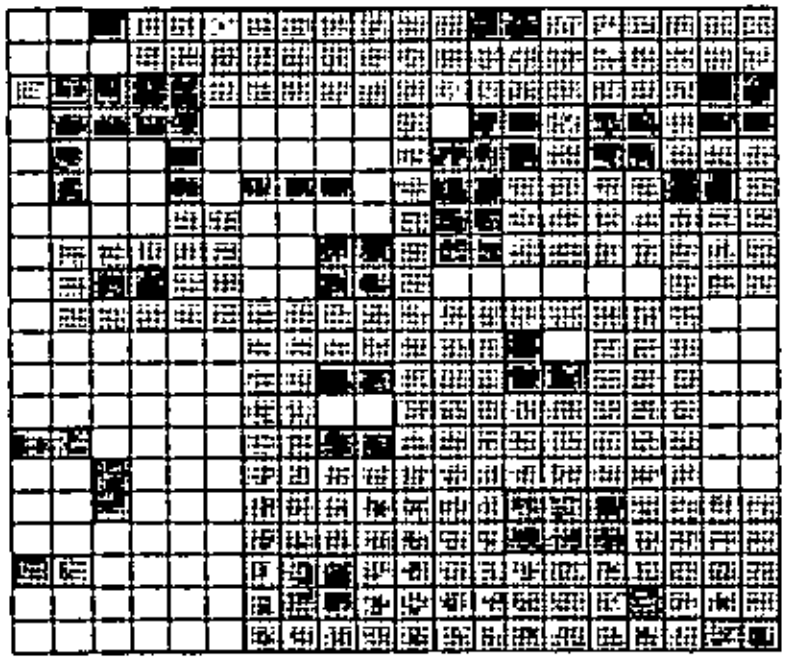
Table 6.1: Data required for the model with their purposes and sources

Sl No.	Required Data	Data Format	Source of data	Purpose
1	DEM	Grid	WARPO	To find out the affected areas and severity of flood
2	Settlement data	Vector	LGED	To show the location of settlements in maps and find out affected settlements
3	Location of Relief Centres	Vector	LGED Upazilla Base map & Field Survey	To identify the relief centre and find out their catchment areas
4	Population data		BBS	To find out the affected population
5	Relief requirement standard		PACT/PRIP	To estimate the amount of relief required per head
6	Locations of 1 Administrative boundary up to mauza level 2. Roads 3 Embankments 4 Rails 5. Rivers 6. Water body	Vector	WARPO & LGED	To prepare base map of study area
7	Locations of 1 Upazilla headquarter 2. Union headquarter 3. Shelters 4. Schools 5. Colleges 6 Madrasa 7. Mosque 8. Growth centers 9. Godowns 10. Health centers 11 Ghats 12 Helipads 13 Government offices 14. NGO offices	Vector	WARPO & LGED	To prepare base map of study area

8	Danger Level and Water Level of the rivers	Attribute of vector data	FFWC	To find out the affected areas and severity of flood

6.4 Digital Elevation Model (DEM)

Digital Elevation Model (DEM) consists of grid cells. The resolution of the existing DEM for Bangladesh is 300 m X 300 m. Each grid cell contains a value of elevation for the area it represents The elevation value represents the height of that particular area from the Mean Sea Level (MSL). The existing DEM, an element of National Water Resources Database, was developed by WARPO. It is an important element in flood disaster management studies including identification of the affected areas under different flood depths. In the present model, the DEM has been used to find out whether an area is affected or not.. During flooding period, the Water Level (WL) of the monitoring stations of different rivers can be collected from Flood Forecasting and Warning Centre. The water levels are measured at different water level stations. From the DEM and the water level of the flood hit areas, the flood depths of the affected areas can be calculated. A hypothetical DEM of an area having different elevation is shown in Figure 6.1:



*Darker shade represents higher elevation

Figure 6.1: DEM consisting cells with different elevation values

6.5 Flood types on the basis of flood depths

The flood in any area can be categorized based on flood depth Flood depth can be calculated from DEM and measured water level of the affected area collected from Flood Forecasting and Warning Center. Flood Forecasting and Warning Center and Master Plan Organization (MPO) have categorized floods based on flood depth The categories of flood are discussed below

Flood types according to the Flood Forecasting and Warning Centre (FFWC)

FFWC is the authorized organization to monitor water level of the different rivers and present flood status map of the affected areas During the flooding season, one of the main objectives of the FFWC is to provide the nation with a comprehensive flood perspective in terms of depth, area and duration of inundation This information serves as an important input and feedback for national and local level decision-making process During flooding, they supply the "Flood status map", which is developed using simulation and GIS software.

The Bangladesh Water Development Board has set up a number of water level stations at selected points of different rivers all over the country to monitor the water level during the flooding period. BWDB has also fixed up the Danger Levels (DL) of the rivers considering the elevation of the stations from MSL (Mean Sea Level), possible impacts of the flood to the nearby floodplain and other aspects. The monitoring stations of BWDB measure the water level of the concerned rivers during the rainy season

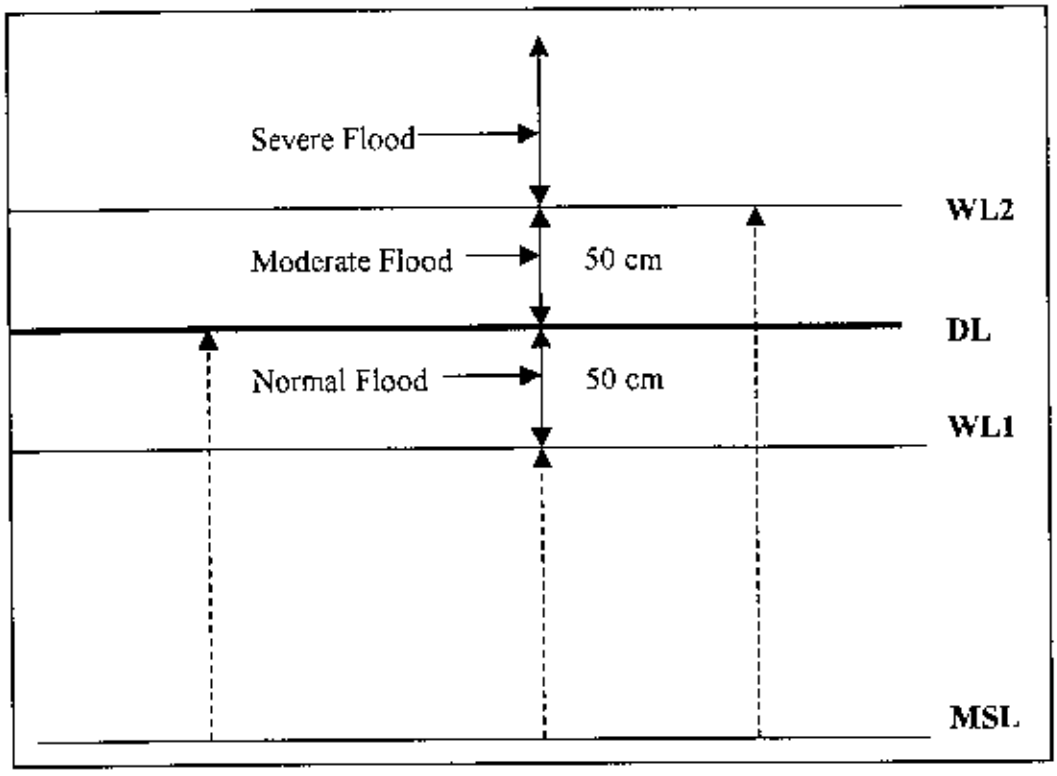
During Flooding, FFWC measures the water levels of the relevant rivers and circulate the flood status in different media including radio and television. They inform the people and relevant organizations about the position of water level with respect to the danger level and present the flood status map The flood status map describes the overall flooding situation in the country FFWC divided the flood into following types (Table 6.2) on the basis of flood depth with respect to the danger level.

Table 6.2: Flood types by FFWC considering the flood depth

Sl No.	Flood types	Flood depth
1	Shallow or Normal Flood	50 cm below DL
2	Moderate Flood	Within 50 cm above DL
3	Severe or Deep Flood	More than 50 cm above DL

Source FFWC (1999)

In Figure 6 2, flood types on the basis of flood depth with respect to the danger level have been shown graphically.



Source. FFWC (1999)

Figure 6.2: Flood types of FFWC based on water level with respect to the danger level

According to FFWC, when the water level is within 50 cm below DL, it is called a Shallow or Normal Flood. In this flood, the effects are not significant. When the water level exceeds the Danger Level and is within 50 cm above DL, it is called a Moderate Flood. In this case the flood effects are higher than before, but still not great. When the water level is more than 50 cm above DL, it is called a Severe or Deep Flood. In this case, the effects are very significant and flood damages may increase tremendously.

Flood types according to the Master Plan Organization (MPO)

In the early eighties, the Master Plan Organization (MPO) developed a flood depth classification from a soil/agricultural reconnaissance survey made by the Soil Resources Development Institute (SRDI) SRDI classified the land into eleven categories based on the depth of inundation at the peak of the monsoon period in an average year. The MPO converted these eleven land type categories into five flood phases/land type (Table 6 3) based on a three day maximum flood depth, theoretically with an exceedence return probability of 1 in 2 5 years (Riverside Technology, Inc. and EGIS, 2000) The following Figure 6 3 illustrates the calculation of flood depth from the water level and the elevation.

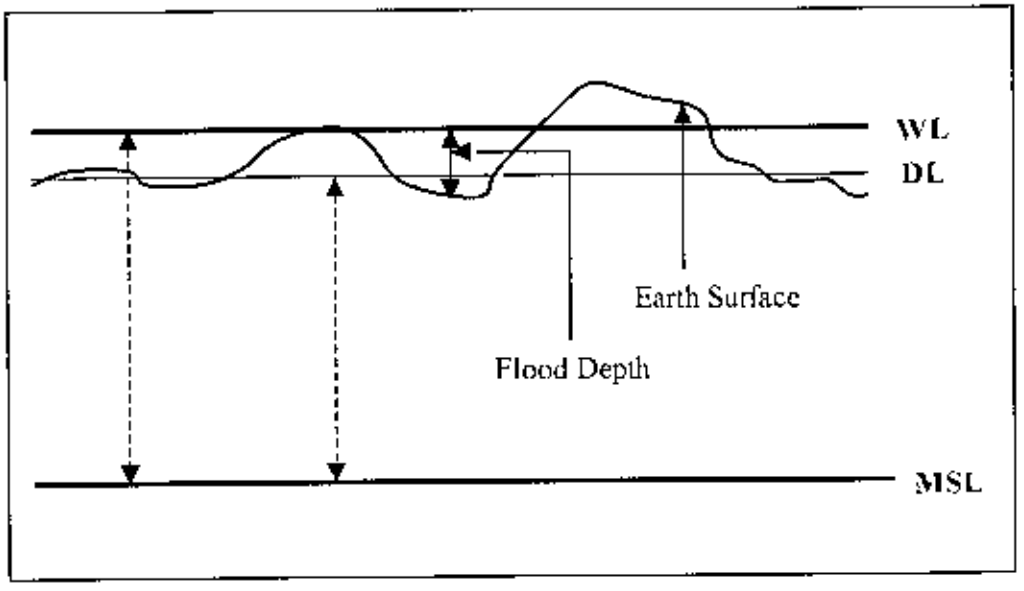


Figure 6.3: Calculation of flood depth with respect to the water level and earth surface

After calculating the flood depth, the category of flood can be ascertained In Table 6.3, the categories of flood are shown

Table 6.3: Flood types based on flood depth

Flood Categories			Flood depth
1	Non Flood	(F0)	0.0 m < Flood Depth < 0.3 m
2	Shallow Flood	(F1)	0 3 m < Flood Depth < 0.9 m
3	Medium Flood	(F2)	0.9 m < Flood Depth < 1 8 m
4	Deep Flood	(F3)	1.8 m < Flood Depth < 2 7 m
5	Very Deep Flood	(F4)	2.7 m < Flood Depth

Source: Riverside Technology, Inc. and EGIS (2000)

The areas like F0 and F1 (Non-flood and Shallow Flood area) do not create any major damage to people, crops and infrastructure. While areas like F2, F3, F4 (medium, deep and very deep) are the potential regions for flood devastation It may be noted that in this system of flood categorization, DL is not relevant. In this study, the flood has been categorized following the above system of flood categorization.

6.6 Assessment of emergency relief requirements

Assessment of emergency relief requirements is very important in emergency relief operation In Bangladesh, government, NGOs, private, international and volunteer organizations take part in emergency relief operation. In most cases, assessment of relief materials is not done following any methods and estimating the affected population of the relief centres. At a result, required relief materials do not reach at the affected place within the shortest time. On the other hand, relief materials are supplied excess in some places So the assessment of relief requirements is needed.

After estimating the affected population of the affected area, the amount of relief required for distributing among the victims can be assessed properly. In "Disaster Management Handbook of Bangladesh" published by PACT Bangladesh (Private Agencies Collaborating Together), the guidelines of relief distribution have been given. According to PACT, the daily relief requirements for an adult person are given in Table 6 4:

Table 6.4: The daily relief requirements for an adult person

Materials	Amount (gm)	Kilocalorie
A main food such as cereal (Rice, Wheat)	350-400	1225-1400
Source of Protein such as Bean, Dal	50	350
Edible oil	20-40	180-360
Total	420-490	1755-2110

Source. Rahman (1993)

It is mentioned here that daily food provides 1880 Kilocalorie energy and 50-gram protein to an adult person Relief for per person per day is estimated 475 gm. In this way, monthly food requirements per persons are estimated 14.25 kg

6.7 Different phases of the model for estimating emergency relief requirements

The model initiated in this study contains the different phases of estimating emergency relief requirements The phases include identification of the affected areas, calculation of flood depths and flood types, identification of the affected settlements, identification of relief centres, demarcation of the catchment areas of the identified relief centres, estimation of the affected population of the relief centres, assessment of relief materials etc These phases are closely interrelated with each other The model will provide the expected information after successful completion of the different phases.

In the different phases of the model for estimating emergency relief requirements, the database developed earlier will be used The different phases of the model are described below:

6.7.1 Identification of the flood affected areas

Flood affected areas can be identified using the DEM and the water level of the nearby monitoring stations The DEM consists of 300m **X** 300m grid cells which represent the elevation of the areas The water level or flood level of the areas during flooding period will be collected from FFWC A hypothetical DEM is shown in Figure 6.4:

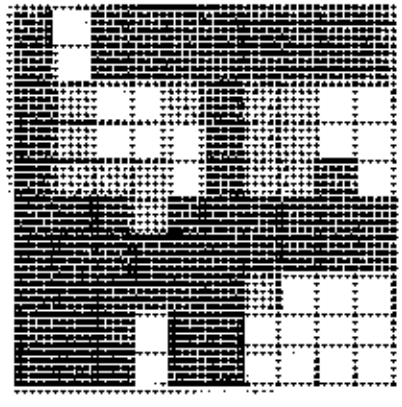


Figure 6.4: DEM showing different elevations

Whether or not a particular area represented by a cell of the raster coverage is affected may be found from the following relationship:

$$f_i = \begin{cases} 1, & \text{if } e_i < w \\ 0, & \text{if } e_i \geq w \end{cases} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where f_i = a binary variable indicating whether cell i is affected by flood
e_i = the elevation of cell i
w = the water level

When elevation of a cell is less than the forecast or observed water level, the value of f_i, a binary variable, will be 1 and the area represented by the cell will be flood affected. On the other hand, when the elevation of the cell is equal to or more than the forecast or observed water level, the value of f_i, will be 0 and the area represented by the cell will not be flood affected. Figure 6.5 shows the affected areas derived by the above procedure from the DEM shown in Figure 6.4.

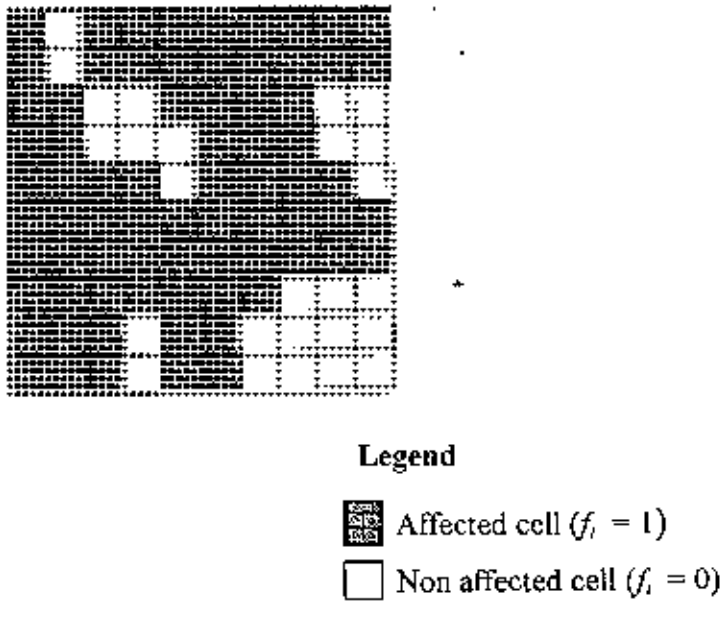


Figure 6.5: Identification of the affected areas using DEM

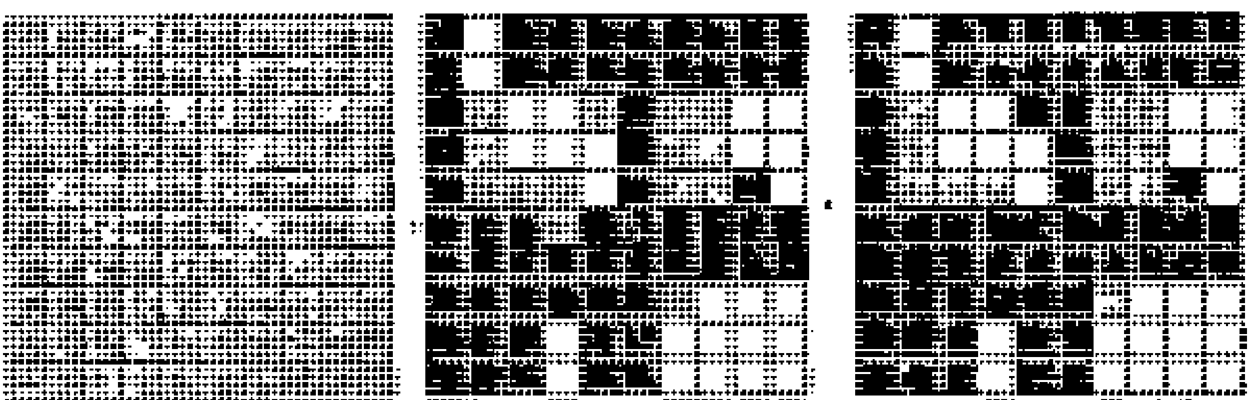
6.7.2 Calculation of flood depths and different flood types

The flood depths of the affected areas represented by the grid cells can be calculated using the measured water level and the elevation of the areas. The depth of flood in an area represented by any given cell in the grid is given by:

$$d_i = \begin{cases} 0 \text{, if } w < e_i \\ w - e_i \text{, otherwise} \end{cases} \quad \text{.. (2)}$$

Where d_i = the depth of flood in cell i
w = the water level
e_i = the elevation of cell i

Following the above formula, flood depth of the different cells in the hypothetical example can be calculated. The process is illustrated in Figure 6.6.



Water Level Elevation Flood Depth

Figure 6.6: The process of calculating flood depth

Now the flood in the affected cells can be categorized based on the flood depth calculated above and Table 6.3.

Figure 6.7 illustrates the category of flood in the affected cell of the hypothetical example grid.

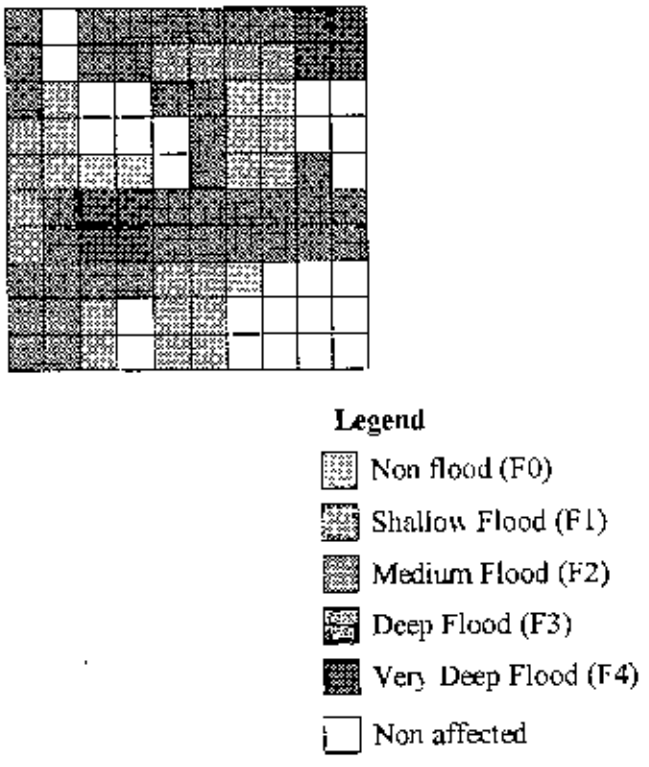


Figure 6.7: The category of flood in the affected cell

6.7.3 Identification of the affected settlements

From the flood affected areas represented by the cells identified above, the affected settlements can be identified to estimate the number of affected population who need emergency relief material. The settlements which have been inundated and affected to a great extent can be identified from the settlements map and the flood depth calculated above. The settlements within the affected cells are assessed to be the affected settlements.

The settlement coverage can be input by digitizing the settlement areas from the Upazilla Base Map prepared by the GIS unit of LGED. The affected settlements can be identified by overlaying the settlement coverage on the flood affected areas coverage. To estimate the number of people who are severely affected and need emergency aid, one must know which settlements are inundated to what extent. Figure 6.8 shows the process of overlaying the flood depth grid over the settlements coverage to estimate the number of affected population.

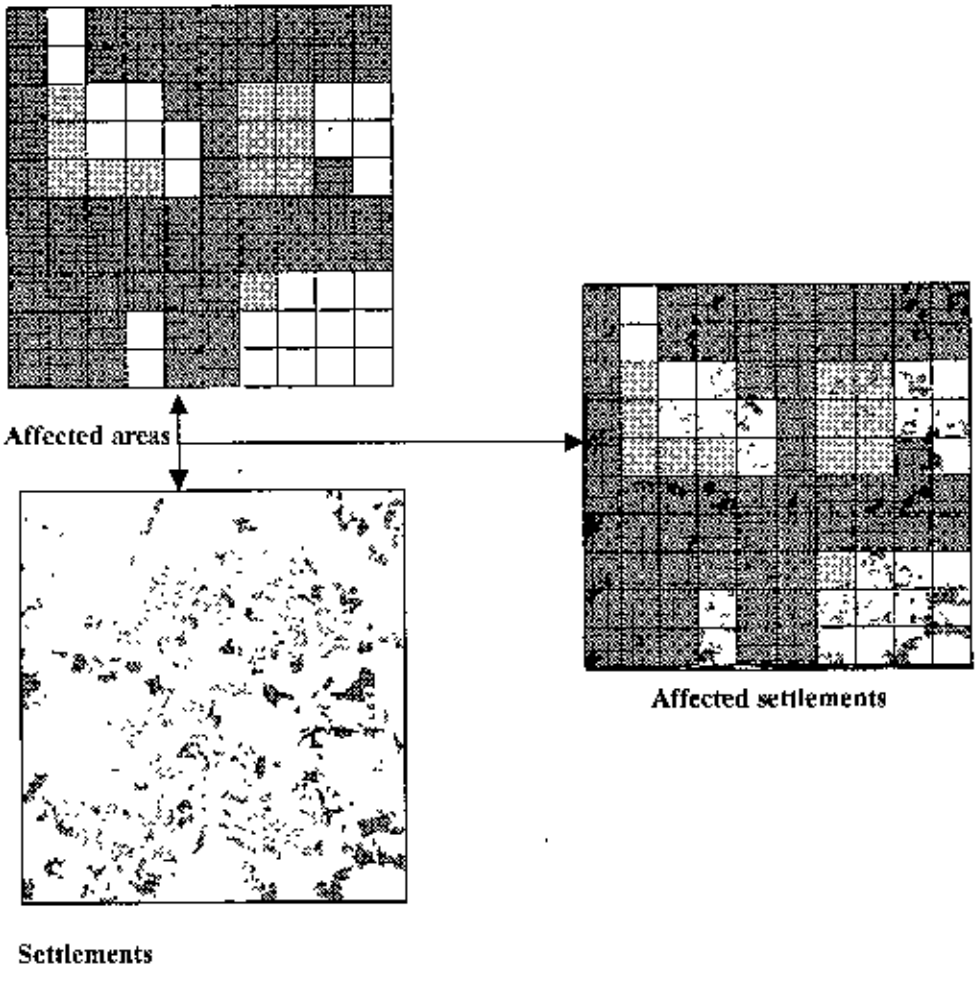


Figure 6.8: Identification of the affected settlements

6.7.4 Redistribution of mauza population to the settlement polygons

The population figure for a given mauza obtained from the census reports can be redistributed to the settlement polygons in the mauza in proportion to their areas, assuming uniform population density with the polygons and zero density outside of them. Once the mauza population, total settlement area of mauzas and area of individual settlements are obtained, the population of the individual settlements under the different mauzas can be found from the following mathematical expression.

$$P_{jk} = \frac{A_{jk}}{A_k} \times P_k \qquad \text{.....(3)}$$

Where P_{jk} = population of settlement j in mauza k
A_k = settlement area of mauza k = $\sum_j A_{jk}$
A_{jk} = area of settlement j in mauza k
P_k = population of mauza k, as give in census reports

6.7.5 Estimation of population of the grid cells

Once redistribution of population of the mauzas to the settlement polygons is done, the population of the grid cells can also be estimated It will help estimate the affected population in different flood categories under different catchment areas of the relief centres. Population of grid cells representing particular areas can be estimated from the following relationship

$$P_i = \sum_{j=1}^{n} \frac{A_{ij}}{A_j} \times P_j \qquad \text{..... (4)}$$

Where P_i = population of cell i
A_{ij} = area of settlement j in cell i
A_j = area of settlement j
P_j = population of settlement j

6.7.6 Identification of the Relief Centres

Identification of the relief centres is very important step for estimating emergency relief requirements in any area. In many disaster prone countries of the world, certain buildings such as schools or community halls are designated as emergency shelters and relief centres by the concerned authority. Public awareness campaigns inform the people about where to go to seek shelter and relief in case of a disaster.

In Bangladesh, there are no such designated shelters and relief centres except some cyclone shelters in the coastal areas. The government, NGOs and some

others organizations have built a number of cyclone shelters in the coastal areas of Bangladesh and reconstructed some existing schools, colleges and other buildings for using them as possible shelters cum relief centres. Among the available buildings and offices, relief centres can be selected at a certain distance considering some physical and socio-economic factors. Relief centres should be chosen in such a way that the affected people can collect the relief materials from their nearest centers within a reasonable distance. Figure 6.9 shows some hypothetical relief centres

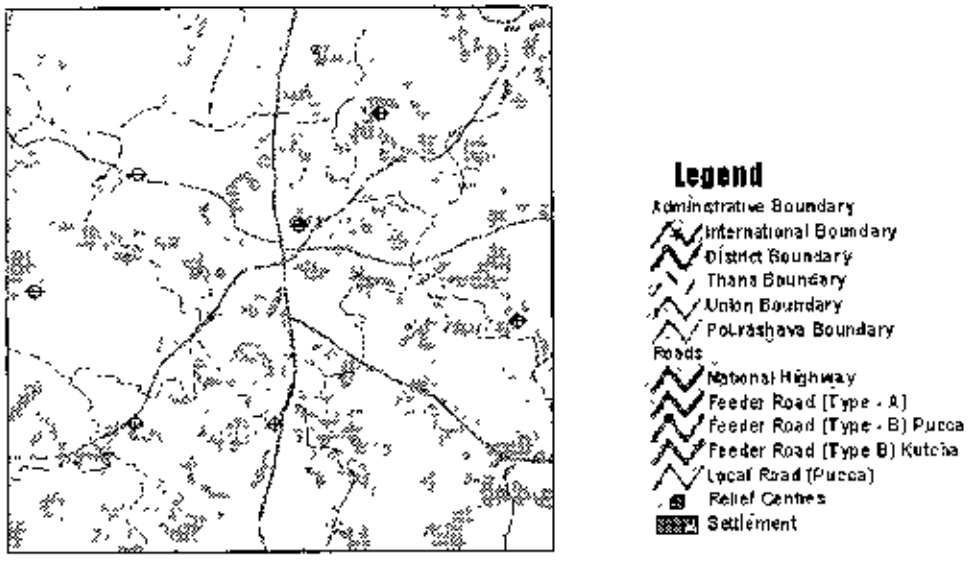


Figure 6.9: Identification of the relief centres

As there is no such designated relief centres in the study area, some establishments of the study area have been selected arbitrarily as the relief centres for showing the application of the model on the study area. Map 6.7 shows the relief centres selected arbitrarily in the study area

6.7.7 Demarcating the catchment areas of the identified relief centres

If one has the location of relief distribution centres in the affected area, the catchment areas or service areas of the respective relief distributing centres can be demarcated. This will help estimate the amount of material to be dispatched to each centre.

The catchment areas of the relief centres can be determined by assigning proximity in ArcView GIS. Here distance is taken into consideration in determining the catchment areas. The catchment areas of the identified relief centres have been shown in Figure 6.10.

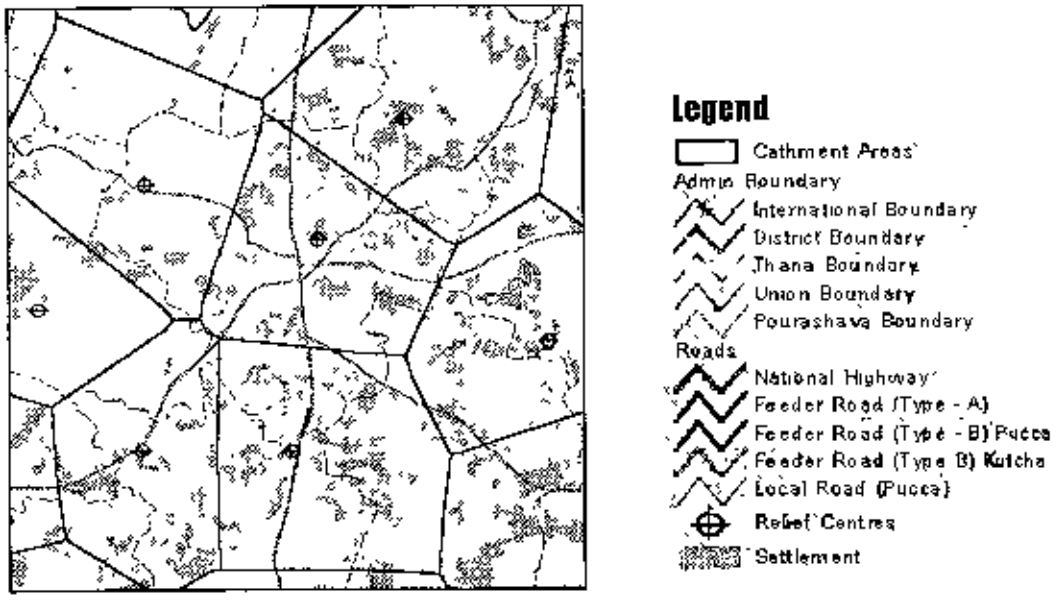


Figure 6.10: Catchment areas of the relief centres

6.7.8 Estimation of affected population for the catchment areas of the relief centres

After identifying the relief centres, their respective catchment areas and estimating population of the grid cells, the number of affected population of the respective catchment areas can be estimated.

The population of the catchment areas of the relief centres can be estimated as described below:

Estimation of population for the catchment areas of the relief centres

The total population served by the relief centres under their catchment areas can be estimated from the model. In earlier phases, relief centres and their catchment areas have been identified and population of grid cells has been estimated. In many cases, one cell may fall under several different catchment

areas. In such cases, population of the cell under a catchment area can be estimated in proportion to its area under that catchment area.

Once the area and population of the grid cells, different relief centres and their catchment areas are obtained, the total population of the relief centres can be estimated from the following relationship:

$$S_l = \sum_{i=1}^{m} \frac{A_{il}}{A_i} \times P_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Where S_l = population of relief centre l, l = 1, 2, 3, 4. ------
A_{il} = area of cell i under catchment area of relief centre l
A_i = area of cell i
P_i = population of cell i

Estimation of affected population under different category of flood for the catchment areas

The population affected under different categories of flood for the catchment area of a relief centre can also be estimated. Flood affected cells have been categorized into different categories of flood above. Now the affected cells under the catchment areas can be categorized into different flood categories to estimate the affected population of the relief centres under different flood categories.

Once the population of the cells under different categories of flood are obtained, the population under the category of flood for the catchment areas can be estimated from the following equation

$$S_{lf} = \sum_{i=1}^{m} P_i \times C_i \times a_f \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Where S_{lf} = affected population of relief centre l under different flood category f
P_i = population of cell i

$$C_i = \begin{cases} 1, \text{ if cell } i \text{ is under flood category } f; \\ 0, \text{ otherwise} \end{cases}$$

α_f = fraction of total population affected when flood category is f

By following the above relationships, the affected population under different relief centres can be estimated The estimation of affected population of the relief centres is very important in assessing the relief requirements.

6.7.9 Estimation of relief materials required

After estimation of the affected population, the relief requirements can be assessed with prescribed standards In assessing the relief requirements, the relief standard used in the model is taken from "Disaster Management Handbook of Bangladesh" published by PACT Bangladesh/PRIP. The relief requirements can be assessed considering the following standards.

Table 6.5: List of relief requirements (main food)

Materials	Amount (gm) / Person / Day	Total Amount (Kg) / Day (For 1000 Person)	Total Amount (Kg) / Week (For 1000 Person)
Rice	400	400	2800
Dal	50	50	350
Edible Oil	20	20	140
Salt	5	5	35
Total	**475**	**475**	**3225**

Source: Rahman (1993)

6.8 Application of the model on the study area

The different phases of the model discussed above have been shown using the study area. The two Upazillas, namely Keshabpur and Manirampur, of Jessore district have been selected as the study area. Some important information of the study area is shown in Table 6.6.

Digital Elevation Model (DEM) of the study area has been collected from WARPO. Other data required for the model were also collected from the

relevant organizations. In this study, water level of the study area observed during flooding has been considered 6 m.

Table 6.6: Some information of the study area

SL No.	Information	Keshabpur Upazilla (1991 Census)	Manirampur Upazilla (1991 Census)
1	Area (in Sq. Km)	258.53	444.72
2	Population	2,00,229	3,26,093
	Male	1,02,438	1,66,306
	Female	97,791	1,59,787
3	Density (per Sq Km)	774	733
4	No of Union	9	17
5	No of Mauza	140	239
6	No of Village	142	249

Source BBS (1992)

The existing physical feature of the study area is shown in Map 6.1 Mauza wise population of the study area is given in Appendix-III. Different phases of the model including identification of the affected areas, identification of the relief centres and their catchment areas, estimation of affected population and assessment of relief requirements have been shown using the study area.

Map 6.2 shows the Digital Elevation Model (DEM) of the study area showing different elevations (in cm). The grid cells of DEM representing the particular areas affected while water level is 6.0 m have been shown in Map 6.3. The affected and non-affected areas can be identified from this map.

Map 6.4 represents the process of calculating flood depth using water level and elevation of the area. The different categories of flood of the affected areas based on the flood depth have been shown in Map 6.5.

The affected settlements of the study area have been identified by overlaying the settlements on the affected areas. This is shown in Map 6.6. Probable relief centres of the study area selected arbitrarily have been shown in Map 6.7. The catchment areas of the relief centres have been shown in Map 6.8. Map 6.9 shows the different category of flood of the study area under different catchment areas.

Map 6.1: Existing Physical Features in the Study Area

Keshabpur and Manirampur Thana

EXISTING PHYSICAL FEATURES

Scale: 1:210000

2 0 2 4 6 8 10 Kilometers

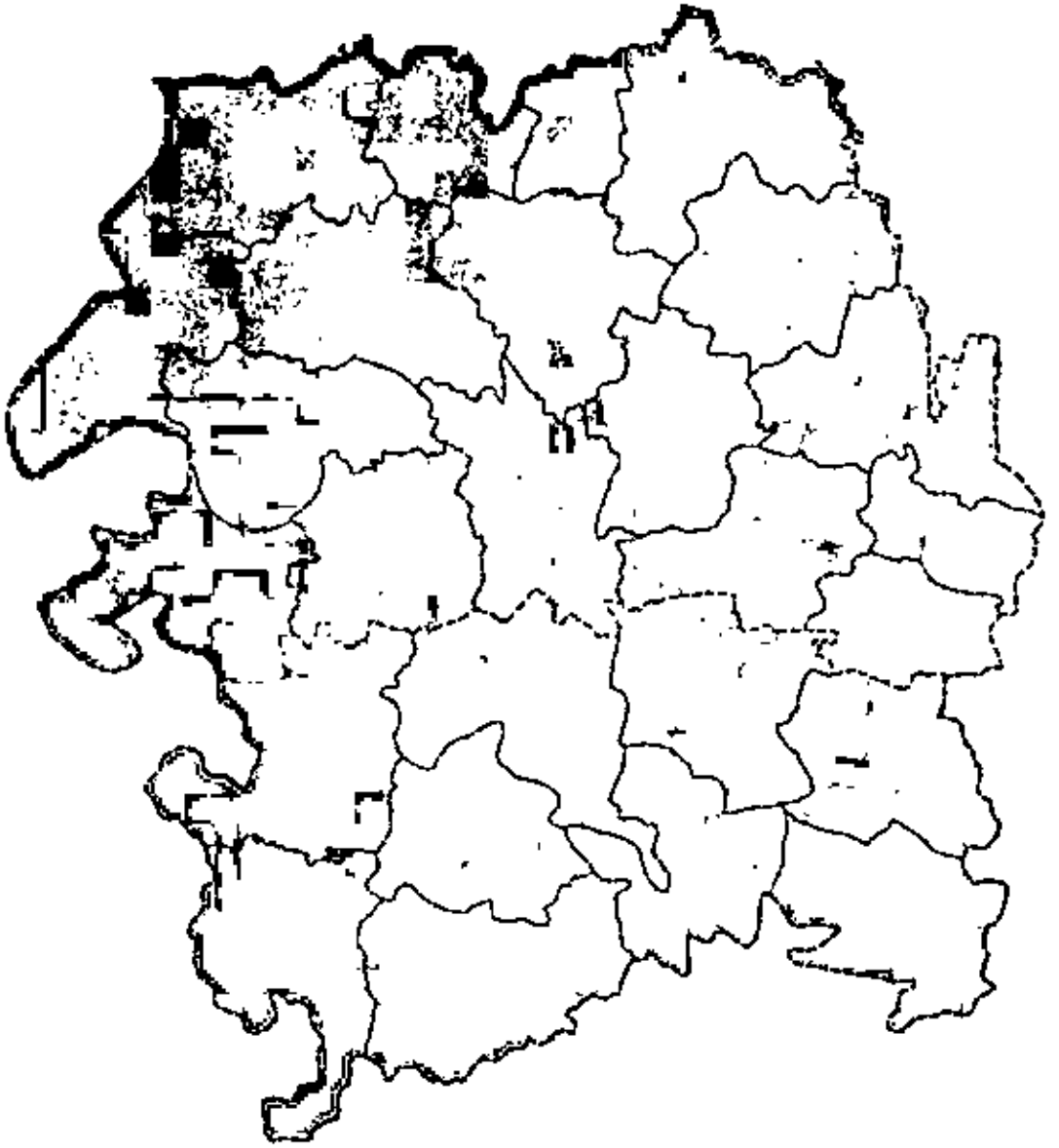
LEGEND

Point Features
- Thana Headquarter
- Union Headquarter
- Growth Centre
- Police Station
- Health Centre
- College
- High School
- Primary School
- Madrasa
- Mosque

Administrative Boundary
- District Boundary
- Thana Boundary
- Union Boundary
- Pourashava Boundary
- Mouza Boundary

Roads
- National Highway
- Feeder Road (Type - A)
- Feeder Road (Type - B) Pucca
- Feeder Road (Type B) Kutcha
- Local Road (Pucca)
- Embankment

- Rivers
- Settlement
- Waterbodies



Keshabpur and Manirampur Thana

Digital Elevation Model of the Study Area

Scale: 1:220000

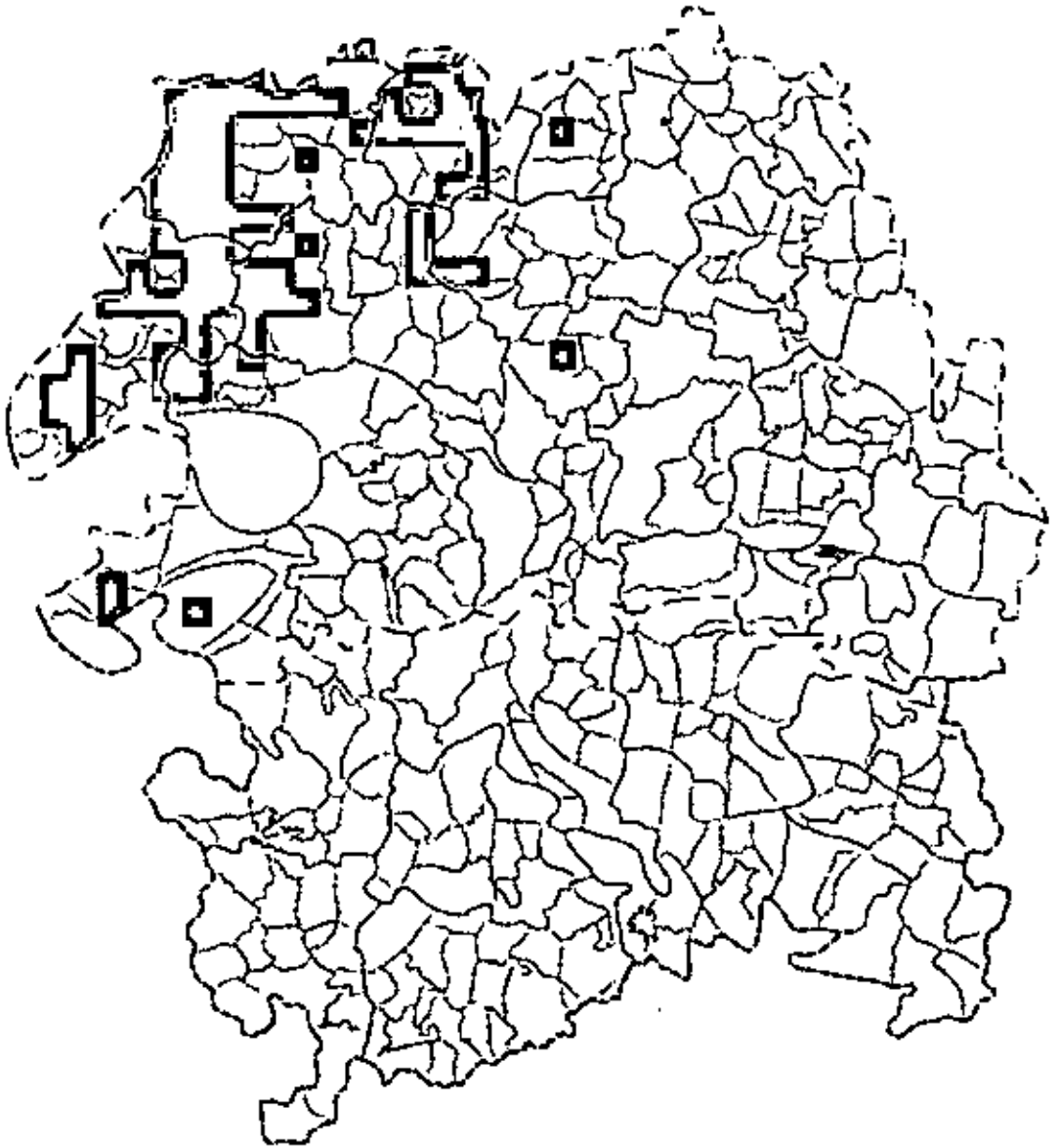
2 0 2 4 6 8 10 Kilometers

LEGEND

Administrative Boundary
- International Boundary
- District Boundary
- Thana Boundary
- Union Boundary
- Pourashava Boundary
- Mouza Boundary

Elevation (cm)
- -24 - 0
- 1 - 100
- 101 - 200
- 201 - 300
- 301 - 400
- 401 - 500
- 501 - 600
- 601 - 700
- 701 - 800
- No Data

Map 6.2: Digital Elevation Model of the Study Area



Keshabpur and Manirampur Thana

Flood Affected Areas within the Study Area

Scale: 1:220000

2 0 2 4 6 8 10 Kilometers

LEGEND

Administrative Boundary
- District Boundary
- Thana Boundary
- Union Boundary
- Pourashava Boundary
- Mouza Boundary

Non Affected Areas
Affected Areas

Map 6.3: Affected Areas using DEM

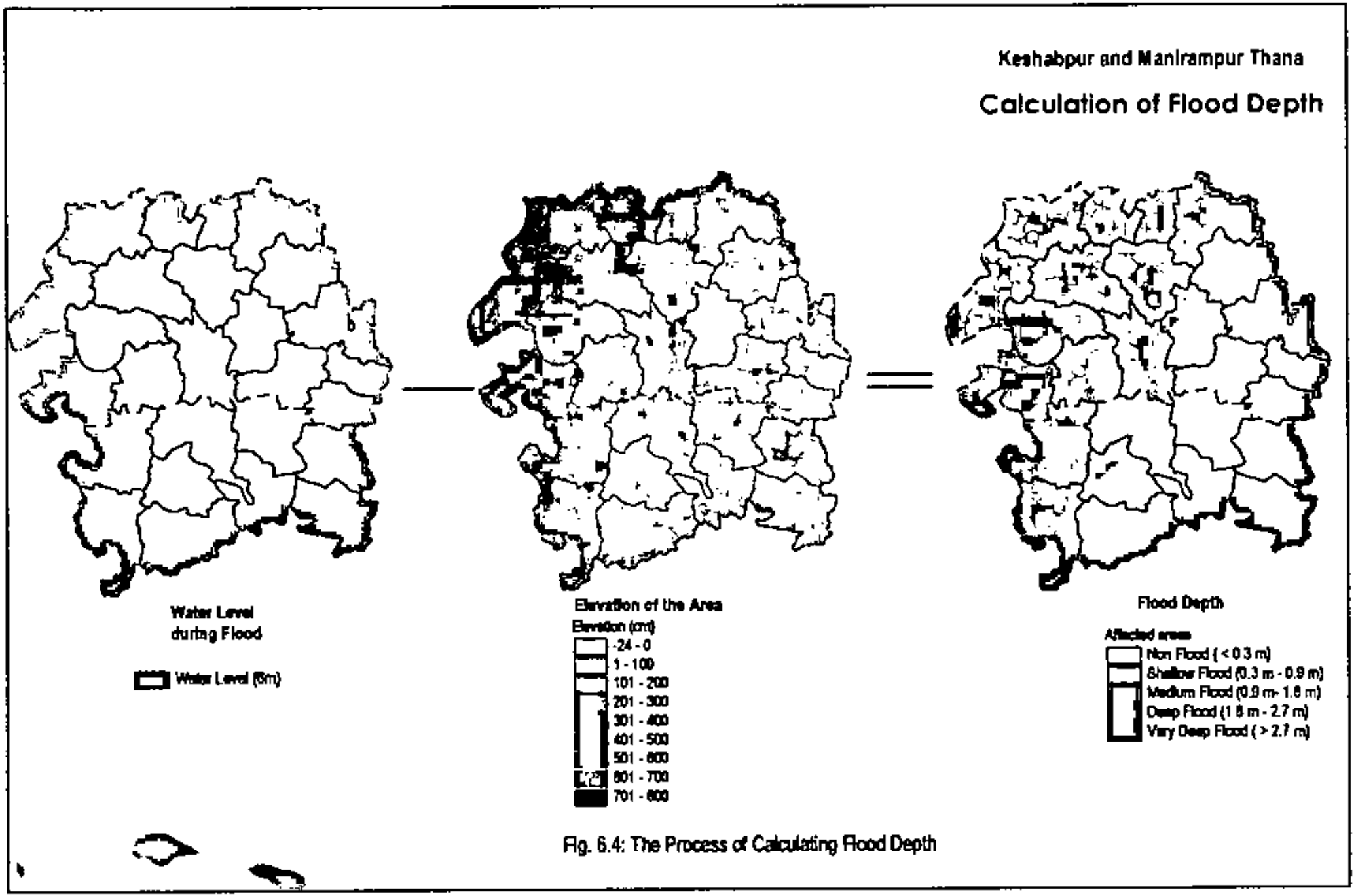
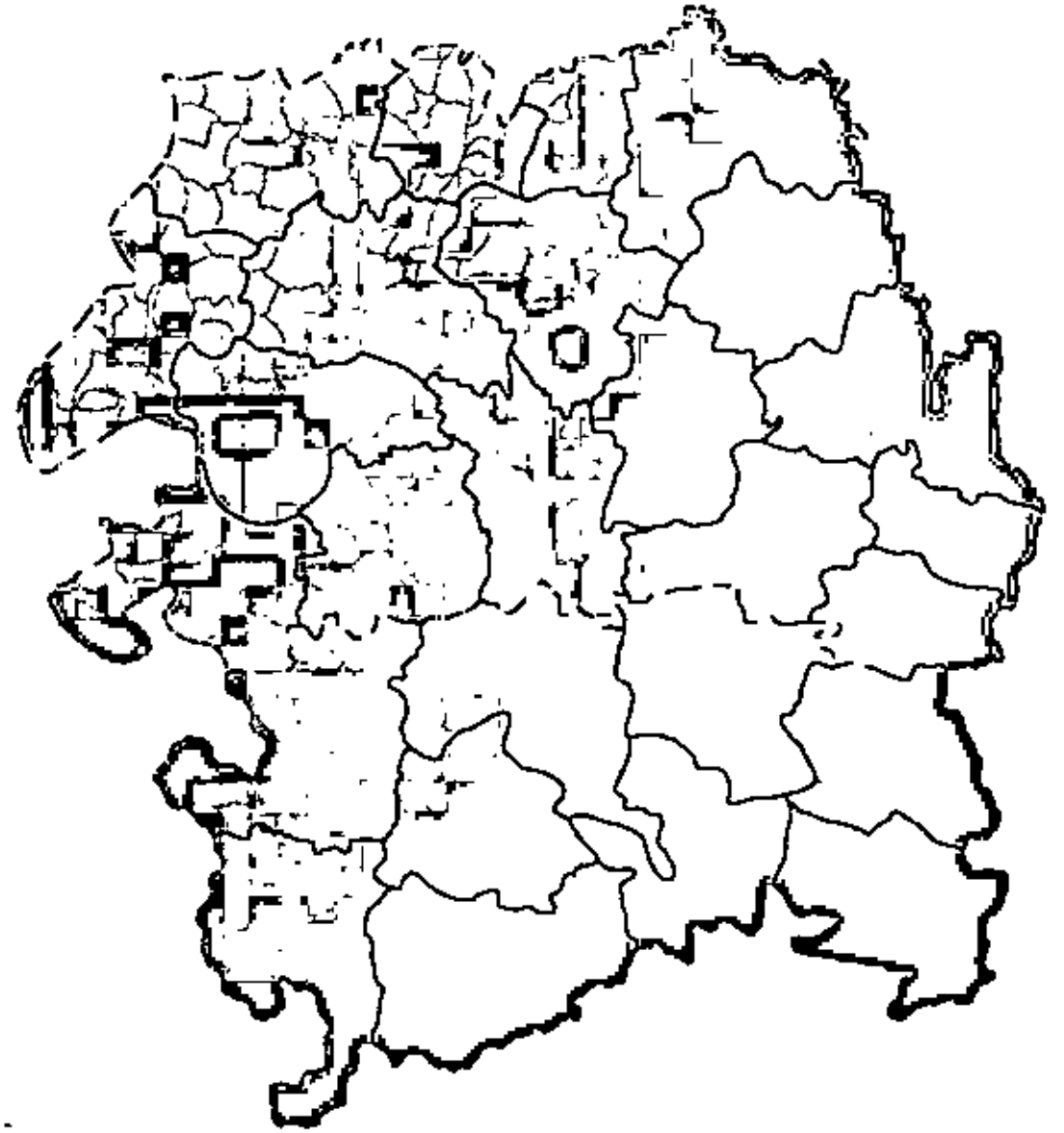


Fig. 6.4: The Process of Calculating Flood Depth



Keshabpur and Manirampur Thana

Category of Flood in the Affected Areas

Scale: 1:220000

2 0 2 4 6 8 10 Kilometers

LEGEND

Administrative Boundaries
- International Boundary
- District Boundary
- Thana Boundary
- Union Boundary
- Pourashava Boundary
- Mouza Boundary

Affected areas
- Non Flood (< 0.3 m)
- Shallow Flood (0.3 m - 0.9 m)
- Medium Flood (0.9 m - 1.8 m)
- Deep Flood (1.8 m - 2.7 m)
- Very Deep Flood (> 2.7 m)

Map 6.5: Category of Flood in the affected Areas

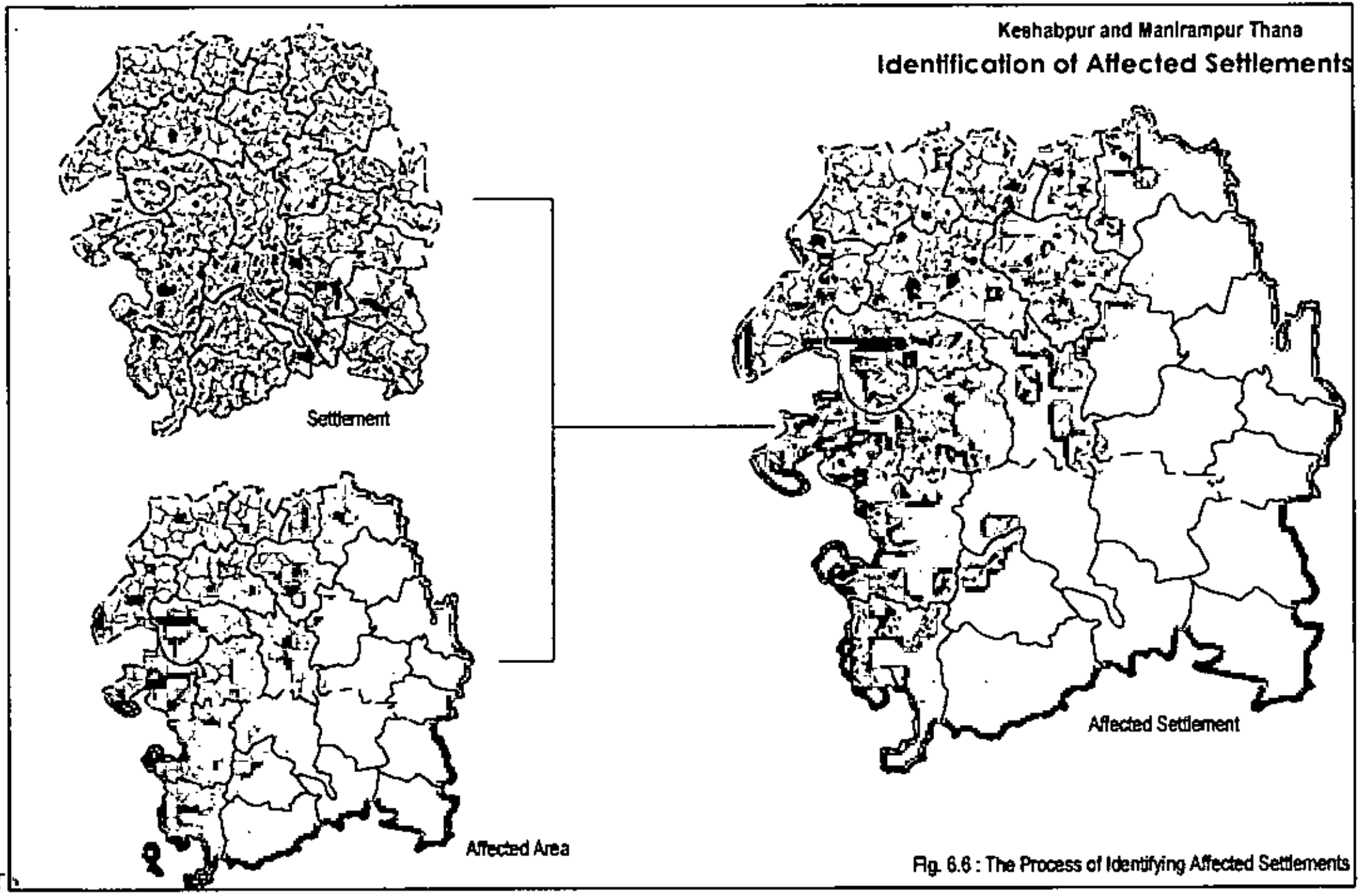
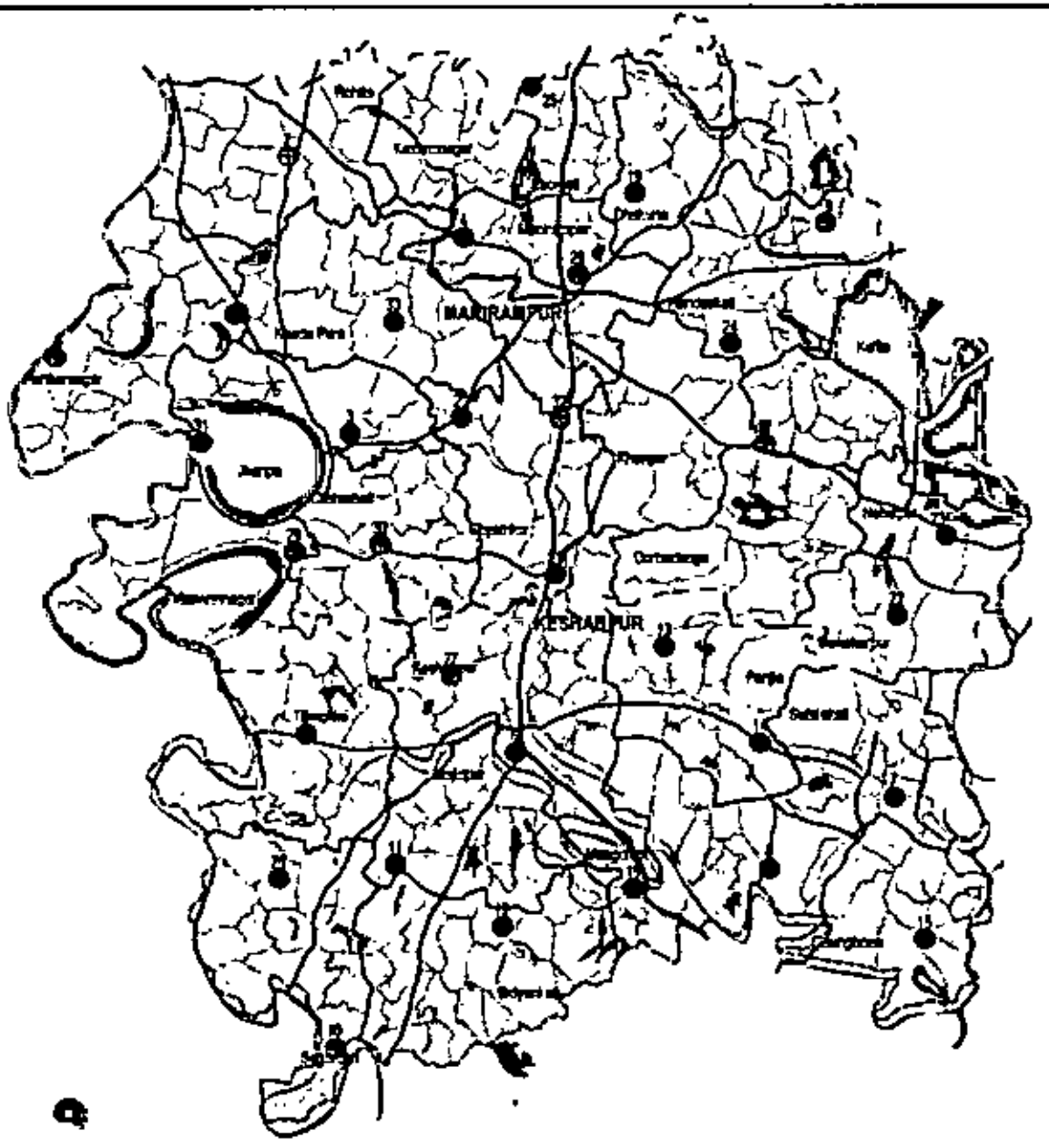


Fig. 6.6 : The Process of Identifying Affected Settlements



Keshabpur and Manirampur Thana

Possible Releif Centres

Scale: 1:210000

2 0 2 4 6 8 10 Kilometers

LEGEND

- Possible Relief Centres

Administrative Boundaries

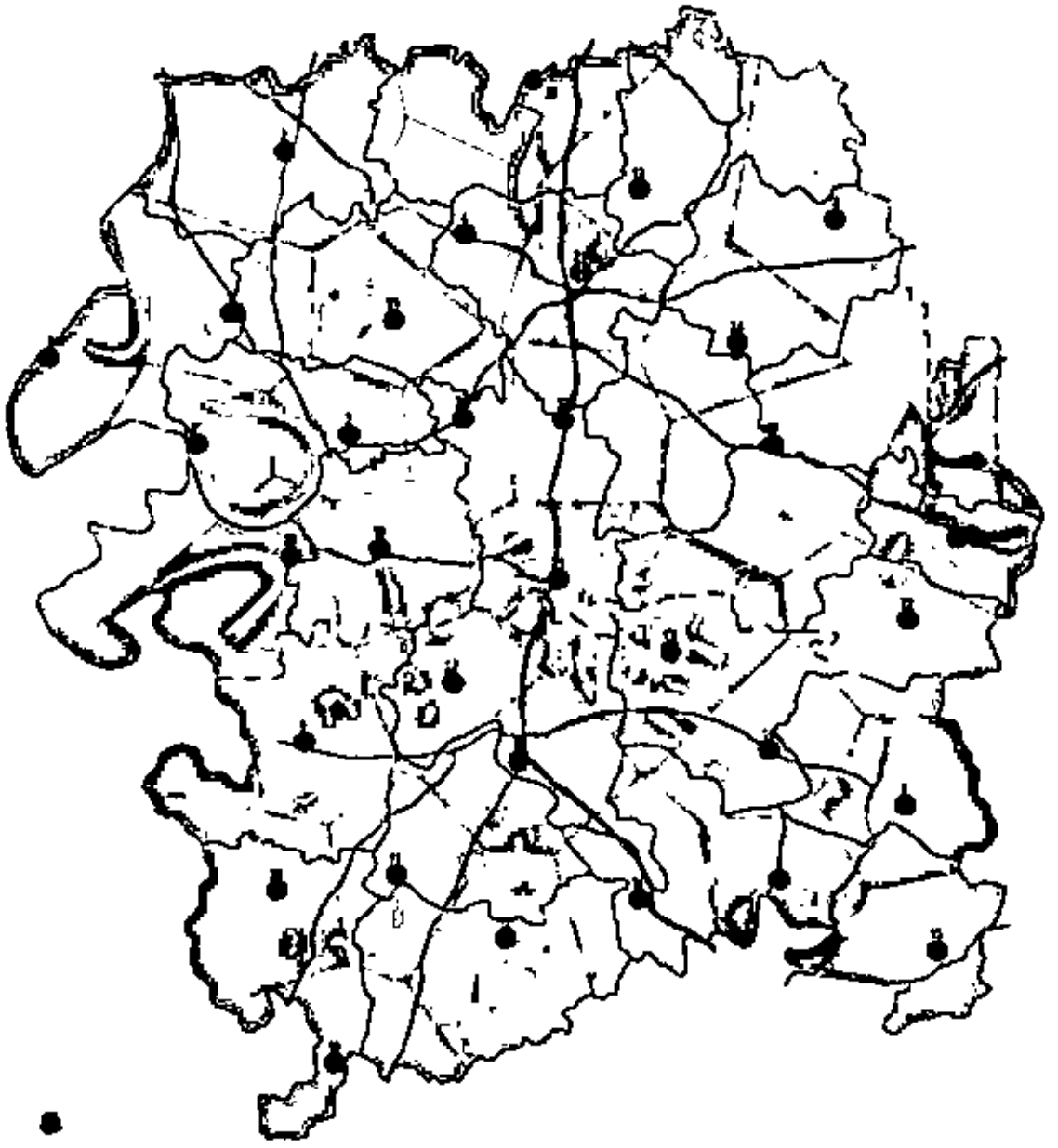
- District Boundary
- Thana Boundary
- Union Boundary
- Pourashava Boundary
- Mouza Boundary

Roads

- National Highway
- Feeder Road (Type - A)
- Feeder Road (Type - B) Pucca
- Feeder Road (Type B) Kutcha
- Local Road (Pucca)

- Affected Settlement
- Water Bodies
- Rivers

Map 6.7: Possible Relief Centres



Keshabpur and Manirampur Thana

Catchment Areas of the possible Relief Centres

Scale: 1:210000

2 0 2 4 6 8 10 Kilometers

LEGEND

- Possible Relief Centres

Administrative Boundaries

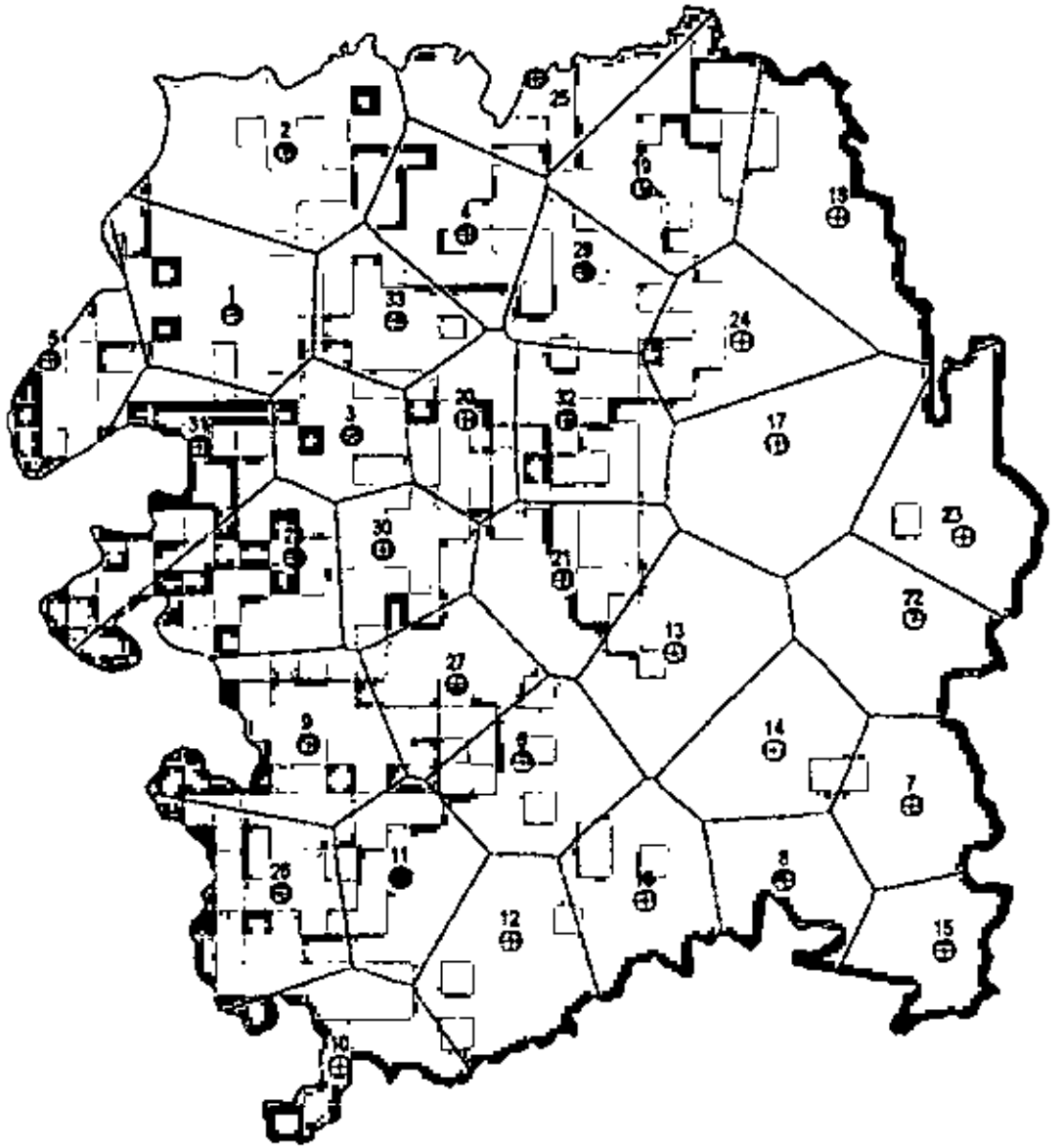
- International Boundary
- District Boundary
- Thana Boundary
- Union Boundary
- Pourashava Boundary

Roads

- National Highway
- Feeder Road (Type - A)
- Feeder Road (Type - B) Pucca
- Feeder Road (Type B) Kutcha
- Local Road (Pucca)

- Water Bodies
- Settlement

Map 6.8: Catchment areas of the possible relief centres



Keshabpur and Manirampur Thana

Category of Flood under different Catchment Areas

Scale: 1:220000

2 0 2 4 6 8 10 Kilometers

LEGEND

- Relief Centres
- Catchment Areas

Affected areas

- Non Flood
- Shallow Flood
- Medium Flood
- Deep Flood
- Very Deep Flood

Map 6.9: Category of Flood under different catchment areas

The number of affected population of the relief centres under different category of flood has been estimated by the equation (6) Under different category of flood, different fractions of total population are affected depending on the severity of flood The flood effect depends upon the flood level. With the increases in flood depth, the effects of flood may be increased. But in rural areas, people build their houses on the high mound. So the effects may differ in different category of flood. There are no standards of extent of effects are occurred by the different category of flood The amount of effects under different category of flood can he determined by the field study.

For the present study, a_f is estimated considering the effects of the different category of flood. It has been considered that 90% of the total population is affected under very deep flood, 70% of the total population is affected under deep flood, 50% of the total population is affected under medium flood and 10% of the total population is affected under shallow flood. The affected population of the catchment areas of the relief centres under different category of flood has been estimated on the basis of this criteria.

The affected population of different catchment areas of the study area have been shown in Table 6.7.

Table 6.7: Affected population of different catchment areas of the study area

Sl No. of Catchment areas	Total population	Total affected population	Affected population under different flood category			
			Shallow Flood	Medium Flood	Deep Flood	Very Deep Flood
1	12135	2466	26	2024	416	0
2	23744	1928	248	1295	385	0
3	19612	10476	234	5287	3970	985
4	14074	878	24	854	0	0
5	15363	2081	38	1442	483	118
6	17088	14471	0	514	1737	12220
7	10085	8797	0	0	1008	7789
8	18480	16632	0	0	0	16632
9	14920	9128	145	2024	5297	1662
10	11262	9001	0	0	3970	5031
11	18510	12199	0	932	1380	9887
12	12674	11068	0	0	1182	9886
13	22047	15432	0	0	1439	13993
14	9026	8014	0	0	382	7632
15	17731	15958	0	0	0	15958

16	12960	11439	0	0	786	10653
17	23235	20911	0	0	0	20911
18	17987	15896	0	0	1021	14875
19	20271	12376	165	4933	2091	5187
20	16353	9284	0	5996	2010	1277
21	15029	11877	0	1037	2861	7979
22	18594	16737	0	0	0	16735
23	13051	11649	0	0	405	11244
24	18519	14104	0	2483	2018	9603
25	21249	11609	108	11501	0	0
26	11807	9751	165	5750	3051	785
27	16134	13243	0	734	2419	10090
28	17947	9043	234	4039	2087	2683
29	13054	5443	198	4699	546	0
30	17366	10042	56	5200	3431	1355
31	17074	9744	230	1704	1175	6635
32	9235	5455	154	1295	2028	1978
33	9706	4411	219	2659	1533	0
Total	**526326**	**341543**	**2244**	**66402**	**49111**	**223783**

After estimating the affected people, the relief requirements have been assessed on the basis of Table 6.5. The relief requirements of the affected people of the study area have been shown in Table 6 8.

Table 6.8: Relief requirements of the affected people in the study area

Sl No. of Catchment areas	Affected population	Daily relief requirements (Kg)				
		Rice	Dal	Edible Oil	Salt	Total
1	2466	986 4	123.3	49.32	12.33	1171 35
2	1928	771 2	96 4	38.56	9 64	915 8
3	10476	4190 4	523 8	209.52	52 38	4976 1
4	878	351.2	43.9	17.56	4.39	417 05
5	2081	832 4	104.05	41 62	10.405	988 475
6	14471	5788 4	723.55	289.42	72 355	6873 725
7	8797	3519.2	439.9	175 96	43.99	4179 05
8	16632	6652 8	831 6	332 64	83.16	7900 2
9	9128	3651 2	456 4	182 56	45 64	4335.8
10	9001	3600.4	450 05	180 02	45 005	4275.475
11	12199	4879.6	609.95	243.98	60.995	5794.525
12	11068	4427.2	553.4	221.36	55 34	5257.3
13	15432	6172 8	771 6	308.64	77 16	7330 2
14	8014	3205.6	400.7	160.28	40 07	3806.65
15	15958	6383.2	797.9	319 16	79 79	7580.05
16	11439	4575.6	571.95	228.78	57.195	5433 525
17	20911	8364 4	1045 55	418 22	104.555	9932.725

18	15896	6358.4	794.8	317.92	79.48	7550.6
19	12376	4950.4	618 8	247.52	61.88	5878.6
20	9284	3713.6	464.2	185 68	46.42	4409.9
21	11877	4750.8	593.85	237.54	237.54	5641.575
22	16737	6694.8	836.85	334.74	83.685	7950.075
23	11649	4659.6	582.45	232.98	58.245	5533.275
24	14104	5641.6	705.2	282.08	70.52	6699.4
25	11609	4643.6	580.45	232.18	58.045	5514 275
26	9751	3900.4	487.55	195.02	48.755	4631 725
27	13243	5297.2	662.15	264 86	66.215	6290.425
28	9043	3617.2	452.15	180.86	45.215	4295.425
29	5443	2177.2	272.15	108.86	27.215	2585.425
30	10042	4016.8	502.1	200.84	50.21	4769.95
31	9744	3897.6	487 2	194.88	48.72	4628.4
32	5455	2182	272.75	109.1	27.275	2591.125
33	4411	1764.4	220.55	88.22	22.055	2095.225
Total	**341543**	**136617.6**	**17077.2**	**6830.88**	**1885.875**	**162233.4**

6.9 Considerations for identification of relief centres

In many disaster prone countries of the world, certain buildings such as schools or community halls are designated as emergency shelters and relief centres by the concerned authority Public awareness campaigns inform the people about where to go to seek shelter and relief in case of a disaster

In Bangladesh, there are no such designated shelters and relief centres except some cyclone shelters in the coastal areas. The government, NGOs and some others organizations have built a number shelters in the coastal areas of Bangladesh and reconstructed some existing schools, colleges and other buildings for using them as possible shelters cum relief centers Among the available buildings and offices, relief centres can be selected at a certain distance considering some physical and socio-economic factors Relief centres should be chosen in such a way that the affected people can collect the relief materials from their nearest centers within a reasonable distance. In the traditional relief operation, relief centres are selected in most cases without any selection procedure. In this case, relief centres are often selected by the influential persons and local leaders in their place of interest. In most cases, the relief materials are not supplied by estimating the relief requirements for the relief centres. The buildings, offices and places may be used as possible shelters

cum relief centres. The different aspects of the establishments for selecting the relief centres are discussed below.

6.9.1 Formal Shelters

In the coastal areas of Bangladesh, a number of multipurpose cyclone shelters have been constructed in the last few years under the Multipurpose Cyclone Shelter Program These shelters are used for different community development programs including social and educational activities along with the shelter and relief distribution purposes during cyclones and floods (BUET & BIDS, 1993). These cyclone shelters have been constructed by the following organizations.

a) Facilities Department, Ministry of Education
b) Public Works Department (PWD)
c) Local Government Engineering Department (LGED)
d) Bangladesh Red Crescent Society
e) Grameen Bank
f) BRAC
g) Proshika
h) others

But these shelters are very insufficient in number in comparison to the requirements. These are also not well located over the country considering all the aspects of emergency response.

6.9.2 Informal Shelters

Besides the formal shelters, the following types of establishments are often used informally as shelters and relief centres during flooding:

a) Primary Schools
b) High Schools
c) Colleges
d) Upazilla headquarters
e) Union Council offices
f) NGO offices
g) Mosques
h) Madrasas
i) Hats/Bazaars
j) Health centres
k) High embankments
l) Others

6.9.3 Factors to be considered for selecting the relief centres

Among the types of establishments available in the areas, some of them can be selected as relief distributing centres considering certain factors. All the buildings and offices where people take shelter during flooding can not be selected as relief centres A number of the available establishments will be selected at a certain distance for relief distribution The following factors can be considered for selecting the relief centres at a certain distance over the areas

a) Location of the structures
b) Nature of the structures
c) Communication facilities with the structures
d) Transportation facilities for moving the relief material
e) Capacity of the structures
f) Physical condition of the structures
g) Settlement pattern of the area
h) Other factors

The above factors should be considered by the concerned authority with due importance in selecting the shelters cum relief centers in the different areas. Relief centres will also be selected in adequate numbers at certain distance over the areas. The distance between the centres can be determined by considering the factors like the distance people prefer to travel for collecting relief material, the number of relief centres to be set up within a certain area and the above mentioned issues related to the relief centres and relief distribution.

When the distance between the relief centres is fixed up by the concerned authority considering the above factors, the relief centres can be selected over the areas following some criteria. Once a relief centre is chosen considering the above factors, at a certain distance from it another relief centre should be chosen from the available establishments. At a certain distance from the selected centre, many establishments like schools, colleges, madrasa, mosque and different government and NGO offices may exist. In this case, an establishment can be chosen as a relief centre according to their priority to be fixed up by the concerned authority.

6.9.4 Priority for selecting relief centres

In different areas, many establishments like formal shelters, informal shelters including schools, colleges, mosque, madrasa, growth centers etc may be located at the certain distance of a selected relief centre But any one of them will be selected at the certain distance. In this case, priority among the available establishments can be fixed up considering the factors stated above.

In determining the priority among the establishments, the factors stated above along with their physical characteristics, their normal functions, their suitability as the relief distributing centre etc. should be considered with due importance. By considering the different factors and issues related to the relief distribution, the priority among the following establishments can be fixed up in the following way:

Table 6.9: Priority among the establishments for use as emergency shelter

Priority	Name of establishments
1	Formal shelters i e recognized cyclone shelters
2	Colleges
3	High schools
4	Primary school
5	Union council offices
6	Madrasa
7	Mosque
8	Growth centres
9	NGO Offices
10	Others

The formal shelters have been given the first priority in selecting the relief centres because of having some suitable characteristics. The formal shelters are constructed at the most disaster prone areas of the country considering the geographical, physical, socio-economic and other characteristics. These are also located where the affected people will be able to reach traveling minimum distance within the shortest possible time during the flooding period. The communication system with the formal shelters is also satisfactory for reaching relief materials. The other priority has also been fixed up by considering their different characteristics and comparing these with each other.

6.9.5 Process of selecting relief centres

The relief centres will be selected in the areas following the above factors and priority. Once one is selected, another relief centre will be selected outside the service area of the relief centre selected before. The process of selecting relief centres will ensure the issues like the estimated number of relief centres at certain distance, proper estimation of relief materials for the relief centres, distribution of these materials properly, avoid of duplication of service areas of the relief centres, better transportation routes for reaching relief materials etc.

The selection process of the relief centres can be illustrated in the following way:

1. At the first stage, the formal shelters like multipurpose cyclone shelters or others according to the priority can be considered for relief distribution.

   Once the formal shelters are selected, then the possible service area of the shelters can be estimated by creating buffer zone of selected shelters with certain distance.

2 At the second step of the selection process, the colleges, second priority in the priority list, available in the affected area can be selected for relief distribution.

   Once the colleges are selected over the area, then the buffer of the colleges with certain distance can be created. Then outside of the buffer, the elements available can be considered for selecting as a relief centre considering the mentioned factors.

3. In this way, high schools, primary schools, mosques, madrasa, NGO offices, growth centers etc. at a certain distant of a relief centre already selected will be considered according to their priority and other factors. Once an element is selected as relief centre at a certain distance i e. outside of the buffer zone of the relief centre, other elements will be considered for selection of the relief centres according to their priority and other factors.

In this way, the relief centres can be selected considering different factors for distribution of relief materials.

Chapter 7

Recommendations and Conclusion

7.1 Recommendations

Geographic Information System (GIS) can play an important role in disaster management strategies especially in emergency relief activities in the most disaster prone countries like Bangladesh An information system can provide different information regarding the disaster to the concerned authority for making emergency decisions. Under this study, a model has been developed for estimating emergency relief requirements for flood victims. Now, different aspects of the model have been illustrated below:

Data base development

Development of data base is very important in this model All the required data should be updated regularly for the emergency relief operation. In this study, data collected for the model from different sources is not fully accurate and updated. DEM collected from WARPO is not updated. Each grid cell of DEM represents a particular area of 300m X 300 in the real field. In this case, the DEM can not provide accurate information of the affected areas. Mauza wise population of 2002 is not available and projected regularly In the present study, 1991 census population has been used to estimate population

The infrastructure like roads, location of different structures, location of settlements collected from different sources is not fully correct. In these cases, the estimated population and relief requirements made under the model will not comply with the real information. So the data base should be developed with updated data and information to get proper information from the model.

Flood depths calculation

Flood depths calculation is very important for identifying the areas affected to different extents. Flood depth has been calculated from the difference of the elevation and the water level. In this case, the elevation value and water level value should be accurate and updated for calculating flood depths properly. Other factors related to flood disaster management in this model have not been considered for calculating flood depths.

Category of flood

In this study, flood has been categorized into different categories on the basis of flood depth made by Master Plan Organization. Bangladesh Water Development Board also developed another classification of flood considering the water level data with respect to the danger level of the different rivers. There should be proper and established system of categorization of flood for avoiding different flood categories of a particular flood by different organizations.

Relief centre identification

In many disaster prone countries, there are designated buildings and community halls as shelters cum relief centres People are informed about their destinations during disaster But in Bangladesh, there are no such designated shelters and relief centres for the people In the model, some structures have been selected arbitrarily as the relief centers. Then their catchment areas have been demarcated and affected population has been estimated for assessing relief requirements. In this study, some considerations have been made for identifying relief centres. During normal time, the different structures will be selected as the shelters cum relief centres considering different aspects. During flooding, this would help identify the shelters and relief centres for the people and estimate relief requirements.

Relief requirement standard

In Bangladesh, many involved organizations such as government, NGOs, international organizations and private organizations use different relief standards There is no common standard for them to assess relief requirements. In this model, the standard proposed by PACT Bangladesh has been used for assessing relief requirements. There may have common relief standard for all the involved organizations.

Further development of the model

The model can be modified and updated with the changing situations The involved organizations will be able to modify the model to meet their needs and requirements.

7.2 Conclusion

Flood is a regular phenomenon in Bangladesh. GIS can play a vital role in reducing the effects and losses caused by the disasters. Some models and tools based on GIS can be developed in Bangladesh like many other disaster prone countries. A model has been developed under the present study for estimating emergency relief requirements and an Information System for managing emergency relief operation over a flood hit region

The model developed in this study will provide the information about the identification of flood affected areas, flood depths of the particular areas, flood types of the particular areas on the basis of flood depth, identification of the shelters and relief centres of the affected areas, demarcation of their catchment areas, estimation of the affected population of the relief centres, estimation of the relief materials of the relief centres etc.

The different organizations involved in estimating emergency relief requirements can be benefited by the model for making emergency relief operation. They will be able to identify the relief centres in the affected areas and demarcate their catchment areas. Under the catchment areas, how many populations affected to what extent can also be known After finding affected population, relief requirements can also be assessed.

This study is an effort towards modern and advanced disaster management strategies. In this country, advanced disaster management strategies especially emergency relief operations are utmost important in national development. Irregularities prevailed in this country in emergency relief operation can be reduced to a great extent by applying the developed tools and models. In maximum cases, the required relief does not reach in the affected area in due

time. Again relief is supplied in excess of requirement In this case, the present model will provide detailed information about the affected areas and relief requirements.

The accuracy of the information provided by the model will depend upon the accuracy of the database used in this study. There is also scope to further develop the model. Some other tools like the present model can be devcloped for estimating emergency relief requirements and flood disaster management in Bangladesh.

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Appendices

Appendix-I

Formation of Different National and Local Disaster Management Committees

1. National Disaster Management Council (NDMC)

1.	**Prime Minister**	**:**	**Chairman**
2.	Minister, Ministry of Water Resources	:	Member
3.	Minister, Ministry of Finance	:	Member
4.	Minister, Ministry of Local Government, Rural Development and Cooperatives		Member
5.	Minister, Ministry of Communication		Member
6.	Minister, Ministry of Health and Family Welfare		Member
7	Minister, Ministry of Food		Member
8.	Minister, Ministry of Home Affairs	:	Member
9	Minister, Ministry of Disaster Management & Relief	:	Member
10.	Minister, Ministry of Agriculture	:	Member
11	Minister, Ministry of River Transport	:	Member
12.	Chief of Army Staff	:	Member
13.	Chief of Naval Staff	:	Member
14.	Chief of Air Staff		Member
15.	**Secretary of Cabinet Division**	**:**	**Member Secretary**
16.	Principal Secretary to the Prime Minister	:	Member
17.	Secretary, Ministry of Agriculture		Member
18	Secretary, Finance Division	:	Member
19	Secretary, Ministry of Health and Family Welfare	:	Member
20	Secretary, Ministry of Home Affairs	:	Member
21.	Secretary, Ministry of Defense	:	Member
22	Secretary, Local Government Division	:	Member
23.	Secretary, Roads and Railway Division	:	Member
24.	Secretary, Ministry of River Transport	:	Member
25.	Secretary, Jamuna Bridge Division	.	Member
26	Secretary, Ministry of Water Resources	.	Member
27.	Secretary, Ministry of Food	:	Member
28	Secretary, Ministry of Disaster Management & Relief	.	Member
29	Member (Socio-economic Infrastructure), Planning Commission	:	Member
30.	P.S O., Armed Forces Division	:	Member

Source: DMB (1997)

2. Inter-Ministerial Disaster Management Coordination Committee (IMDMCC)

1.	**Minister, Ministry of Disaster Management & Relief**	:	**Chairman**
2	Secretary of Cabinet Division		Vice Chairman
3	Principal Secretary to the Prime Minister, Prime Ministers Office		Member
4	Member(Programming), Planning Commission	:	Member
5.	Secretary, Ministry for Foreign Affairs	:	Member
6.	Secretary, Ministry of Agriculture	.	Member
7.	Secretary, Ministry of Defense		Member
8.	Secretary, Ministry of Water Resources	:	Member
9.	Secretary, Education Ministry	.	Member
10	Secretary, Ministry of Information		Member
11.	Secretary, Ministry of Housing & Public Works		Member
12.	Secretary, Ministry of Power, Fuel and Mineral Resources	:	Member
13.	Secretary, Ministry of Civil Aviation & Tourism	:	Member
14.	Secretary, Ministry of Fisheries and Livestock	:	Member
15.	Secretary, Ministry of Post and Telecommunication	.	Member
16.	Secretary, Ministry of Environment and Forest	:	Member
17	Secretary, Ministry of Disaster Management & Relief	:	Member
18.	Secretary, Finance Division, Ministry of Finance	.	Member
19.	Secretary, Local Government Division	:	Member
20.	Secretary, Ministry of Home Affairs	:	Member
21.	Secretary, Roads and Railway Division	:	Member
22	Secretary, Jamuna Bridge Division	:	Member
23	Secretary, Ministry of River Transport	.	Member
24.	Secretary, Ministry of Food		Member
25	Secretary, Ministry of Health and Family Welfare	.	Member
26	Principal Staff Officer, Armed Forces Division	:	Member
27.	Director General, NGO Affairs Bureau	:	Member
28.	Director General, Disaster Management Bureau	:	Member
29.	Director General, Directorate of Relief & Rehabilitation	:	Member
30	Secretary General, Bangladesh Red Crescent Society	:	Member

Source: DMB (1997)

3. National Disaster Management Advisory Committee (NDMAC)

Chairman		An Expert experienced in the Disaster Management programs nominated by the Prime Minister
Member	:	Elected Member of Parliament (MP) from disaster prone areas
	:	Representatives from Government Institutions
	:	Representatives from Universities
	:	Representatives from NGOs
	:	Representatives from Helping Organizations
	:	Experienced persons from other organizations in the areas of Water Resources, Meteorology, Earthquake engineering, Physical Infrastructure planning, Social Anthropology, Education, Disaster management etc.
	:	Chairman, Red Crescent Society
	:	President, Federation of Bangladesh Chamber of Commerce & Industry
	:	President, Institute of Engineers, Bangladesh
	:	Chairman, Insurance Company Association
	:	Krishi Bank & Grameen Bank
	:	Director General, Directorate of Relief & Rehabilitation
Member Secretary	:	Director General, Disaster Management Bureau

Source: DMB (1997)

4. Union Disaster Management Committee

1.	**Chairman of the Union Council**	:	**Chairman**
2.	Members of the Union Council	:	Member
3.	Representative from the teachers	:	Member
4	Government Employees of Union Council	:	Member
5.	Women Representatives	:	Member
6.	Representatives from Cyclone Preparedness Program (CPP)	:	Member
7.	Representatives from Red Crescent Society	:	Member
8.	Representatives from NGOs	:	Member
9.	**Secretary of the Union Council**	:	**Member Secretary**

Source: DMB (1997)

5. Upazilla Disaster Management Committee

1.	**Upazilla Nirbahi Officer (UNO)**	**:**	**Chairman**
2	Chairman of the Union Councils	:	Member
3	Officers of the concerned Divisions in the Upazilla level	:	Member
4.	Women Representatives	:	Member
5.	Representatives from Upazilla Central Cooperative Association (UCCA)	:	Member
6.	Representatives from Cyclone Preparedness Program(CPP)		Member
7.	Representatives from Red Crescent Society	:	Member
8	Representatives from NGOs	.	Member
9.	**Upazilla Project Implementation Officer (PIO)**	**:**	**Member Secretary**

Source: DMB (1997)

6. District Disaster Management Committee

1.	**Deputy Commissioner**	**:**	**Chairman**
2.	Officers of the concerned Divisions in the District level		Member
3.	District Executive Officers	.	Member
4	Women Representatives		Member
5.	District level Representatives from Red Crescent Society	:	Member
6.	Representatives from Cyclone Preparedness Program(CPP)	:	Member
7.	Representatives from NGOs	:	Member
8.	**District Relief and Rehabilitation Officer (DRRO)**	**:**	**Member Secretary**
9.	Representatives from Armed Forces	:	Member

Source: DMB (1997)

Appendix-II

Damage Assessment forms to be filled up by the concerned authority

1. Assessment of Approximate Damage and Emergency Need

Within one hour of a disaster striking an area or as early as possible, the Union Disaster Management Committee is instructed to send the particular form regarding assessment of approximate damage and emergency need as a primary report to the Upazilla Nirbahi Officer, District Administration and the control room of the Ministry of Disaster Management and Relief by telephone or any other means.

S.O.S. Form

Approximate Damage and Emergency Need

Name of Upazilla... ....

1.	Affected Union (No)	:	
2.	Affected People (Approx. No.)	:	
3.	Damaged house (Approx. No.)	:	
4	Death (Approx. No)	:	
5.	Search and Rescue	:	Necessary/Not Necessary
6.	Primary Treatment	:	Necessary/Not Necessary
7.	Potable Water	:	Necessary/Not Necessary
8.	Made Food	:	Necessary/Not Necessary
9.	Cloths	:	Necessary/Not Necessary
10.	Emergency Shelter	:	Necessary/Not Necessary

Source: DMB (1997)

2. Damage Assessment Form

Upazilla Nirbahi Officer (Chief Executive Officer of Upazilla) will send this form to the Control Room of the Ministry of Disaster Management and Relief through concerned Deputy Commissioner by collecting information from the different sectors at Union Council and Upazilla level.

Damage Assessment Form

Upazilla	Affected Union (No.)	Affected Area (Sq. KM)	No. of affected People			Death	Injured	No. of affected Family			Completely Affected House	Partially Affected House
1	2	3	4			5	6	7			8	9
			Max	More	Partial			Max	More	Partial		

Source: DMB (1997)

Appendix-III

Mauza wise population of the Study Area

1. Keshabpur Upazilla

Geocode				Name of Mauzas	Population
ZL	TH	UN	MAU		
41	**38**	**09**		**Bidyanandakati Union**	**27649**
41	38	09	035	Aulganti	1176
41	38	09	049	Baga	1102
41	38	09	126	Bausala	2803
41	38	09	147	Bhabanipur	245
41	38	09	168	Bhandarkhola	1488
41	38	09	189	Bidyanandakati	705
41	38	09	231	Burihati	2949
41	38	09	336	Fatehpur	865
41	38	09	399	Hariaghop	1453
41	38	09	413	Hasanpur	1427
41	38	09	420	Hizaldanga	569
41	38	09	455	Kabilpur	736
41	38	09	476	Kakilakhali	894
41	38	09	490	Kaliarai	960
41	38	09	560	Khopdahi	599
41	38	09	609	Lalpur	281
41	38	09	651	Mahadebpur	816
41	38	09	665	Mominpur	1764
41	38	09	742	Nehalpur	892
41	38	09	777	Parchakra	2503
41	38	09	826	Rajakati	440
41	38	09	861	Saksekanpur	122
41	38	09	987	Teghari	1417
41	38	09	994	Titabazitpur	446
41	**38**	**19**		**Gaurighona Union**	**16700**
41	38	19	007	Agarhati	1089
41	38	19	175	Bharat Bhaina	2338
41	38	19	182	Bherchi	2378
41	38	19	224	Burali	1362
41	38	19	287	Daskahania	945
41	38	19	350	Gaurighona	2909
41	38	19	518	Kashimpur	1211
41	38	19	868	Sannyasgachha	3394
41	38	19	910	Sarutia (near Bherchi)	1074
41	**38**	**28**		**Keshabpur Union**	**32540**
41	38	28	014	Altapol	7022

Geocode				Name of Mauzas	Population
ZL	TH	UN	MAU		
41	38	28	063	Bajitpur	919
41	38	28	070	Baliadanga	2151
41	38	28	154	Bhagati Narendrapur	3445
41	38	28	210	Brahmakati	1212
41	38	28	238	Byasdanga	973
41	38	28	322	Durmutia	2114
41	38	28	385	Habaspol	862
41	38	28	539	Keshabpur	1358
41	38	28	553	Khatiakhali	683
41	38	28	630	Madhyakul	2793
41	38	28	637	Maguradanga	1155
41	38	28	728	Mulgram	4145
41	38	28	812	Ramchandrapur	1140
41	38	28	833	Sabdia	1033
41	38	28	896	Sarfabad	483
41	38	28	980	Sujapur	1052
41	**38**	**38**		**Majidpur Union**	**19999**
41	38	38	028	Atenda	808
41	38	38	042	Bayesa	2895
41	38	38	056	Bagdaha	1308
41	38	38	301	Deuli	1577
41	38	38	427	Hizaltala	620
41	38	38	595	Kusaldia	701
41	38	38	602	Lakshminathkati	1078
41	38	38	658	Majidpur	2189
41	38	38	714	Mirzapur	925
41	38	38	784	Patra para	648
41	38	38	791	Protappur	2036
41	38	38	938	Sikarpur	1873
41	38	38	945	Sreefala	1754
41	38	38	959	Sreerampur	1587
41	**38**	**47**		**Mangalkot Union**	**18221**
41	38	47	091	Bara pathra	814
41	38	47	112	Barenga	1976
41	38	47	119	Basundia	1317
41	38	47	259	Chhota pathra	1674
41	38	47	273	Chuadanga	1402
41	38	47	357	Chagha	423
41	38	47	532	Kedarpur	613
41	38	47	546	Khandarpapur	1968
41	38	47	644	Magurkhali	1414
41	38	47	679	Mangalkot	3235
41	38	47	756	Pancharai	1220

Geocode				Name of Mauzas	Population
ZL	TH	UN	MAU		
41	38	47	763	Panchpota	1320
41	38	47	819	Ramkrishnapur	845
41	**38**	**57**		**Panjia Union**	**19433**
41	38	57	140	Belkati	1930
41	38	57	217	Brahmandanga	1226
41	38	57	315	Dongaghata	237
41	38	57	343	Garbhanga	1776
41	38	57	392	Had	755
41	38	57	434	Imamnagar	420
41	38	57	616	Lepakati	496
41	38	57	623	Madardanga	2068
41	38	57	672	Mandardanga	854
41	38	57	686	Manoharnagar	4193
41	38	57	749	Panch Bankabarsi	826
41	38	57	770	Panjia	1581
41	38	57	805	Rajnagar Bankabarsi	1628
41	38	57	840	Sagar Dattakati	1241
41	38	57	917	Sataiskati	202
41	**38**	**66**		**Sagardari Union**	**25555**
41	38	66	077	Banshbaria	1511
41	38	66	098	Barihati	1798
41	38	66	203	Bishnupur	1246
41	38	66	266	Chingra	3428
41	38	66	308	Dharmapur	1514
41	38	66	329	Fatehpur	619
41	38	66	371	Gobindapur	967
41	38	66	378	Gopsona	2018
41	38	66	448	Jhikra	1023
41	38	66	525	Kasta	1870
41	38	66	581	Kumarpur	1439
41	38	66	700	Meherpur	2045
41	38	66	721	Mrizapur	1083
41	38	66	798	Raghurampur	499
41	38	66	847	Sagardari	2761
41	38	66	931	Sekhpura	1317
41	38	66	952	Sreepur	417
41	**38**	**76**		**Sufalakati Union**	**14432**
41	38	76	021	Arua	2869
41	38	76	280	Dahari	576
41	38	76	364	Giridharnagar	408
41	38	76	406	Hariaghop	769
41	38	76	462	Kaemkhola	394
41	38	76	469	Kakbandhal	854

Geocode				Name of Mauzas	Population
ZL	TH	UN	MAU		
41	38	76	483	Kalagachhi	727
41	38	76	497	Kalicharanpur	1129
41	38	76	504	Kanaidanga	882
41	38	76	567	Kismat Santala	292
41	38	76	588	Krishnanagar	495
41	38	76	693	Maynapur	181
41	38	76	735	Narayanpur	2439
41	38	76	875	Santala	525
41	38	76	903	Sarutia	1417
41	38	76	973	Sufalakati	475
41	**38**	**85**		**Trimohini Union**	**25700**
41	38	85	105	Barandali	3545
41	38	85	133	Begampur	1575
41	38	85	161	Bhalukghar	2606
41	38	85	245	Chalita Baria	625
41	38	85	252	Chandra	3002
41	38	85	294	Dattanagar	263
41	38	85	441	Janpur	2203
41	38	85	511	Kariakhali	1009
41	38	85	574	Kumarpol	1938
41	38	85	707	Mrizanagar	3167
41	38	85	854	Sahapur	722
41	38	85	882	Sarappur	413
41	38	85	889	Saraskati	334
41	38	85	924	Satbari	4044
41	38	85	966	Sreerampur	254

2. Manirampur Upazilla

Geocode				Name of Mauzas	Population
ZL	TH	UN	MAU		
41	**61**	**05**		**Bhojgati Union**	**10134**
41	61	05	129	Bhojgati	1379
41	61	05	174	Chalkidanga	1608
41	61	05	219	Deluabati	373
41	61	05	243	Donar	1225
41	61	05	361	Herergati	1121
41	61	05	434	Jamjami	1248
41	61	05	487	Kandarpur	636
41	61	05	698	Molladanga	710
41	61	05	795	Pathalia	480
41	61	05	990	Tuniaghara	1354
41	**61**	**11**		**Chaluahati Union**	**21984**

Geocode				Name of Mauzas	Population
ZL	TH	UN	MAU		
41	61	11	032	Atghara	1704
41	61	11	044	Baje Chaluahati	900
41	61	11	178	Chaluahati	2775
41	61	11	300	Gauripur	1579
41	61	11	308	Ghiba	461
41	61	11	333	Gopikantapur	998
41	61	11	377	Harispur	590
41	61	11	385	Hayatpur	1225
41	61	11	414	Ichani	381
41	61	11	605	Lakshmanpur	990
41	61	11	686	Mobarakpur	2924
41	61	11	771	Panichhatra	344
41	61	11	836	Ramnathpur	1171
41	61	11	844	Rasulpur	1257
41	61	11	848	Ratandia	1547
41	61	11	852	Ratneshwarpur	1334
41	61	11	901	Singher Khajura	621
41	61	11	986	Tripurapur	1183
41	**61**	**16**		**Dhakuria Union**	**21039**
41	61	16	064	Balianpur	491
41	61	16	101	Barpara	992
41	61	16	113	Bhabanipur	383
41	61	16	162	Brahmandanga	1226
41	61	16	166	Brahmanpur	855
41	61	16	182	Champakona	1163
41	61	16	223	Dhakuria	2239
41	61	16	280	Gabkhali	1910
41	61	16	442	Joypur	5028
41	61	16	499	Karerail	315
41	61	16	613	Laukunda	975
41	61	16	812	Protapkati	1666
41	61	16	925	Subalkati	1324
41	61	16	962	Tarua Para	707
41	61	16	970	Telikur	219
41	61	16	994	Uttarpara	1546
41	**61**	**22**		**Durbadanga Union**	**19500**
41	61	22	028	Ashanagar	491
41	61	22	052	Bajitpur	778
41	61	22	077	Bantbila	1519
41	61	22	097	Bara Gharia	1096
41	61	22	158	Biprakona	912
41	61	22	211	Dattakona	1518
41	61	22	251	Durbadanga	2835

Geocode				Name of Mauzas	Population
ZL	TH	UN	MAU		
41	61	22	373	Harina	1175
41	61	22	471	Kajiara	1188
41	61	22	483	Kaminidanga	595
41	61	22	536	Khatuadanga	1649
41	61	22	564	Konakola	953
41	61	22	592	Kusarikona	369
41	61	22	596	Kuskhali	581
41	61	22	726	Narikelbaria	410
41	61	22	775	Parala	1319
41	61	22	950	Shyamnagar	2112
41	**61**	**27**		**Haridaskati Union**	**20725**
41	61	27	040	Bahadurpur	2513
41	61	27	134	Bhomardaha	801
41	61	27	138	Bhulberia	436
41	61	27	194	Chandua	874
41	61	27	231	Diganga	486
41	61	27	365	Haridaskati	2144
41	61	27	389	Hazrail	725
41	61	27	406	Hogladanga	2498
41	61	27	475	Kajirgaon	309
41	61	27	515	Katakhali	1232
41	61	27	568	Koramara	258
41	61	27	576	Kuchlia	1121
41	61	27	588	Kumarsinga (kumar Sima)	460
41	61	27	633	Madhupur	526
41	61	27	718	Nalghona	121
41	61	27	731	Nebuganti	1101
41	61	27	759	Panchbaria	1443
41	61	27	763	Panchkatia	2228
41	61	27	873	Samaskati	803
41	61	27	921	Sreepur	646
41	**61**	**33**		**Hariharnagar Union**	**19616**
41	61	33	093	Barachetla	941
41	61	33	156	Binodkati	242
41	61	33	247	Dumurkhali	1649
41	61	33	263	Enayetpur	1980
41	61	33	320	Goalbari	688
41	61	33	337	Gopmahal Madanpur	164
41	61	33	369	Hariharnagar	1461
41	61	33	467	Kaemkola	892
41	61	33	540	Khatura	1226
41	61	33	560	Kola	414
41	61	33	625	Madanpur	1992

Geocode				Name of Mauzas	Population
ZL	TH	UN	MAU		
41	61	33	629	Madhupur	576
41	61	33	637	Mahadebpur	691
41	61	33	645	Mahatapnagar	458
41	61	33	694	Moktarpur	1695
41	61	33	767	Panchpota	1244
41	61	33	860	Rupaspur	806
41	61	33	865	Sauli	943
41	61	33	958	Tajpur	1064
41	61	33	974	Tentulia	490
41	**61**	**39**		**Jhanpa Union**	**21315**
41	61	39	186	Chandipur	2124
41	61	39	239	Dodaria	516
41	61	39	357	Hanuar	5552
41	61	39	446	Jhanpa	6880
41	61	39	454	Joka	713
41	61	39	479	Kamalpur	821
41	61	39	523	Khalia	1204
41	61	39	657	Mallikpur	978
41	61	39	670	Manoharpur	1341
41	61	39	897	Sholakhada	1186
41	**61**	**44**		**Kashimnagar Union**	**12082**
41	61	44	020	Arazi Gayespur	139
41	61	44	304	Gayespur	323
41	61	44	324	Goal Para	517
41	61	44	410	Humatala	606
41	61	44	418	Itya	2612
41	61	44	503	Kashimnagar	1778
41	61	44	548	Khojalipur	602
41	61	44	580	Kulipasha	594
41	61	44	682	Mathurapur	1146
41	61	44	710	Nadra	1288
41	61	44	735	Nebugati	648
41	61	44	820	Rahmatpur	16
41	61	44	905	Sirili	421
41	61	44	909	Sirili Madanpur	949
41	61	44	938	Sundra	443
41	**61**	**50**		**Khanpur Union**	**20392**
41	61	50	060	Baliadanga	1699
41	61	50	121	Bharatpur	3525
41	61	50	316	Ghugudaha	598
41	61	50	328	Gopalpur	2119
41	61	50	527	Khanpur	7035
41	61	50	621	Machna	3894

Geocode				Name of Mauzas	Population
ZL	TH	UN	MAU		
41	61	50	804	Phedaipur	783
41	61	50	978	Tentulia	739
41	**61**	**55**		**Kheda Para Union**	**21930**
41	61	55	105	Basantapur	400
41	61	55	190	Chandpur	794
41	61	55	235	Dighirpar	1544
41	61	55	284	Galdaha	2605
41	61	55	296	Garibpur	353
41	61	55	402	Helanchi	1996
41	61	55	422	Jalalpur	777
41	61	55	450	Jogipol	457
41	61	55	462	Kadambaria	1020
41	61	55	511	Kashipur	3876
41	61	55	532	Kharinchi	1712
41	61	55	544	Kheda Para	2855
41	61	55	572	Krishnabati	1094
41	61	55	653	Majhiali	754
41	61	55	661	Mamudkati	1313
41	61	55	816	Raghunathpur	580
41	**61**	**61**		**Kultia Union**	**15415**
41	61	61	008	Alipur	927
41	61	61	016	Amajhuta	969
41	61	61	024	Arsingari	352
41	61	61	048	Bajekultia	346
41	61	61	203	Dahakula	1009
41	61	61	207	Danga Mahishdia	1458
41	61	61	276	Gabardanga	325
41	61	61	381	Hatgachha	804
41	61	61	584	Kultia	1223
41	61	61	601	Lakhaidanga	784
41	61	61	649	Mahishdia	581
41	61	61	747	Padmanathpur	812
41	61	61	783	Pariali	1573
41	61	61	808	Poradanga	2038
41	61	61	889	Satgati	686
41	61	61	930	Sujatpur	1528
41	**61**	**67**		**Manirampur Union**	**26141**
41	61	67	056	Bakaspol	1934
41	61	67	142	Bijoyrampur	3160
41	61	67	215	Debidaspur	1455
41	61	67	255	Durgapur	3173
41	61	67	272	Faytabad	654
41	61	67	288	Gangra	850

Geocode				Name of Mauzas	Population
ZL	TH	UN	MAU		
41	61	67	345	Hakoba	1712
41	61	67	426	Jaljhara	3004
41	61	67	458	Juranpur	1260
41	61	67	641	Mahadebpur	1659
41	61	67	666	Manirampur	1468
41	61	67	690	Mohanpur	1445
41	61	67	791	Patan	443
41	61	67	913	Solapur	457
41	61	67	917	Sonadanga	275
41	61	67	942	Swarupdaha	388
41	61	67	954	Taherpur	1539
41	61	67	982	Thatkamalpur	1265
41	**61**	**72**		**Manoharpur Union**	**10262**
41	61	72	117	Bhabanipur	646
41	61	72	495	Kapalia	2529
41	61	72	519	Khakundi	1569
41	61	72	674	Manoharpur	5075
41	61	72	828	Rajipur	443
41	**61**	**78**		**Maswimnagar Union**	**24237**
41	61	78	125	Bharatpur	477
41	61	78	170	Chakla	4336
41	61	78	341	Hakimpur	997
41	61	78	393	Hazrakati	2931
41	61	78	491	Kanthaltala	855
41	61	78	552	Kismat Chakla	864
41	61	78	609	Lakshmikantapur	499
41	61	78	678	Maswimnagar	2690
41	61	78	743	Noali	2383
41	61	78	787	Parkhajura	6008
41	61	78	840	Rampur	1577
41	61	78	877	Samserbagh	620
41	**61**	**83**		**Nehalpur Union**	**11089**
41	61	83	069	Balidaha	3013
41	61	83	739	Nehalpur	4295
41	61	83	755	Panchakari	3781
41	**61**	**89**		**Rohita Union**	**23109**
41	61	89	036	Baghdob	1223
41	61	89	109	Basudebpur	1948
41	61	89	268	Erenda	1997
41	61	89	292	Gangulia	1338
41	61	89	430	Jalkar Rohita	1061
41	61	89	507	Kashimpur	1138
41	61	89	556	Kodla Para	2089

Geocode				Name of Mauzas	Population
ZL	TH	UN	MAU		
41	61	89	706	Muragachha	1268
41	61	89	722	Naoa Para	641
41	61	89	751	Palashi	1665
41	61	89	800	Pati	973
41	61	89	824	Rajbari	1030
41	61	89	856	Rohita Basudebpur	2134
41	61	89	881	Sharanpur	1050
41	61	89	885	Sharashkati	1713
41	61	89	893	Selamatpur	1841
41	**61**	**94**		**Shyamkur Union**	**27123**
41	61	94	004	Agarhati	1260
41	61	94	012	Aminpur	2149
41	61	94	073	Bangalipur	1174
41	61	94	198	Chinadula	1036
41	61	94	227	Dhaligati	685
41	61	94	259	Durgapur	357
41	61	94	312	Ghughurail	1431
41	61	94	349	Halsa	580
41	61	94	353	Hasadanga	2192
41	61	94	438	Jamla	1300
41	61	94	617	Lauri	3578
41	61	94	702	Mujgunni	2649
41	61	94	714	Nagarghop	334
41	61	94	779	Pardia	1229
41	61	94	832	Ramnagar	1076
41	61	94	869	Said Mamudpur	397
41	61	94	934	Sundalpur	941
41	61	94	946	Shyamkur	4512
41	61	94	966	Teghari	243

Source: BBS (1992)