2 8 2 Outline of Water-related Agencies

(1) National Water Resources Council (NWRC)

The National Water Resources Council is the highest national body on all water policy issues, including coordinating all aspects of water management, resolution of inter-agency conflicts, and adaptation of common standards for the water sector The NWRC has an executive committee that issues directives to water management institutions The council is headed by the Prime Minister and the executive committee is headed by the Minister of Water Resources The Council is coordinating over 40 agencies and at least 13 different ministries involved directly or indirectly in the water sector

(2) Ministry of Water Resources (MOWR)

The Ministry of Water Resources is the apex body regarding the water resources sector of the country The Minister is the head of the Ministry and appointed by the Prime Minister The Secretary is the administrative head of the Ministry There are a number of implementing agencies under the ministry One of the principal mandates of the ministry is to provide administrative control, overall strategic planning, budgetary provision, expenditure control, establishment management and monitoring of the line agencies The Ministry also works on policy formulation All projects and procurements planned by the line agencies must be approved by the Ministry. The Ministry also has the authority to approve funds for goods and services procurement from 10 million to 100 million taka It may be noted that procurement less than 10 million taka can be approved by the line agency and over 100 million taka must be approved by the National Economic Council (NEC) The line agencies of MOWR are presented in **Figure 2.8.1** and their mandates briefly outlined in the **Supporting Report**.

2 8 3 Water-related Law and Regulations

(1) National Water Policy

The National Water Policy is the umbrella policy for the water sector The National Water Policy was prepared by the MOWR and enacted in 1999, with the intention of guiding both public and private actions for ensuring optimal development and management of water

According to this policy, ownership rests with the State and the users are accorded certain rights. The policy provides provision to regulate water use in areas of scarcity, to protect downstream users and to confer secure, defensible and enforceable water rights on private and community bodies The Policy also mentions the priority ranking for the water rights In general, the priority for allocating water during critical periods in the water shortage zones will be in the following order domestic and municipal uses, non-consumptive uses (like navigation, fisheries, and wild-life), sustenance of the river regime, and other uses (like irrigation, industry, environment, salinity management, and recreation) Regarding the institutional setup, the Policy states that there should be separation of policy, planning, and regulatory functions from implementation and operational functions

(2) National Water Management Plan (NWMP)

The National Water Management Plan was prepared by WARPO and the draft final was completed in December 2001, and is available at WARPO's website (www warpo.org) The Plan in now under active consideration by the National Water Council for approval The Plan was prepared with the intention of operationalising the directives given by the National Water Policy The Plan is a framework plan within which line agencies and other organizations are expected to plan and implement their own activities in a coordinated manner It is proposed that NWMP will be reviewed and updated every five years The Plan is presented in three phases in the short-term (2000-2005) it is considered as a firm plan of ongoing and new activities, in the medium term (2006-2010) it is an indicative plan, and in the long term (2011-2025) a perspective plan

Though there are broad guidelines on flood forecasting, there is no specific framework or project outlined on flood forecasting in the NWMP

(3) National Water Code

It is now under preparation to align with the Policy requirement It will review and consolidate the laws governing ownership, development, appropriation, utilization, conservation, and protection of water resources WARPO is now preparing a draft However, it is not known exactly when this will be enacted In this law, among other things, there should be clear demarcation about the protected land requirement on both sides of the river

2.8 4 Bangladesh Water Development Board (BWDB)

(1) Institutional Setup

Originally established in 1959 as the Water Wing of the East Pakistan Water and Power Development Authority, the organization was restructured in 1972 as BWDB and its mandate is set to water resources development It planned and executed 625 projects till June 30, 2002 throughout the country including flood control, dredging, drainage, irrigation, town protection, coastal protection, erosion control, and land reclamation (Annual Report, 2001-2002, BWDB)

Bangladesh Water Development Board Act, 2000 redefines the power and functions of the BWDB

Power and responsibility

- Control surface water flows and underground aquifers
- Develop standards and guidelines for O&M

- Procure plant, equipment and ancillary material
- Procure advisory and consultancy services
- Levy and collect service charges for O&M and cost recovery
- Undertake the execution of any water-related project

Functions

- Construction of dams, barrages, reservoirs, embankments, regulators, etc for river development, flood control, drainage, irrigation and drought prevention
- Dredging, re-excavation and desilting of water channels
- Soil preservation, land reclamation and estuary control
- River training and river bank protection
- Construction and maintenance of coastal embankment
- Prevention of salinity intrusion and desertification
- Rainwater harvesting
- Flood and drought forecasting and warning
- Hydrological survey and investigation
- Forestry and fishery development
- Basic and applied research
- Development of water users' and other stakeholders' associations

The National Water Policy of 1999 made the following stipulations about the mandate and structure of BWDB (Annual Report, BWDB, 2000-2001)

- Emphasizing the separation of policy functions from those of operation and management
- Confining BWDB's planning function to sub-regional and local levels only (WARPO will be the exclusive agency for macro level water resources planning)
- Making BWDB responsible for execution of projects above 1000 ha, leaving the development of small-scale projects to local bodies
- Proposing management transfer of small and medium scale projects to beneficiaries
- Emphasizing the involvement of stakeholders at all stages of the project cycle.

(2) Manpower

Until recently there was a staff of around 18,000 in BWDB A re-organization was ordered in 1998, where the total staff strength was set at 8,860 Total staff strength is being reduced through progressive retirement by natural attrition and it is now 9,706 (June 30, 2002) It was 10,069 on June 30, 2001. It is expected that by 2006, the re-organization process will be completed The staff composition as per re-organization is shown below It is to be noted that support staff number is about 3 times the number of professional staff

(3) Organizational Structure

BWDB is an autonomous body under the MOWR. Under recent reforms, policy functions are vested in a Governing Council and the Board's activities are now confined to executive and operational functions only

There is a 13 member Governing Council of BWDB, headed by the Minister of Water Resources The main function of this Council is to give advice on the board's policy, planning, and operation The other members of the Council are secretaries of four ministries, namely water resources, finance, local government, and environment, Director Generals of BWDB, and WARPO, two Government-nominated water specialists, one NGO representative, one chartered accountant, and two beneficiary representatives

The Director General (DG) is the Chief Executing Officer of BWDB. There are five wings each headed by Additional Director Generals (ADG), in charge of administration, finance, planning, O&M-1 and O&M-2 Under the ADG (Planning), there are Chief Planning, Chief Engineer Design, and Chief Engineer Hydrology. Flood forecasting comes under Chief Engineer Hydrology

The organizational structure of BWDB focusing on flood forecasting and warning services is given in **Figures 2.8.2** and **2.8.3**

(4) Institutional Strength of BWDB

With a long history of water resources management, BWDB has developed significant institutional strength over the years, such as.

- Staffed with experienced and skilled manpower
- Country-wide network
- Ample experience of project planning, design, implementation and operation
- Computerized accounting system
- Specialized units like flood forecasting, hydrology, dredging and others

(5) Human Resources Development of BWDB

BWDB is an engineering based organization Officers are firstly recruited at the level of Assistant Engineer and are provided with basic training at the Central Training Academy of BWDB Afterwards, demand-based short specialized training is provided.

Hydrology, particularly flood hydrology, is a specialized subject It is essential to provide routine and specific training to staff working in this field However, at present, there is no provision for continuing education and advanced training

BWDB practices periodic rotation of duties for its staff Hydrology service, as part of BWDB, also comes under this rule. It often occurs that a staff member who has never been exposed to hydrology service is transferred to Hydrology at a managerial post This can create some problems

(6) Budget Allocation

The budget of BWDB is divided into revenue and development The revenue budget includes establishment (salary, office maintenance), non-development (repair, O&M) and loan repayment The development budget is for implementation of new projects. The budgets of BWDB for the last few years are as follows

Budget Allocation for BWDB

Unit: Million Taka

Year	Revenue Budget	Development Budget			Grand Total
		GOB	Donor	*Total*	
1995-96	2,677 6	2,528 1	3,774 2	*6,302 3*	**8,979.9**
1996-97	2,619 9	3,319 7	5,262.7	*8,582 4*	**11,202.3**
1997-98	2,188 4	3,498 0	5,442 5	*8,940 5*	**11,128.9**
1998-99	2,408 1	4,041.8	6,750 9	*10,792 7*	**13,200.8**
1999-00	2,944 5	5,331.4	5,391.5	*10,722 9*	**13,667.4**
2000-01	3,133 4	5,520 1	4,357 5	*9,877 6*	**13,011.0**
2001-02	2,886 0	5,338.7	2,524 3	*7,863*	**10,749.0**

Source Annual Reports, 2000-2001, and 2001-2002, BWDB

In 2000-2001, development allocation was for 87 on-going projects of which 81 were investment projects and 6 were technical assistance projects In 2001-2002, the development program consisted of 98 projects, of which 92 were investment projects and 6 were technical assistance projects

It should be noted that the development budget of BWDB for 2001-02 was reduced considerably compared to that for 1998-99

Yearly revenue budget allocation for PFFC for the last 4 years is given below.

Breakdown of the Budget Allocation for PFFC

Unit: Lakh Taka

Year		Circle[1)]	C&I	FFWC	SWPB	RMPB	GWPB	Total
1999-2000	Revenue[2)]	35.4	150 0	19 6	15.0	NA	16 6	NA
	Non-Dev	4 5	49.8	6 0	6.0	2 0	7 0	75 3
	Total	*39 9*	*199 8*	*25 6*	*21.0*	*NA*	*23 6*	*NA*
2000-2001	Revenue	40 4	147 0	29 3	27 8	8 3	23 9	276 7
	Non-Dev	71.0	72 6	7 0	6 8	4 0	8 0	169 4
	Total	*111 4*	*219 6*	*36 3*	*34 6*	*12.3*	*31 9*	*446 1*
2001-2002	Revenue	34 0	162 0	29.1	31 8	8 1	22 5	287.5
	Non-Dev	36 0	88.3	6 0	5 5	4.0	7 0	146 8
	Total	*70.0*	*250 3*	*35 1*	*37 3*	*12 1*	*29.5*	*434 3*
2002-2003	Revenue	33 4	170 0	NA	31 1	8 0	18 3	NA
	Non-Dev	13 5	79 8	6 5	5 5	4 0	7 0	116.3
	Total	*46 9*	*249.8*	*NA*	*36 6*	*12 0*	*25 3*	*NA*

Source PFFC

Notes 1) The budgets for 'Index and Publication Branch' and 'Management and Services Branch' are included in that of circle
2) Revenue budget of PFFC is equivalent to establishment (salary, office maintenance) budget

The non-development revenue budgets of the 4 circles under the Hydrology service in 2000-2001 and in 2001-2002 are as follows

Non-development Budgets of Four Circles under the Hydrology Service

Unit lakh Taka

Circle	2000-2001	2001-2002
PFFC	170 68*	146 87
SWHC	137 35	108 25
GWHC	52 00	57 3
RMRC	52 00	54 25

Note*: The figure of PFFC's non-development revenue budget for 2000-2001 is different from that shown in the table 'Breakdown of the Budget Allocation for PFFC' above This is minor or rounding error according to PFFC staff

2.8 5 Flood Forecasting and Warning Center (FFWC)

This center was established within BWDB in 1972. The principal functions of this center are,

- data collection from field stations,
- data collection from other relevant agencies like BMD and SPARRSO,
- flood forecast model operation,
- flood warning issue, and
- operating 'Flood Information Center' during flood period (from May to October 15).

FFWC is headed by an Executive Engineer There are in total 9 engineers working in the center

During the wet season, FFWC issues a Daily flood bulletin, Special flood bulletins, Monthly flood bulletins, Annual flood bulletins and Flood mapping During the dry period, FFWC issues a weekly Low Water Monitoring Report

FFWC sends their bulletins to the Prime Minister's office, various government departments, media, district administrations (partially), and BWDB divisional offices (partially) Mode of information dissemination is fax, telephone, email and, more recently, through website (www ffwc net)

CHAPTER 3 CURRENT FLOOD FORECASTING AND WARNING SERVICES

3.1 History of FFWS Development in Bangladesh

The flood forecasting and warning services in Bangladesh commenced in 1972 when the Flood Forecasting and Warning Center (FFWC) was established under BWDB. The center has now operated for in excess of 30 years.

Initially, ten real-time flood monitoring stations were established and flood forecasts were based on gauge-to-gauge correlation analysis and the Muskingum-Cunge flood routing model. During the period between 1989 and 1994, a hydrological and hydraulic approach was applied under the FAP10 project 'Expansion of Flood Forecasting and Warning Services' financed by DANIDA. In this project, the MIKE11 modeling technique (refer to **Section 3.5**) was applied and 16 water level forecasting points were established for its operation. During the period between 1995 and 1999, another DANIDA project was conducted. Achievements included 1) development of MIKE11 supermodel with GIS, 2) expansion of water level forecast points from 16 to 30, 3) arrangement of flood warning manual, and 4) staff training for the operation of the flood forecasting model.

In 2000, a further DANIDA-funded project 'Consolidation and Strengthening of Flood Forecasting and Warning Services (CSFFWSP) Phase-II' was launched. The planned main outputs are:

1) expansion of flood forecast to all flood prone areas in Bangladesh (forecasting points to be increased to 50),
2) improvement of accuracy and lead time of the forecasting model,
3) improvement of dissemination,
4) technology transfer, and
5) making suggestions for establishment of sustainable institutions.

This DANIDA project is scheduled to be completed in the middle of 2005.

At the same time, current FFWS in Bangladesh is associated with Environment Monitoring Information Network (EMIN), Community Based Flood Information System (CFIS), and Climate Forecast Application in Bangladesh (CFAB) study projects.

3.2 Overall FFWS in Bangladesh

3.2.1 General

As a result of the abovementioned projects, Bangladesh now has in place a FFWS comprising:

- An observation network of real-time water level and rainfall stations extending over much of the country coupled with a data transmission network for the transfer of this information to FFWC in Dhaka.

- A hydraulic flood model (MIKE11) linked with rainfall-runoff and flood forecasting modules for the evaluation of flood levels (developed by Danish Hydraulic Institute, DHI) Referred to as the Supermodel, this is now installed at the FFWC and is operated through the flood season (from 1 May to 15 October)
- Flood Warning Bulletins issued daily during the flood season and dissemination of flood warnings by the FFWC to the relevant authorities. These bulletins incorporate both real-time flood level information based directly on the water level observation network, results from the flood forecasting analyses for the prediction of future flood levels, and details on observed rainfalls
- Flood evacuation plans aimed at minimizing both damage and loss of life through direct utilization of this information
- Monthly and annual flood reports are regularly published and distributed

In this JICA Study, FFWS is considered to comprise five major components, namely;

1) Observation System,
2) Data Transmission System,
3) Analysis System,
4) Dissemination System, and
5) Response System

Among these components, BWDB and FFWC are responsible only for observation, data transmission, analysis and a part of the dissemination systems. These are outlined in **Figure 3.2.1** Other parts of the dissemination system and overall response system are, in principle, controlled by line-agencies of the Ministry of Disaster Management and Relief (MDMR) and local government authorities

In this Chapter, present conditions of the existing system, problems encountered in its operation and conceivable solutions to address these issues are outlined and explained for each of the major components For ease of understanding, the current status of the FFWS and problems encountered are summarized in **Table 3.2.1**

In addition, organizational and institutional matters related to the existing FFWS are also described.

3.2.2 Existing Telemetric Network

(1) Current Status

In 1985 and 1996 the Government of Bangladesh established a telemetric system using Japanese debt relief funding It comprised 14 automatic hydrometeorological observatories, 5 repeater stations and 1 control office in Dhaka Although the purpose of its installation was to improve the service and performance of flood forecasting and warning services, the basis of the installation plan is unclear as documents describing the planning or design basis are not available

As discussed below, a large part of the system is no longer operational due both to natural causes (erosion, sedimentation etc) and limitations of the existing telecommunication system In September 2003 only 5 out of the original 14 telemetric gauging stations were continuously transmitting data to the control office of the FFWC. The status of the existing telemeter system is tabulated below

Status of Existing Telemeter System as of September 2003

No	Location	Year of Installation	Present Condition	Notes
1	Tongi / Dk	1996	Under repair	
2	Mirpur / Dk	1996	Working	
3	Rekabibazar /Dk	1996	Working	
4	Mill Barak / Dk	1996	Being shifted Operational in Sep ,2003	Will complete soon
5	Nayarhat / Dk	1996	Working	
6	Narayanganj /Dk	1996	Working	
7	Jatrapur	1996	Not working	WL gauge pipe destroyed
8	Pankha	1996	Not working	River course shifted
9	Sherpur	1985	Not working	Partially repaired in 1996
10	Shayestaganj	1996	Not working	Equip shifted to Dhalai
11	Dhalai	1985	Under Repair Operational in Sep	Equip shifted from Shayestaganj
12	Monu	1996	Partially working Operational in Sep., 2003	Transmission problem, under investigation
13	Kamalganj	1985	Not working.	Partially repaired in 1996, under repair
14	Zakiganj	1996	Not working	No repeater connection

According to PFFC, the number of functional telemetric gauging stations will increase to 9 in the near future Servicing will include use of functioning parts of those stations in a state of total disrepair and spare parts stored in PFFC. However, considering that the equipment was initially installed in either 1985 or 1996, it is now largely outdated and it is unlikely that many of these stations would be integrated into the existing FFWS

(2) Cause of Inadequate Situation of Existing Telemeter System

As the cause of dysfunction of a number of telemeter equipment, BWDB listed up many items as discussed in the following sections Based on the opinions of BWDB and the results of the inspections and reconnaissance conducted by the Study Team, the cause of this inadequate situation of existing telemeter system can be summarized as follows:

- Since the existing system has its own database format, which is not compatible with existing flood forecasting analysis system, manual input of the telemetric data into the analysis system is necessary
- Due to frequent disconnection of BTTB's lease lines, the stability (sureness) of data acquisition is considerably insufficient
- As a result, the data transferred through two different systems (manual and telemeter) should be input by single method (manual input) if the existing telemetric data is to be incorporated in the existing analysis system.
- It is much easier to apply a single system from the viewpoint of data management and daily operation

- The motivation of the proper maintenance of the existing telemeter system is therefore not developed

The Study Team considers that the above cycle causes the improper situation of current telemeter system.

(3) Utility Value of Existing Telemeter Equipment

Taking the above into consideration, incorporation of the existing telemetric equipment or facilities into FFWS improvement plans is not assumed. Detailed assessments of the causes of failure of the existing telemeter system are nonetheless discussed in the following sections in relation to proposals for the effective planning of an improved FFWS

It is recommended that those existing telemetric facilities/equipment are used continuously not for the purpose of real-time data collection but for the purpose of verification of the quality of manually observed data to be collected for the FFWS purposes

It is also recommended that the parts available from the equipment which is out of order are kept by BWDB as spare for the repair of remaining ones

(4) Necessary Measures for Effective Use of Newly Installed System

A system with function of automatic data input is proposed in this Study taking the current analysis system into account (refer to succeeding Chapters) Considering the situation described above, following measures should be undertaken by BWDB in order to secure the effectiveness of the system to be proposed in this Study

i) Provision of Incentive/Motivation for Repair and Maintenance

The necessity and importance of the observation system should be understood by all of the staff concerning FFWS Accurate and timely flood forecasting information cannot be provided without acquisition of accurate and timely hydrometeorological information The staff should understand this and sufficient manpower and budget should be allocated for the operation and maintenance activities

ii) Training of Technical Staff

Advanced knowledge may be necessary for making proper repair and maintenance of sophisticated mechanical equipment. Other than the technology transfer to be provided by manufacturer etc, the technology exchange within BWDB is also important. The leaders of the C&I division, which is in charge of repair and maintenance of mechanical equipment, should understand basic knowledge of those equipment and transfer the know-how to their colleagues frequently Since the knowledge of mechanics is widely applicable for other fields too, the cultivation of this may be welcomed

3.3 Observation System

3.3 1 General

The current observation system mainly comprises

- hydrometeorological records inside Bangladesh obtained at selected gauging stations,
- hydrometeorological records outside Bangladesh transmitted from India,
- radar images obtained by the BMD radar system, and
- satellite images received at FFWC and transmitted from SPARRSO.

The present situation on these items is discussed below.

3 3.2 Number and Location of Gauging Stations in Bangladesh

As outlined in **Section 2.4**, an extensive network of water level and rainfall stations is currently operated by BWDB However, data from the majority of sites are initially retained in the regions and forwarded to the central office in Dhaka only on a monthly (or longer) basis.

To satisfy requirements for the FFWS and also provide direct flood level information on a real-time basis, a network of manually observed hydrometeorological stations has been established and progressively expanded. According to the information provided by FFWC, the present network comprises

- 91 water level gauging stations observed five times daily at three hourly intervals from 0600 to 1800 hours, and
- 56 rainfall gauging stations observed at 0900 hours daily defining rainfall over the previous 24 hours

Their locations are shown on **Figure 3.3.1**

Data from all sites are to be transmitted to FFWC around 0900 daily using either a wireless system or mobile/fixed telephones

According to 'Guide to Hydrometeorological Practices' published by the World Meteorological Organization (WMO), the minimum densities of rainfall observation networks recommended for general hydrometeorological purposes are

a For flat regions of temperate, Mediterranean, and tropical zones, 600 to 900 km^2 per station

b For mountainous regions of temperate, Mediterranean, and tropical zones, 100 to 250 km^2 per station

c. For small mountainous islands with irregular precipitation, 25 km^2 per station

d For arid and polar zones, 1,500 to 10,000 km^2 per station

There are currently 269 rainfall gauging stations under the management of BWDB. Of these, 56 stations are currently utilised for flood forecasting and warning purposes With a total land area for Bangladesh of 147,000 km^2 the densities of the BWDB and FFWC networks are 546 km^2 and 2,625 km^2 per station respectively

Compared with the WMO standard, the density of BWDB network meets the demand considering that Bangladesh is categorized within area 'a' of the above climatologic/topographic classification Although the FFWC network is lower than required by the WMO standard, the number of the rainfall gauging stations operated by FFWC is judged applicable for the following reasons

- One of the main outputs of the FFWS is flood water levels at the selected monitoring/forecasting points. This is dominated not only by precipitation over the country but also by precipitation in and inflow from the upstream areas located outside Bangladesh, topographic information, evapotranspiration and so on Since there are many uncertainties between rainfall as an input and water level/discharge as an output, increasing the number of rainfall gauging stations used would not contribute to any significant improvement in the performance of existing FFWS.
- Point rainfall is also one of the important items included in the FFWC outputs Rainfalls in major cities and towns are adequately defined by the existing network, as shown in **Figure 3.3.1** Accurate aerial distribution of the rainfall in less developed areas is not as important as the prompt dissemination of the rainfall data for the major centers (Of course it is very important as a basic hydrometeorological parameter to be accumulated/analyzed but this is adequately met by the more dense BWDB network)

Regarding the number of water level gauging stations, there are no similar standards to those for rainfall gauging stations Appropriate densities should be decided according to the information to be obtained, the kind of planned project, and so on

In the current FFWS, 91 water level stations are adopted from a total of 342 tidal/non-tidal water level gauging stations operated by BWDB In this Study, the number of current real-time water level gauging stations (91) is judged acceptable for the following reasons:

- Locations nearby major cities and towns have been covered by the present FFWC network as shown in **Figure 3.3.1**
- Those locations of importance from hydrological/hydraulic aspects, such as confluence or divergence points on large-scale rivers have been covered.
- Major trans-nation boundary points at the border between Bangladesh and India have been covered
- Major locations at the downstream end of the river system that define boundary conditions for the hydraulic model have been covered.

To further confirm the adequacy of the number of water level gauging stations, additional analyses were also undertaken This was based on a preliminary analysis to define the relationship between the number of gauging stations and forecast accuracy using FFWC's current analysis system Details, presented in the **Supporting Report**, again confirmed that the existing number of water level gauging stations is appropriate

As a result, the location and number of both rainfall and water level gauging stations were confirmed as acceptable in this Study

3.3 3 Current Situation of Domestic Observation System

(1) General

Based on a list of hydrometeorological stations obtained from FFWC, an inventory survey was undertaken during this Study to define location, existing structural condition, likely accuracy of observed data, method of data transmission, condition of associated instrumentation, and so on for each station This included a qualitative assessment of instrumentation and general site conditions (which could influence recording accuracy). A comprehensive set of site photographs was also obtained to assist in assessing the possibility of upgrading specific sites as part of a more comprehensive automatic telemetry network, as discussed below.

A summary of the results of the inventory survey is presented in **Table 3.3.1** and more detailed results are given in **ANNEX-I**

(2) Manual Observation System

Overall, the following points should be noted:

a. Rainfall Gauging Stations

The majority of stations are fully operational and instrumentation is in good order However, distance from the gauge to surrounding structures or vegetation is considered insufficient at approximately 50% of the sites.

b Water Level Gauging Stations

The majority of sites are in good condition

During the flood season, data are forwarded to FFWC at around 0900 hours daily by wireless or mobile phone/fixed telephone from some 74 stations. During the remainder of the year (dry season), information is sent by courier or post

It was noted during field visits that only a single gauge plate is generally used at most sites (68 stations). This must be periodically moved to allow observations to continue throughout the year BWDB indicated that it is not possible to install a series of gauges at these sites to cover the entire water level range. This is due to large variability in river thalweg (the river course can change substantially from year to year or from flood to flood) and general instability of the river channel and embankments. Although a permanent gauge would be preferable, the BWDB confirmed that at all stations the gauge plate is resurveyed after each re-installation based on the local benchmark (BM)

However, the inventory survey revealed that the distance between the BM (or temporary TBM) and manual gauge location is rather long in many stations subject to gauge shifting It is therefore recommended to transfer the BM or TBM closer to the gauge locations so that gauge shifting can be done more effectively and accurately

(3) Automatic Observation System (Non-telemetric Stations)

Locations of the automatic gauging stations are illustrated in **Figure 3.3.2**. A general summary of the automatic stations and their current status is presented in **Table 3.3.1** Based on the inventory survey, the following comments are made

a Rainfall Gauging Stations

All stations are of the tipping bucket recorder type Of the 15 stations installed, only 5 remain operational The main reasons for non-functioning of these stations are related to equipment failure (clocks, piping and so on) Lack of spare parts or expendables such as recording charts is also a concern to the operators

b Water Level Gauging Stations

All stations are installed with float-wells except for one site (Bandarban) that has a pressure transducer

Of the 17 stations, only 5 were operational during the inventory survey An additional 3 were stated by the gauge readers to be mechanically in good order but river levels were below their respective intakes

Primary reasons for failure of the remaining 9 stations include bank erosion or flood damage causing structural failure and/or siltation of the inlet pipes. At 10 stations, bridges either exist or are under construction Gauges are, however, constructed on bridges at only 2 of these sites

Overall, lack of sufficient operation and maintenance has resulted in the majority of automatic stations no longer functioning

(4) Telemetric Observation System

A more detailed outline of the status of the existing telemetry network is presented in **Table 3.3.2**

Among the existing 14 telemetric stations, 5 stations were established in the mid-1980s in the north-east region of the country (comprising both automatic rainfall and water level recorders) The remaining 9 stations were installed in 1996, predominantly around Dhaka and at the international boundaries on the Padma and Jamuna Rivers. The locations of the stations are shown on **Figure 3.3.2**.

Of those stations installed in the initial programme in the mid-1980s, none continue to transmit data to the FFWC The primary reason is related to failure of the data transmission system and associated equipment.

To date, information from the existing telemetry system has not been utilized in flood forecasting or flood monitoring The reasons given by FFWC are:

- data for a number of the stations are not available,
- accuracy of the telemetered data has not been verified, and
- there is no interface between the telemetered data and the analysis system

(5) Discussions

Manual Observation System

Overall, the existing manually operated hydrometeorological network provides a satisfactory coverage for use in the FFWS The inventory survey indicated all stations incorporated in the flood warning system are generally in good condition apart from those problems related to

- the need to periodically shift the gauge plate at most sites, and
- poor clearance at a significant number of rainfall gauges.

For the former, it is recognized that this cannot be avoided at many locations. Consideration should therefore be given to installing the gauges at any permanent structures that may exist at least at high water levels This would involve installing gauge plates in the following manners·

- installing on existing embankments,
- extending inclined railings with gauge plates attached on embankments similar to the Rajshahi water level station, or
- transferring gauge plates to nearby bridges

Automatic Observation System

The major problems are associated with operation of both the network of automatic stations plus the existing telemetry network The majority of stations (both water level and rainfall) are in poor working condition with many not operating at all

Ongoing operation and maintenance are therefore a major concern. Sufficient funding is essential if the existing network and any proposed expansion are to be maintained For the automatic and telemetry water level stations, a number have also failed during large floods, highlighting the need to install stations at more permanent locations whenever possible Finally, at a small number of sites river levels during the dry season fall below the intakes of the gauges. Although this should not affect recording during higher flows, low flow information, essential for water resource management, is not recorded

Transmission of data from the manually operated network occurs daily during the flood season as required and reviews of the FFWC (and BWDB) database indicate the procedures implemented to verify the voracity of data at the FFWC ensures its general accuracy Nonetheless, manual entry is time consuming and increases the possibilities of additional errors being made during this process Digital transmission of manually observed data should therefore be considered with checking then being fully computerized

3 3 4 Quality of the Data Stored in FFWC's Database

(1) General

According to FFWC staff, one of the major problems affecting their operations is unreliability of water level data transmitted from the manual observatories Based on the hydrometeorological data collected by FFWC, the quality of the data was assessed As indexes of this data quality, 1) percentages of missing data and 2) percentages of doubtful data were evaluated.

(2) Percentages of Missing Data

Based on the FFWC database, missing data represent some 16 2% and 13 5% of the total data required through the monsoon (May – October) and flood (June – September) seasons respectively.

The numbers of observatories with less than 10% missing data were 56 for the monsoon season and 65 for the flood season

According to FFWC, the main factors causing missing data are as follows

- Telecommunications problems such as interference, malfunction of wireless equipment etc
- Human factors of the gauge reader or wireless operator such as idleness, urgent business, sickness etc
- Problems with the manual staff gauge such as its being washed away, stolen, vandalised etc
- Budget shortages for the employment of gauge reader or wireless operator

(3) Percentages of Doubtful Data

The following two types are considered as typical examples of doubtful data

- Type 1 Data sample whose value differs considerably from those around it
- Type 2 Data sample whose value is exactly the same as those around it

Based on the FFWC database for the period from May to October, "types 1 and 2" errors were evaluated for each observatory The result is summarized in the table below showing the percentage of doubtful data by flood type and by requirement of the current forecasting model It should be noted that the data assessed by the Study Team had already been previously checked and corrected, if necessary, by FFWC as part of their standard data input procedure

Percentage of Doubtful Data

Flood Type	Model Requirement	Total Number of Data Samples	Percentage of Type 1 Doubtful Data Samples (%)	Percentage of Type 2 Doubtful Data Samples (%)
Normal (Monsoon)	Required	155,118	0 016	9.5
	Not Required	85,726	0 024	12.6
Total of "Normal (Monsoon)"		*240,844*	*0 019*	*10 6*
Flash	Required	72,841	0 037	6.3
	Not Required	34,519	0 104	6.1
Total of "Flash"		*107,360*	*0 059*	*6 2*
Tidal	Required	15,358	0 026	0.0
	Not Required	21,997	0 068	0.4
Total of "Tidal"		*37,355*	*0 051*	*0 2*
Total of Observatories with Model Requirement		243,317	0 023	8 0
Total of Observatories without Model Requirement		142,242	0 051	9.1
Total of All Observatories		**385,559**	**0.033**	**8.4**
Maximum among the Observatories*			***0.302***	***23.5***

Note* The percentages shown in the marked row are the highest ones among the observatories

From the above the following conclusions can be drawn

- As a whole, the percentage of "type 1" doubtful data is small (about 33 for one lakh samples). This indicates such errors are readily observed and corrected by FFWC staff during the manual data checking procedure
- Among flood types, the percentage of "type 1" doubtful data is remarkably small in those areas subject to monsoon flood compared to flash and tidal flood areas Again such errors are readily identified for the monsoon flood area during preliminary data checking because of the relatively smooth changes in water level fluctuation
- When comparing data for those stations required or not required for modeling, the percentage of "type 1" doubtful data for those stations required is less of that for those stations not required It appears more careful checking is undertaken of data for those stations required for modeling
- As a whole, the percentage of "type 2" doubtful data is large. This may be due to difficulties in identifying and confirming the data are actually in error, particularly for stations in monsoon flood areas.
- The percentage of "type 2" doubtful data is high for stations in flash flood areas This may also indicate difficulties in identifying and confirming errors of this type for data recorded at stations in these areas
- In tidal affected areas, the occurrence of "type 2" doubtful data is rare
- Comparing percentages for those stations required for the modeling, the percentage of "type 2" doubtful data does not decrease much even if more careful data checking is conducted.

3 3.5 Hydrometeorological Record outside Bangladesh

There is an agreement between Bangladesh and India that mentions hydrometeorological data exchange for flood forecasting and warning purposes This was originally concluded in 1972 through the arrangement of the Joint Rivers Commission (JRC) in both Dhaka (Bangladesh) and New Delhi (India) At present, data from 20 observatories located in India are transferred to Bangladesh through BMD's wireless communication or point-to-point direct communication systems (refer to **Section 2.4**)

As shown in **Figure 2.4.10**, all water level stations whose records are available in India are located within 100 km upstream from the international border with Bangladesh Moreover, there is a regulation for the data transmission for 14 stations (excluding the 6 'point-to-point' stations) that

- water level and discharge data are reported to Bangladesh only if the water level reaches or exceeds the warning level set at 1 m below danger level, and
- rainfall data are reported to Bangladesh only if the rainfall amount exceeds 50 mm/day

Due to these limitations and regulations, sustainable use and incorporation of hydrometeorological data from Indian observatories in FFWC's current system are not possible In 1996 the FFWC through the JRC Bangladesh outlined to the Indian authorities a means of improving flood-related data exchange In this proposal Bangladesh, or FFWC, requested:

- continuous data transfer during the monsoon season (May 15 – Oct. 15),
- data transfer from additional Indian observatories, and
- provision of river cross-section data of the Ganges, Brahmaputra, Teesta and Barak Rivers

The outline of the proposal is illustrated in **Figure 3.3.3**

However, the proposal has not yet been accepted by the Indian side This is possibly because the level of improvement in results of the FFWS in Bangladesh due to the availability of this information was not adequately or fully explained to the Indian authorities.

3 3 6 Radar and Satellite Image

Radar and satellite images are available at FFWC as supporting information for flood forecasting and warning activities Although they are not directly utilized for flood forecasting analysis at present, the information is useful when FFWC makes some assumption or estimation on current and future rainfall amounts or estimation of future boundary conditions in the hydraulic simulation model used in flood forecasting.

A terminal unit of the system in the computer room of FFWC is directly connected to the BMD radar system This allows FFWC staff to monitor the radar image over Bangladesh in real-time However, since the information available in FFWC is image data only, numerical analyses utilizing radar data to quantify rainfall cannot be undertaken at present.

Regarding the satellite image, FFWC has a dedicated computer for receiving and analysis of NOAA satellite information A GMS image is also available from SPARRSO on an on-demand basis FFWC can therefore monitor the satellite image on a real-time basis According to FFWC staff, these satellite images are useful not only for the estimation of future hydrometeorological conditions but also for interpreting the causes of previous or current conditions of inundation

3.4 Data Transmission System

3 4 1 Communication Network during Flood

During a flood, many kinds of data and information are transmitted to FFWC by telephone, mobile phone, fax, wireless radio, BMD data network (intranet network of Bangladesh Meteorological Department), internet, satellite and telemeter

After analysis by the FFWC, a flood bulletin is published and disseminated to relevant agencies by fax and E-mail (Refer to **Figure 3.4.1**).

A summary of information collected and disseminated by FFWC is presented in **Tables 3.4.1** and **3.4.2** respectively

3 4 2 Communication System of FFWC

FFWC

Hydrological Data utilized by FFWC:

Hydrological data (water-level, rainfall, etc.) utilized by FFWC basically consist of wireless radio, telemeter, and post mail (refer to **Figure 3.4.2**)

Wireless Radio In principle, the FFWS is to use real-time data collected through wireless radio observation stations

Telemeter Only in the event that the above data are not obtained, data (limited to a few stations) collected through the telemeter system are utilized Under actual conditions, telemeter data are not used.

Post Mail : For the purpose of theoretical analysis, a wide range of data collected by post mail from various observation stations are utilized

Forecast Timetable

At FFWC, collected data are processed according to the following timetable.

9 00	Transmitting through wireless radio the data that have been collected until 6 00 on current day.
9.00 – 10.30	Forecast analysis
10 30 – 12·00	Preparation of a statistical bulletin
12 00 – 15 00	Preparation of "Daily Flood Bulletin" and Flood Map
15.00	Dissemination of information

Utilizing the data collected at 9·00 am, a forecast is made for the following 24 and 48 hour time periods

Attempted Interface between Telemeter System and FFWS

Data from the existing telemeter system are not currently used for FFWS However, there has been one attempt to connect the two systems The interface between the two networks was tried experimentally by creating an input interface (software) on the FFWS side and connecting the cable to both systems. However, it appears that the experiment ended in failure The system engineer of the telemeter control system should have participated in the experiment

Using data from Telemeter Network System

It appears that data from the telemeter network system have hardly been used The reasons for this may be as follows

- The current telemeter system was considered as a pilot project, consisting of 14 gauging stations only
- There is no connection between the telemeter system and FFWS It is considered to be difficult to connect the two systems without a system engineer for the telemeter control system
- The volume of data coming from the 14 stations is considered insufficient to increase the forecast accuracy or to justify modification of the existing hydraulic modeling software.
- The next project, to increase the number of stations and to connect the two systems, was considered to be implemented in succession

Unified administration and sharing of data is necessary

FFWC has created a database of various data and information (including river cross-sections, river structures etc) FFWC has used the database for flood forecasting and warning analysis, while the BWDB Green Road office has used another database maintaining the original data for other purposes including water resources development plans, river morphology, etc So there are two databases with almost the same contents resulting in duplication of data entry and maintenance at different locations A system of unified administration and sharing of data is necessary

Furthermore, BWDB's divisional offices at present have no means of accessing the FFWC or Green Road office database Therefore, it is necessary to construct a network internal to the BWDB, inclusive of FFWC and BWDB's divisional offices, to allow unification and sharing of the existing database

Governmental Emergency Communications Network is necessary

FFWC is currently connected to the BMD network and is thus able to access BMD's data provision server and utilize the meteorological data collected and prepared by the BWDB This so-called Governmental Emergency Network, a kind of interagency network connecting BMB and various relevant agencies, provides a critical service in disseminating valuable meteorological information and supplying a hot line telephone. FFWC and BWDB need to effectively utilize the data available at various relevant agencies and connect via hot line telephone among various relevant agencies, as DMB does, by taking full advantage of the Governmental Emergency Network

Wireless Communications Network Systems of FFWC

Basic Flow of Data Collection

Observation data collected at 91 water-level and 56 rainfall gauging stations are sent to Dhaka, the majority through HF short-wave radio transmissions From the time of data collection to the data entry into the FFWS system, the following four steps are involved

a A gauge reader reads the gauge data at the gauging station and relays them to an operator at a radio station

b. The operator at the radio station transmits the data to Dhaka through a transceiver with voice communication.

c An operator in Dhaka rewrites the data received from the radio station.

d The rewritten data are then input into the FFWS server by a FFWC staff member.

The fact that there are four staff members involved in processing the collected data seems to be the cause for possible dissemination of erroneous data or delay in data provision.

Data Collection and Transmission Schedule

The schedule for data collection and transmission varies from season to season

The gauge data are observed daily at three hourly intervals from 0600 to 1800 They are transmitted to Dhaka weekly in the dry season and daily in the flood season

At the important tidal gauging stations, hourly observations are taken

Season		Observation	Data Transmission
Stations	Dry Season	Daily 6 00, 9:00, 12 00, 15·00 and 18·00	Weekly on Saturday 9 00 – 12 00
	Flood Season	Previous Day: 9·00, 12:00 15:00 and 18 00 On the Day 6.00	On the day· 9:00

Data Reception Method at Dhaka

In principle, a data transmission request is sent by Dhaka and in response, the station that receives the request is to send out the collected data Since it is almost impossible to simultaneously receive and process collected data from almost 90 stations, these stations are divided into five different blocks and each block's transmission time is scheduled at ten-minute intervals to allow a process of "a transmission request and data transmission" to take place

At the Dhaka reception station, there are two HF trans-receivers Two operators are on duty to make the most effective use of these two trans-receivers The data collection is carried out each morning from 9 00am However, radio voice is noisy and it is rather difficult to process all data collected without error from almost 45 radio stations per operator

Ability of Wireless Radio Operator, Accessibility to the Radio Station, abd Backup Facilities

The radio operators have sufficient knowledge to use the wireless radio But, their telecommunication ability on wireless radio is not high, thus technical maintenance seems to be lacking For example, radio cable is reeled wastefully and thus causes radio noise Also, batteries for the transceiver are not maintained resulting in power trouble and shortened battery life

Accessibility for the operators is good because almost all are living near the radio station But there is, however, no other backup staff for almost all radio stations

Telemeter Network System

Network Configuration

The telemeter network system consists of 14 observation and 11 repeater stations equipped with VHF radio and a central control station in Dhaka BTTB's repeater stations (one is a BRTA repeater station) are used as relay stations in the network The data collected at each gauging station are transmitted to the BWDB's repeater equipment established in BTTB's repeater stations via VHF radio. The repeater stations then send the received data to Dhaka's central control station via BTTB's network through connection with BTTB's multiplex equipment (see **Figure 3.4.3)**

Survey Results

The survey results indicate that Dhaka's central control station has received proper observatory data from only five telemeter gauging stations The following factors seem to be the cause.

Lack of maintenance budget

At almost all gauging stations in the Moulvi Bazar region, the telemeter equipment experienced difficulties and was removed for replacement. Because the equipment was initially installed in 1985 and improved in 1995, spare parts needed for repairing the older equipment are not readily available and are hard to procure even in Japan

BWDB cannot handle major maintenance activities such as replacing/upgrading equipment Also damaged gauging stations have been left unrepaired

The reliability and serviceability of transmission lines is low

BTTB and BRTA have not been effective in dealing with this situation The defective lines have not been repaired and sometimes the connections between BWDB's repeater equipment and BTTB's multiplex equipment have been cut at the BTTB repeater stations

Detailed situations for each station are discussed in **Table 3.4.3**

Electric power source

Reliability of electric power is very low There are power blackouts at least once a day, some lasting as long as 30 minutes

Telemeter station

Solar power is used for all the telemeter stations Considering the hours of sunlight, the reliability of solar power is sufficient

FFWC

Power for important computers is provided through their own UPS (Uninterrupted Power Supply) A small generator is available during lengthy periods of power shortages.

There is a large CVCF (constant voltage constant frequency) system in the telemeter control room to provide reliable power to the telemeter control system only

Operation and Maintenance System

Condition of operation and maintenance of Data Transmission System Lack of maintenance budget and staff

C & I Division in Dhaka handles all aspects of management and maintenance of the wireless radio system and the telemeter system's observation, relay and control stations The Division is staffed by one manager, one electrical engineer and two assistant engineers. It appears that an attempt is being made to carry out the basic tasks of compiling maintenance manuals and conducting routine maintenance However, in addition to the lack of staffing, they do not even have a single vehicle This limits their ability to fully carry out their duties

Condition of operation and maintenance of electrical facility: technical level of electrical engineer is high but lack of electrical engineering resource

The electrical engineer was trained in Japan in connection with the installation of the telemeter system in 1995. Therefore, it is safe to assume that the skill level of the engineer is relatively high in that he is able to carry out various repair jobs for parts as well as a variety of maintenance tasks such as replacing a base panel by referencing the repair But at almost all radio stations, operators do not have electrical ability Thus there seems to be a lack of maintenance of the electric facility, for example lack of battery water and bad radio cabling

Issues relevant to maintenance

The parts of the wireless radio system are easily obtainable and thus repair jobs can be carried out rather smoothly. However, some parts of the telemeter system, such as program chips, are not that easy to procure. In such a case, the necessary part is obtained by contacting the manufacturer

Parts used in those telemeters installed in 1985 are no longer readily available on the market and there are not too many original manufacturers that can still supply them.

Looking into the future, in the event that a new network system is to be constructed, it is suggested that the availability of system parts on the market and the system's economic efficiency as well as the usage of the global standard as a base technology should be seriously taken into account How long one can expect to procure necessary parts and equipment in the market is highly critical to deciding on the sort of system to be constructed

3.5 Analysis System

3 5 1 Data/Information Incorporated in and Output from the Analysis System

As mentioned in above subsections, basic data/information assembled by FFWC on a "real-time basis" comprises:

- water level data at 91 gauging stations widely spread over Bangladesh,
- rainfall data at 56 gauging stations widely spread over Bangladesh,
- hydrometeorological data at 20 observatories located in India,
- BMD radar images, and
- NOAA and GMS satellite images.

In addition to the above real-time information, the following data/information are incorporated in the analysis model (Supermodel) as "base information":

- river (branch) network data in and around Bangladesh (topographic coordination of branch route),
- longitudinal and cross-section data of rivers (branches),
- dimensions of existing river structures whose effects on the hydraulic phenomena are not negligible,
- topographic information of floodplains (area-elevation relationship of each floodplain, referred to as 'flood cell'),
- evapotranspiration data,
- Digital Elevation Model (DEM) on which simulated flood inundation mapping is generated, and so on

As described in the next subsection, there are three kinds of activities covered by the analysis system, that is, 1) monitoring, 2) real-time simulation and 3) forecasting. The following table summarizes the main input/output information of those activities

Main Input/Output Information of Analysis Activities

Activities	Input Data	Output Data	Remarks
Monitoring	- Observed Water Level - Observed Rainfall	- Observed Water Level - Observed Rainfall	Mathematical model is not employed.
Real-time Simulation	- Observed Water Level - Observed Rainfall - Branch Route - Structure's Dimension - Topographic Data - River Cross-section - Evapotranspiration	- Simulated Water Level - Simulated Discharge	Mathematical model is employed
Forecasting	- Observed Water Level - Observed Rainfall - Future Water Level - Future Rainfall - Branch Route - Structure's Dimension - Topographic Data - River Cross-section - Evapotranspiration	- Forecast Water Level - Forecast Discharge	Mathematical model is employed

3 5 2 Monitoring, Real-time Simulation and Forecasting

The activities undertaken in the analysis system during the wet season (May – October) can be roughly divided into three, i e 'Monitoring', 'Real-time Simulation' and 'Forecasting' Monitoring is also conducted continuously in the dry season (November to April) on a weekly basis

In the monitoring activity, as-recorded hydrometeorological data obtained from the field are presented in the bulletin or web page, after quality checking. Monitoring items include water levels and rainfall Quality checking of water level information is undertaken mainly by comparing time series trends Rainfall is checked by comparison with radar and satellite images or rainfall records of nearby stations The checking processes are undertaken manually

In real-time simulation, a hydrological and hydraulic approach together with a GIS technique is applied This is based on MIKE11 modeling software developed by the Danish Hydraulic Institute (DHI) The outputs of this real-time simulation are hydraulically calculated water levels at defined points, often where observed water level data are not available. In other words, interpolation of water level information along the river branches is made based on modeling using observed water level and rainfall data

In the forecasting activity, the same software as utilized for real-time simulation is employed Water level forecasting in the dry season (lowflow forecasting) is one of the outputs of the on-going DANIDA project (CSFFWSP), with this system now under preparation. The lowflow forecasting is therefore not included in current FFWC activities

The above three activities can be merged into 2 components reflecting the required hydrological / hydraulic calculations. The 'monitoring' activity does not require such calculations, while 'real-time simulation' and 'forecasting' require rather complicated analyses Monitoring, real-time simulation and forecasting activities are described in more detail in the following subsections

3 5 3 Monitoring

As mentioned above, there are 91 water level and 56 rainfall gauging stations from which data are transferred to FFWC in real-time Experts in FFWC check the quality by temporal plotting or comparison with data of nearby stations

Regarding the water level data, current status (the water level at 0600 hours of the day) of each gauging station is monitored and displayed on the bulletin and web page together with the station's danger level in meter PWD Rise or fall in water level from the previous day is also calculated and reported.

For rainfall data, the totals for the three previous 24 hour periods (as at 0900 hours daily) are presented for each station in the bulletin and web page For the current month, cumulative rainfalls and historical average and maximum monthly rainfalls are also given

In the dry season, data at 18 water level stations and 18 rainfall gauging stations are checked and reported in a weekly bulletin The hydrometeorological information is not displayed in the FFWC web page during the dry season

3 5 4 Real-time Simulation and Forecasting

Real-time simulation and forecasting activities are carried out by FFWC staff utilizing MIKE11 together with a GIS technique.

(1) Outline of Software for Real-time Simulation and Forecasting

The MIKE11 software package is applied for the current hydrological and hydraulic modeling. This package is further divided into a series of modules such as Hydrodynamic (HD), Structural Operation (SO), Rainfall-Runoff (RR), Flood Forecasting (FF) and so on

For generation of the flood inundation map, MIKE11 GIS is employed. MIKE Flood Watch, operating under the Arcview environment, is utilized for preparation of the flood bulletin and updating of web contents. In the application of the MIKE11 model, this also acts as something like an Operating System (OS) for the above applications. More detailed information on the MIKE11 modeling system is presented in the **Supporting Report**

(2) Description of Supermodel 2001

The modeling undertaken for the FFWS in Bangladesh is based on the applications outlined above It is referred to as the Supermodel As the MIKE11 modeling system has powerful flexibility for expansion of a modeling area, FFWC continues to expand and update the modeled area with the assistance of an on-going DANIDA project The current analysis model is called 'Supermodel 2001 (SM2001)' The branch network of SM2001 is shown in **Figure 3.5.1**

The data transferred from observatories are entered manually into the computer and utilized to prepare flood forecasts at selected forecast points for both current period (ToF) (real-time simulation) plus the following 24, 48 and 72 hours (forecasting)

The SM2001 requires data for a total of 52 boundary water level gauging stations that effectively 'drive' the simulation (refer to **Figure 3.5.1**) Real-time water levels or associated discharges are available for 23 of these sites These could be referred to as 'base' boundary stations The other 29 boundary stations are currently set as constant discharge inputs (0 3, 2 or 10 m^3/sec) or their discharges are based on scaling flow from the most relevant nearby base station. Of the 'base' boundary stations, 5 define tidal levels and the remaining 18 define inflows from the major rivers flowing into the country or inflows/water levels at model boundaries within the country

Additionally, water level data from 27 stations within the FFWC network located internally within the country are also used to improve model performance in real-time as 'Internal Boundaries (IB)' as shown in **Figure 3.5.1**

Data from 37 rainfall gauging stations are used in conjunction with the NAM rainfall-runoff model to derive inflow flood hydrographs to the branch network model for the local catchments either wholly within the modeled area within Bangladesh or those smaller catchments originating in India For this purpose, the modeled area has been divided into a total of 114 sub-catchments The areas of those sub-catchments vary from around 200 to 4,500 km^2. Only 24 hour rainfall data are available from the rainfall gauging stations, as discussed in **Section 3.3**. It is also noted that data are not available to define rainfall depth or aerial variability for those portions of sub-catchments within India.

The basin average rainfall for each sub-catchment is assumed to be areally uniform The temporal distribution within the 24-hour period is also assumed uniform

(3) Real-time Simulation

Real-time information issued by the FFWC in the Daily Flood Bulletin is based directly on observations forwarded daily from the network of water levels stations.

Currently, modeling is therefore not explicitly required to issue real-time flood level warnings It is, however, required to 'fit' the model based on the most up-to-date river levels and inflows to provide accurate start-up conditions for forecasting.

Based on the results of real-time simulation (simulated water level at each calculation point, referred to as a 'h-point'), the flood inundation map of the modeled area is generated utilizing the GIS technique. Although the Digital Elevation Model (DEM), which defines the topography of the country, has a resolution of 300 x 300 m, this was generated using the topographic mapping developed in the 1960's The current DEM therefore does not have sufficient accuracy due to both possible changes in ground elevation and a lack of information on the structures constructed in the country since that date. To address this problem, FFWC is now making efforts to gather topographic information and update the DEM

(4) Forecasting

The procedure for forecasting is essentially the same as real-time simulation except when using the model in this mode, *all boundary data must be estimated prior to the analyses* This is undertaken by the FFWC Also, no future water level data are available for the internal stations

For water levels, recorded data for 'base' boundary stations are reviewed and extrapolated using observed trends as well as qualitatively taking into consideration any water level information from upstream areas such as stations in India.

For rainfall, available satellite and radar information (available in real-time in the FFWC computer room) are also considered This involves initially assessing rainfall patterns on a qualitative basis and then quantifying rainfall estimates for each site. The procedure necessarily relies on experience and a quantitative judgment

Based on the results of the analyses, the FFWC then includes in the Daily Flood Bulletin forecasts for selected stations located along the main rivers for the following 24 and 48 hours This only occurs when the forecast levels exceed target levels for the stations. For the flash flood areas, the forecasts are only qualitative up to the beginning of July as it is felt the accuracy of the results from the modeling is insufficient to provide quantitative estimates

(5) Time Requirements for Running Supermodel 2001

According to FFWC staff, it takes some 20 minutes to run the SM2001 for hydrological and hydraulic calculation, 20 minutes for exporting simulation results (water level at each 'h-point') to the GIS database, and 30 to 35 minutes to generate flood inundation maps of the entire area

(6) Accuracy of Flood Forecast

As noted above, in the period of forecasting the boundary conditions are estimated and no data are available to define future water levels at the internal points Therefore inaccuracies are likely in the forecasts To obtain a better appreciation of the magnitude of such errors, the actual forecasts by FFWC for 2001, 2002 and 2003 (till around the end of August) were reviewed.

The errors in the forecasts for each station and forecast time were expressed in terms of an absolute error (AE) For each year the mean absolute error (MAE), maximum error and those AE's that exceeded a given percentage of time were computed.

The detailed results are listed in **ANNEX-VI** A summary of the MAE's is presented in **Table 3.5.1** based on a grouping of stations according to their flooding characteristics, that is stations located in either monsoonal or flash flooding areas The results indicate:

i) forecasting accuracy at the stations is generally consistent from year to year,
ii) accuracy of forecasting reduces as forecast duration increases for both regions,
iii) forecasting accuracy is significantly higher in those areas subject to monsoonal flooding (MAE's less than around 0 20m), remaining good for durations up to 48 hours and only marginally less accurate at 72 hours, and
iv) forecasting accuracy for those areas subject to flash flooding is only average for the 24 hour duration and reduces further as the duration increases

The inaccuracies in the input boundary estimates for 2002 and 2003 are presented in detail in **ANNEX-VI** A summary is given in **Table 3.5.2** These were based directly on the modeling results obtained from FFWC and highlight the increase in errors of the boundary estimates as forecast duration increases They also indicate that the larger errors occur for those boundary stations in the flash flood regions Also included are the maximum errors. These are significantly larger than the MAE's, particularly for those stations in the north-east and north-west flash flood regions

To clarify possible reasons for the inaccuracies of the upstream boundaries, a more detailed analysis of the actual flood forecasts for 2001 and 2002 was undertaken This involved extracting observed and estimated/forecast future water levels (at 24, 48 and 72 hour periods) for selected stations on the model boundaries and those forecast stations immediately downstream These were located in regions subject to flash and monsoonal flooding and included.

- Pankha and Hardinge Bridge (Padma River, monsoonal flood region),
- Noonkhawa and Serajganj (Jamuna River, monsoonal flood region),
- Monu Railway Bridge and Moulvi Bazar (north-east flash flood region),
- Sarighat and Sylhet (north-east flash flood region), and
- Panchagarh and Bhusirbandar (north-west flash flood region)

The upstream boundary stations, which are based on input by FFWC, are listed first

The water level hydrographs for Pankha and Hardinge Bridge (monsoonal flood region) and Monu Railway Bridge and Moulvi Bazar (flash flood region) are shown on **Figures 3.5.2** and **3.5.3** for part of the flood season They include observed water levels and 24, 48 and 72 hour forecasts.

For the boundary locations, the following points were apparent

a Flash Flood Regions

A pattern of short duration, individual flood hydrographs is observed with relatively rapid increases and decreases in water level Whenever a rise or fall in the observed hydrograph occurs, boundary estimates over the following days tend to lag the observed hydrograph (for all forecast durations)

The greater the rate of rise or fall, the greater is the difference or error in boundary estimation

The same results were also apparent for those other stations analyzed that are located in flash flood regions

b Major Rivers Subject to Monsoonal Flooding

The variability in the observed flood hydrograph is less Although the estimated boundary hydrographs again sometimes lag the observed record the differences, or errors in boundary estimation, are relatively small

For those stations immediately downstream at which flood forecasts are made, the same patterns are also apparent for the concurrent periods Although the general trend in the observed water level hydrograph is matched by the forecasts, flood peaks particularly for the 48 and 72 hour periods often lag the actual events by as much as two days Those for the 24 hour forecasts are slightly more accurate This suggests that errors occurring in the forecasting at the internal stations are to some extent a result of inaccuracies in estimation of the upstream boundary conditions

The important point to note from this analysis is that accurate forecasts of water levels (in both timing and magnitude) are to some extent dependent on the accuracy of future boundary estimations This is particularly the case for flash flood areas

3.5.5 Problems Encountered by Analysis System

As outlined above, the current analysis system shows better performance for monsoonal flood forecasting However, some problems are apparent in the current analysis system These are summarized below.

- Input errors often occur due to the manually operated data encoding work
- The data from the telemetry system installed in the 1980s and 1990s have not been effectively utilized due to the absence of a suitable interface system
- The current system analyzes short cycle flood phenomena such as flash floods assuming an averaging of rainfall both areally over the catchments and temporally over the 24 hour periods even though calculations are based on 30 minute intervals
- There is a model requirement that future hydrometeorological conditions of boundary stations and rainfall stations should be input for water level forecasting Such information is estimated by the staff of FFWC based primarily on experience
- The accuracy of the generated flood inundation maps is low due to outdated topographic information
- The current system cannot accurately forecast more than 72 hours ahead even for the monsoonal areas because the hydrometeorological information received from India is limited.
- Because of the complexities of setting up and running the model, the required transfer of knowledge among experts requires a strong commitment from the FFWC to the continuing training of its staff

- The operation manual of the Supermodel has not yet been prepared for the FFWC, although the software manuals for MIKE11 issued by DHI are available

3.5.6 Conceivable Solutions

(1) Development of Automatic Data Input System

Installation of an automatic data input system can contribute to minimizing the likelihood of input error associated with manual operation It is also effective in minimizing time currently required for manual data input The direct transmission of observed hydrometeorological data in digital format meets this requirement, particularly as MIKE Flood Watch has a function for automatic data import

(2) Updating of Topographic Information

The updating of topographic information is necessary for improvement in the accuracy of the generated flood inundation maps In addition, it will enhance the accuracy of hydraulic calculation because of improved definition of the floodplain topography

(3) More Frequent Operation of Simulation Model

Additional operation of the SM2001 model could enable the FFWS to issue more accurate information on flood levels more frequently, an important consideration for the people and infrastructure especially in the flash flood regions. Considering the large difference in the time scale of the rise and recession of the flood hydrograph between monsoonal and flash flood areas, the development of an independent analysis system for flash flood regions may be preferable

(4) Establishment of a Method for Accurate Boundary Forecast

The current forecasting procedure requires the input of future up- and downstream boundary conditions (water level or discharge)

a Future Downstream Boundary Condition

In terms of future downstream boundary conditions, the existing tidal table is currently employed for their estimation with satisfactory results

b Future Upstream Boundary Condition

In terms of future upstream boundary condition, many attempts have been made for estimation based on the data available within Bangladesh. For example, a short and medium-term weather forecasting technique is being developed as part of the Climate Forecast Applications in Bangladesh (CFAB) project in conjunction with BWDB. If this proves successful, the CFAB model could provide discharge estimates for short (5 day) and medium term (20-25 day) timeframes for major rivers These could then be applied for more accurate estimation of future upstream boundary conditions for monsoonal areas

In addition to the above study, efforts for the collection of relevant hydrometeorological data from India are currently being made by BWDB and Bangladesh JRC The incorporation of data from stations upstream of model boundaries is the simple and most reliable way to enhance the accuracy of water level estimates at the international boundaries (entrance points to Bangladesh)

Considering the short lag time between rainfall and runoff, accurate monitoring of rainfall at short intervals over flash flood areas is necessary, although it must be remembered that catchments of many of the main rivers are located outside Bangladesh According to the rainfall record within Bangladesh, rainfall and rainfall gradients in flash flood regions are high (see **Figure 2.4.1**) and there is large spatial variability. Utilization of radar information is one of the solutions to define rainfall data not only within Bangladesh but also those parts of the catchments located outside Bangladesh where rivers flowing through flash flood areas originate

(5) Staff Training and Preparation of Operation Manual

For sustainable operation of a sophisticated mathematical model such as the Supermodel, the smooth transfer of knowledge is necessary Preparation of a detailed operation manual for the Supermodel to clarify the required daily routines to be followed is most useful. It is recommended that training programs are established according to this operation manual

3.6 Warning Dissemination System

3 6 1 Present Condition

FFWC of BWDB is responsible for issuing flood warning. FFWC produces flood bulletins and flood warnings every day during the monsoon period starting from April and ending in November This product provides flood information to the organizations and policy makers and general people. FFWC circulates this message from the office of the Prime Minister down to the district level including the media (TV, Radio and Newspaper etc), NGOs, and foreign missions and donors. The river situation, flood forecast and flood warnings are also available on the FFWC website, which is updated daily.

At present, flood warning is calculated in terms of water level of the rivers at 54 points The warning says how high or low the water level is with respect to the danger level at each site.

It is noted that Danger level of a river is a level above which it is likely that the flood may cause damage to crops and homesteads Danger level is defined for a particular measuring station for the area in its immediate vicinity. Danger level and flood severity as defined by BWDB are given below (Source Daily Flood Bulletin, FFWC).

Danger level

Not embanked river	*Embanked river*
It is about annual average flood level	It is fixed slightly below design flood level of the embankment

Flood severity

Normal flood	When water level is up to 50 cm below danger level
Moderate flood	When water level is up to 50 cm above danger level
Severe flood	When water level is more than 50 cm above danger level

In order to understand the current warning dissemination and response management and to develop appropriate dissemination and response procedures, pilot studies were conducted under the on-going DANIDA project for 3 flood vulnerable locations of the country These included Sundarganj Upazilla in Gaibandha, Chouhali Upazilla in Sirajganj and Louhaganj Upazilla in Munshiganj

According to the report of the pilot study (Development of People Oriented Flood Warning Dissemination Procedures, November, 2001), in the past people never received flood warning They mostly knew about the flood situation from public places like markets, neighbors and friends Sometimes they also receive information through radio, television and newspapers However, the information they receive through media is of a general type, not area specific As a result, they cannot take action based on that information On the other hand, the report finds that the need for receiving advanced and appropriate flood warning was rated very highly.

Similar information was also obtained by the Study Team through the field investigation, workshop, and awareness survey conducted during this Study. The Study Team conducted surveys in 15 locations throughout the country. The major findings are·

- No formal flood warning dissemination exists in rural areas
- Local government administrations and NGOs should jointly work for warning dissemination
- Village committees should be formed for warning dissemination
- Awareness building is necessary
- Farmers should get information on flood possibility
- Local teachers and religious leaders should be involved
- Suggested means of dissemination include loud speakers, radio/TV, village meetings, newspaper, red flag, posters and leaflets.

The present flood warning dissemination procedure is given in the flow chart in **Figure 3.6.1**. FFWC is responsible to provide flood warning up to district level However, in practice, FFWC provides flood warning to the district administration only when water level nears danger level. Below district administration, it is the responsibility of the local government institutions with indirect support from MDMR Depending on the degree of disaster, the District Disaster Management Committee (DDMC) inform Upazilla Disaster Management Committees (UZDMC) by fax, phone and sometimes by police wireless Though information is supposed to go to Union DMC from Upazilla DMC, in most cases, information does not properly reach the Union level. The major reason is that the communication between Upazilla and Union is not good in all cases According to the Standing Orders of Disaster Management, the Union DMC is responsible to inform village people

During the field investigation carried out by the Study Team in various districts, Upazilla and union in and around Sylhet, Rajshahi, Barisal, Faridpur, and Narayanganj, it was also found that although flood warnings are not received, there is good communication between district and Upazilla regarding the actual flood situation.

3 6.2 Problems Encountered

Lack of root level dissemination Warning dissemination is not yet satisfactory in the vulnerable communities Though FFWC issues flood warnings with 24 and 48 hour lead times, the flood information not always reaches the ultimate users in time

Short lead time Various stakeholders mentioned that the present lead time is inadequate to take proper response action They also mentioned that a 7 day lead time for warning is considered useful and a 5 day lead time is considered as required for proper response action

Ambiguous warning message The information provided in the present format is not easily understandable. The present flood information is given as the water level above the local danger level. Present danger levels are marked only at selected places adjacent to major rivers and it is not possible to relate these to inundation at certain inland places Many local people do not have any idea where the local danger level marks are situated Further, it is not possible to interpret the likely level of water inundation at resident's places based on such limited information

Improper danger level The present danger levels are rather old and should be reviewed In some cases, new embankments have been constructed since the last danger levels were adopted In some cases, no flooding now occurs even though there are warning messages issued.

Use of old topographic map: The topographic map used for flood forecasting is outdated and inaccurate It is therefore not possible to make accurate forecasts of depths of flooding and warnings based on calculated inundation can be misleading.

Accuracy of warning. Flood forecasting in the tidal region is often not accurate due to the cyclonic weather and its influence on tidal levels

No specific warning for structures: Even BWDB does not routinely use flood warning for the operation of their own river structures Other agencies operating river structures also do not use flood forecasting specifically in their operation.

3 6 3 Conceivable Countermeasures

Proper root level warning dissemination Improvement of flood warning dissemination will increase the benefit of FFWS even with the limitations in present flood warning accuracy

As explained before, there is no fixed setup for warning dissemination below the Upazilla level The major bottleneck is the information transfer from Upazilla to Union. One of the options is to have a wireless set at Union. However, to ensure proper maintenance of the wireless, it has to be purchased by the community Another option is to send a messenger from Upazilla to convey the message to Union. Some incentive can be given to these messengers

Another alternative can be conceived in line with the Cyclone Preparedness Program (CPP). Under the proposed Flood Preparedness Program (FPP), volunteers could be trained in each village to act as warning disseminators

According to the report of the DANIDA-supported pilot study (Development of People Oriented Flood Warning Dissemination Procedures, November, 2001), recommendations on warning dissemination are as follows

- Flood type, timing, water level, expected duration should be included in warning
- Area to be inundated should be informed
- At least 5 days lead time is required
- Good reliability must be ensured
- Messages must be easily understandable
- Local dissemination mechanism must be enforced.

According to the same report, the following suggestions were associated with the dissemination agent

- At the union level, the Union Council Chairman and Members should be regarded as lead dissemination agents.
- Imam of the local mosque, teachers of local schools, and NGO workers should be entrusted with the main dissemination responsibility.
- Some viewed that paid staff should be employed for dissemination.
- Some viewed that the staff of BWDB should carry out the duty of warning dissemination.

The same Study also pointed out the means of information dissemination as suggested by the people. These included the use of loud speakers (mainly through mosques), drum beating, interpersonal communication, hoisting red flags and red light focusing.

Sufficient lead time: The Study Team, through discussion, awareness surveys and consultative workshops, obtained the views of the people regarding sufficient lead time required to take response measures. The general conclusion was that in future the lead time should be increased as much as possible This lead time can be different based on the flood type In flash flood area, at least 4 hours is required for evacuation In other areas, at least 4 days is required from the agricultural and other damage reduction viewpoints FFWC should issue flood warnings with a lead time that is maximised based on technological limitations

Clear warning message Area-wise flood forecasting should be developed Instead of giving water level at major rivers, inundation maps should be issued All important structures located in the particular area should be included in the map and response actions should be prepared

Until there is a proper warning for the local area, the possibility of establishing gauges in important places of the village related to the danger levels should be considered. In this way, people will understand the meaning of the danger level-based warning.

Review of danger level Danger levels should be reviewed periodically IFWM of BUET undertook a study on the criteria of establishing danger levels That study should be consulted for use in ongoing reviews of danger levels

Preparation of new topographic map To issue more accurate flood warnings, topographic mapping should be updated urgently However, until that can be done, FFWC should at least provide warnings to Upazilla level even in general terms.

Accuracy of warning Flood warning accuracy is important especially in tidal and flash flood areas. If people lose faith in the warning, proper evacuation could not be ensured

Specific warning for structures Warning should be provided for all river structures so that proper response action can be undertaken in case of emergency Forecasts of inundation of major highways should be initiated to provide better countermeasures for flooding of roads and highways and ensure better transportation planning

3.7 Response System

3 7 1 Present Condition

The ultimate target of the flood forecasting and warning services is the response system, by which it would be possible to reduce damage during floods. There are various aspects of the response system shown below. Among these, the most important is to eliminate loss of human life

Prevention items	*Response measures*
Human life loss	Evacuation
Livestock loss	Evacuation with livestock
Movable property damage	Evacuation with movable property
Immovable property damage	Preventative measures
Crop damage	Early harvesting, if possible
Fishery damage	Early catching or removal to safe place
River structure damage (embankment, pumping house, canal, gates, port, ferry terminal, bridge, etc)	Respective preventative measures

Though it is mentioned in the Standing Orders on Disaster (1999) that the Disaster Management Committee (DMC) of District, Upazilla and Union level will assist in evacuation, it was found from the field investigation, workshops and awareness surveys conducted by the Study Team that no regular fixed systems for evacuation exist

Because of the lack of security, people in general do not want to evacuate In the cases of severe flooding in 1987, 1988 and 1998, the inundation periods were very long, more than one month at least People do not want to evacuate for the entire period leaving their property Except in the flash flood and tidal flood prone areas, flood waters rise very slowly, at around 20 to 30 cm per day In the early stages of flooding, people make platforms within their house and start to live there If flood waters increase further, many of them prefer to live on the roofs of their houses Only in the extreme case, where flood water exceeds roof level, are they forced to evacuate It was found that in all such cases people evacuated on their own

When people are forced to evacuate, they mostly move to roads, embankments, nearby schools and other high rise structures In cases of prolonged flooding, living standards of the people evacuated are generally miserable There are severe shortages of food, medicine, drinking water and sanitation facilities

The Study Team conducted surveys in 15 locations throughout the country The major findings were

- There is no organized and pre-planned evacuation
- There is lack of transport for evacuation and relief
- People do not want to evacuate leaving their house because of lack of security
- Security is a problem in the shelter, especially for women
- Insufficient food, medicine and safe water in shelters
- Poor food preparation and cooking arrangements in shelters
- Local teachers and religious leaders should be involved
- Village committees should be formed for evacuation management

At present there is no setup to move livestock People themselves arrange elevated places by putting earth for the livestock shelter.

There is no guideline for the people about prevention of damage to immovable property, agricultural crops and fisheries

There is also no set policy to prevent damage of river structures based on flood warning

3.7 2 Problems Encountered

No formal evacuation system The present setup for the evacuation system is seen as unsatisfactory Though it is stated in the Standing Orders on Disaster (1999) that Union and Upazilla DMC will assist evacuation, it is not practiced.

No designated flood shelter Although there are 1841 cyclone shelters designated (some of them specifically constructed as cyclone shelters), there are about 200 designated flood shelters In times of emergency, people shelter on roads, embankments, schools and other high-rise facilities. Sometimes, district DMC and

Upazilla DMC declare some facilities as evacuation shelters, but many times people just move to such places independently

Lack of security People do not want to evacuate because there is lack of security This sometimes leads to loss of life.

Lack of transport Since no formal evacuation system exists, there are also no transportation plans for the people to move to shelters.

Low living condition in shelter As there are no designated flood shelters, it is not always possible to ensure acceptable living conditions Lack of food, medicine, drinking water and sanitation facilities causes diseases and health nuisance This also discourages people from moving to shelters

Lack of awareness: People are not motivated to make quick response.

No shelter for livestock: Livestock is an important asset of rural Bangladesh Loss of livestock also indirectly hampers agriculture as cows are mainly used with ploughs However, there is no setup for sheltering of livestock at present.

No guideline to prevent property damage There is no guideline for people regarding prevention of damage to immovable property, agricultural crops and fisheries.

No response guideline for river structures At present, there is no set policy to prevent damage to river structures based on flood warning

3 7 3 Conceivable Countermeasures

Establishment of formal evacuation system: A formal evacuation system should be established where Upazilla DMC will be the supervisor and Union DMC will be the executor Local NGOs should be involved in the process. Volunteers should be trained, in a similar manner to CPP, to assist in the evacuation process

Designation of flood shelter Upazilla DMC should nominate some structures as flood evacuation centers In case no such places exist, new shelters should be constructed similar to cyclone shelters These could be used as schools in normal times

Proper security measures: Upazilla DMC should arrange proper security during the period people are evacuated Volunteers drawn from the flood affected people can patrol the area under supervision of Upazilla DMC.

Arrangement of transportation The Upazilla DMC should prepare to arrange proper transportation during the time of emergency

Ensure proper living condition in the shelters Once the shelter is designated, it is possible to plan properly to ensure acceptable living conditions can be provided Upazilla DMC will fix and inform District DMC about the route of relief movement to the shelter There should be prior planning for drinking water and sanitation facilities in the shelters

Awareness building People must be motivated to take prompt response action.

Orientation courses, small meetings and inter-personal contact are the most effective modes of awareness building Flood drills are also required for improved evacuation, as practiced by the Cyclone Preparedness Program (CPP)

Shelter for livestock There should be some arrangements for livestock shelter.

Guideline to prevent property damage There should be proper area specific guidelines prepared by District DMC to prevent flood damage District DMC should periodically issue response measures based on warning information. In this regard, District DMC should work closely with Directorate of Agricultural Extension (DAE) and Fisheries Department

Guideline for river structures There should be proper facility specific guidelines prepared by respective agencies

BWDB should start integrating flood forecasting with flood management for its important projects such as Megna Dhanogoda, Chandpur Irrigation, Pabna Irrigation, Ganga Kapotak, NNIP, DND, CPP, etc In the polder area, warning should be utilized for increased pumping in an anticipated flood water rise

All agencies that maintain river structures like Roads and Highways Department (RHD), Railway, Local Government Engineering Department (LGED), Department of Public Health Engineering (DPHE), Bangladesh Inland Water Transport Corporation (BIWTC), Port Authorities, Bangladesh Agricultural Development Agency (BADC), and Local Government Institutions, etc. need to have their own action plan fully integrated with the flood warning.

3.8 Organizational and Institutional Matters

3 8 1 Current Situation of Flood Forecasting Sector

(1) Institutional Analysis of Flood Forecasting Sector

Apart from the FFWC and BWDB, many organizations are related to the flood forecasting sector A holistic institutional analysis was therefore undertaken to comprehend the sector situation

A matrix showing each institution's relation in policy making, laws and regulations, strategic planning, implementation, monitoring & information management, awareness raising, education, research & training, and resource mobilization is shown in **Table 3.8.1**.

(2) On-going Relevant Projects

Consolidation and Strengthening of Flood Forecasting and Warning Services (CSFFWS) This is an ongoing DANIDA-assisted project with a total cost of around 4 5 million US$ The project period is from 2000 to 2004. The Project is now extended up to 2005

Water Sector Improvement Project (WSIP), Water Management Improvement Project

(WMIP) A World Bank preparation mission concerning this project was conducted in July 1999 The project is still in the process of negotiation The main focus of WSIP will be reorientation of BWDB's role in the water sector by divesting small water sector schemes to Water Management Associations (WMA) and to .enable it to effectively manage larger schemes which would remain under BWDB's jurisdiction

The name of this project is now changed to Water Management Improvement Project (WMIP) and this is taking over the entire scope of the WSIP

Comprehensive Disaster Management Program (CDMP) This is a multi-donor financed up-coming project coordinated by UNDP It is a five year project started in 2003 with an estimated project cost of 14 5 million US$ Despite its title, the CDMP is, in fact, concerned primarily with institutional and organizational aspects, not major physical works

It is to be noted that there is no item regarding flood warning dissemination and response included in Phase I

Others

Following projects are undergoing other than the projects those are mentioned above

1 Environment Monitoring Information Network (EMIN) Project
2 Community-based Flood Information System (CFIS) Project
3 Climate Forecast Application in Bangladesh (CFAB) Project

(3) Donor Activities in Flood Forecasting Sector

A large number of donors are actively supporting the sector. These include multilateral agencies such as World Bank, Asian Development Bank and Islamic Development bank, bilateral agencies from Japan, UK, Canada, Germany, Denmark, and Netherlands, and UN agencies like UNDP. There is a committee on the water sector under the Local Consultative Group (LCG) for coordination of the donor side in this sector This committee sits regularly to review the sector activity, progress of donor assisted projects, and future donor strategy.

(4) Disaster Management

Disaster management includes cyclone protection, flood proofing, erosion control, and drought management, in addition to the wider and more general requirements for disaster preparedness and post-disaster relief The Ministry of Disaster Management and Relief (MDMR) is the responsible ministry for this and implements these activities through two line agencies, namely Disaster Management Bureau (DMB) and Directorate of Relief and Rehabilitation, one center, namely the Emergency Operation Center (EOC), Local Government Institutions like District, Upazilla and Union Councils, and NGOs such as Red Cross There is an Inter-Ministerial Disaster Management Coordination Committee headed by the Minister of MDMR and National Disaster Management Council chaired by the Prime Minister

(5) Role of Local Government in Flood Situation

At present, the Local Government Institutions (LGIs) are relatively weak They are largely dependent on the Department of Public Health Engineering (DPHE) and Local Government Engineering Department (LGED) to undertake their works program Generally, decisions on projects to be taken up are made centrally Funding and recruitment are also centrally controlled Another major weakness of the LGIs is that they are only allowed to handle small amounts of funds There are also severe technical limitations placed on parts of LGIs

In the context of the flood, LGIs are responsible for flood warning dissemination and evacuation. Because of their weak institutional strength, it is not always possible for them to deliver the required service.

(6) Role of NGOs in Flood Situation

Local, national and international NGOs provide goods and services to the community In some sectors, like micro-credit, non-formal education, primary health care and income generation activities, the NGOs of Bangladesh are internationally recognized for their success NGOs are increasingly influencing public opinion on various issues namely land reform, gender equality, education, water supply and sanitation, environment and water management NGOs are also involved with advocacy for the underprivileged groups

Because of their intense interaction with the people, the NGOs are in an advantageous position Some of the NGOs are banking on this and embarking into specialized fields Some of the NGOs are already engaged in the flood-related sectors in different ways These include mainly post-flood response, flood proofing livelihood, and recently, warning dissemination, evacuation, and flood awareness building

(7) Information Management and Research and Development

The National Water Policy emphasizes research and information management. The Policy also assigns responsibility to WARPO for development of a central database and management information system that would consolidate information from various agencies in the water sector NWMP also recommends that WARPO should receive and archive copies of all water sector reports including their digital formats.

The National Water Resources Database (NWRD) has been set up in WARPO with support from CEGIS and IWM The primary activity of NWRD is to meet the demand of water resource planners for a consolidated and reliable databank At present, NWRD has more than 300 data layers in several main groups like base data, surface water, groundwater, soil and agriculture, fisheries, forestry, socio-economy, meteorology, environment and images.

3 8 2 Problems on Institutional Matters

(1) Institutional Weakness of BWDB

Centralized administration of BWDB BWDB is a top down centralized agency Field offices of BWDB are responsible only for operation and maintenance of the existing facilities Planning and design activities are carried out centrally Projects are implemented by project offices Because of this, there is a lack of coordination among various units of BWDB at field level Hydrology field level staff cannot properly utilize the logistics of the O&M wing To reduce cost, hydrology should share various logistical facilities including cars with the O&M offices

Centralized administration of Hydrology The Hydrology service is also a centralized unit The field offices of Hydrology just collect the data Data entry, validation, compilation, storage and flood forecasting is done centrally As a result, it is not always possible to take the regional context into account. Since there are no field staff of C&I division, every time there is a problem with the data transmission, staff of C&I have to go to the field from Dhaka.

Organizational setup of Hydrology In the present organization of Hydrology (**Figure 2.8.3**), all field observations are done by three data collection circles. Data are then transferred to PFFC for processing by the three respective branches However, PFFC also includes FFWC and an electro-mechanical division As a result, PFFC has various different types of work responsibility.

Inadequate O&M budget According to the Annual Report of BWDB 2000-2001, actual O&M budget allocation is significantly less than the requirement The comparison is shown below

Unit Million Taka

Year	O&M Fund Available	BWDB's Projection for Fund
1995-1996	2,677 62	5,029 37
1996-1997	2,619 87	4,300 22
1997-1998	2,188.37	4,073 15
1998-1999	2,408.09	4,249 60
1999-2000	2,944 45	4,563 98
2000-2001	3,133 43	4,369.03
2001-2002	2,886 00	4,063 33

Source. Annual Report, BWDB, 2001-2002

In 2001-2002, the O&M fund available was only about two-thirds of that required.

Weak accountability: Accountability of the staff is rather weak Because of this, full utilization of human resources cannot be assured

Poor monitoring system. There is no set monitoring guideline in BWDB Monitoring is done in discrete ways Also, a feedback system is non-existent

(2) Operation and Maintenance

No formal operational procedure In most cases, it was found that there is no set operational manual for the operation of specific facilities of BWDB. Further, no ledger book is kept for each facility Also, there is no permanent inspection and monitoring schedule It was found by the Study Team that many items of equipment and ancillary facilities have been stolen from various facilities

Untimely budget allocation It is reported that it sometimes takes 3 to 6 months to receive the allocated budget by the circle and division office This creates problems in proper operation and maintenance

Poor water levy collection As explained in **Section 2.8.4**, water levy collection is extremely poor

Vacancies in key positions BWDB faces a paradoxical situation in that while it has a sizeable staff surplus, it suffers from acute shortage of professional staff As at 30 June, 2001, there were 200 vacant technical posts (Annual Report, BWDB, 2001-2002)

Insufficient logistics support Logistics required for proper operation and maintenance are lacking.

(3) Information Management

Lack of integrated data management: Though information on various projects of BWDB is maintained in a scattered way, there is no central integrated database. Difficulty in retrieving project information not only makes the planning process hard but also hampers operation and maintenance work However, the office of the Chief Engineer is now preparing a database for all projects

Old topographic mapping The present Digital Elevation Model (DEM) is based on rather old topographic information Because of this, accurate area-wise flood forecasting is not possible

(4) Skill Development

Staff Training: At present, there are BWDB training facilities and staff members receive training From time to time, they also go abroad to receive training However, most of these are demand driven There is no set rule and no provision for continuing education.

Merit based promotion In most cases, the promotions of BWDB staff are based on seniority. For better efficiency, merit based promotion must be introduced

Quick rotation. Usually, BWDB personnel are rotated every few years This is not always conducive to skill development, especially for hydrology services

Lack of incentives: There is no overtime allowance for BWDB officers There is an allowance for research, design and planning staff However, staff of FFWC do not get any incentive though they must work long hours during emergency situations

Applied research The river network of Bangladesh is complex Many of the physical phenomena like erosion, siltation, flash flooding and river course change are not well understood Some research is carried out by IWM, CEGIS and IWFM of BUET More research is needed to understand these phenomena so that proper steps can be taken.

Lack of multi-disciplinary staffing Interaction of the water sector with many other sectors, especially social sectors, requires multi-disciplinary staff

(5) Inadequate Warning Dissemination and Response

Weak Local Government Institutions Because of the weak local government institutions, they cannot carry out their stipulated duties of flood warning dissemination and evacuation.

No setup like CPP The Cyclone Preparedness Program (CPP) is functioning very well However, there is no such setup for flood management

No warning and response for river structures At present, there is no specific warning dissemination for river structures operated by BWDB and other agencies Subsequently, there is no response system incorporating flood warnings.

(6) Planning Issues

FFWS in NWMP The National Water Management Plan will become an umbrella plan for the water resources sector after its approval Although there are some indicative directions for FFWS in the NWMP, there are no specific targets and execution course.

Program-based approach of NWMP· NWMP adopted a program-based approach As a result, specific intentions and schemes are not underlined. A separate study should be undertaken for each sub-sector to identify the schemes

No up-to-date water balance study For comprehensive water sector planning, a detailed water balance assessment is essential However, no up-to-date study is available

FFWS in CDMP A new project, the Comprehensive Disaster Management Program (CDMP), has been started in 2003 with UNDP support However, FFWS is not well defined in this program

No land use policy Until now, there is no nationwide land use policy Absence of this may lead to unplanned development, which in turn, could create increased flood and water logging hazards

No water code A national water code is under preparation Without clear water rights and water allocation, it is difficult to develop proper water resources development plans

(7) Limited Participation of NGOs and Private Sector

Private sector participation It is widely recognized that the public sector can no longer be, nor should be, the provider of all infrastructure and services There are practical advantages in an increased role of the private sector Infrastructure will be often provided more speedily Increased efficiency associated with innovation, management expertise and incentives will reduce risks and time and cost overruns However, since flood management and especially flood warning services is a sensitive sector, it is possible to entrust only part of the services with the private sector.

Participation of NGOs Achievements of NGOs in Bangladesh are considered as a success story Involvement of NGOs in CPP has also proved to be effective At present, no such role is defined for NGOs in flood disaster management

3 8 3 Conceivable Countermeasures

(1) Institutional Strengthening of BWDB

Decentralized administration of BWDB For efficient functioning, better coordination and cost reduction, regional offices should have more authority Some regional offices can be established that can carry out planning, designing and hydrology-related activities As mentioned in the earlier section, World Bank and IDA are also advocating decentralization of BWDB

Decentralized administration of Hydrology For better field level coordination and consideration of local context, regional offices of Hydrology service can be established In addition to data collection, compilation, and relevant maintenance, these offices can also provide regional flood warning Comparative merit of the centralized and decentralized administration of Hydrology service in respect to the FFWS is given in **Table 3.8.2**.

Organizational setup of Hydrology PFFC should be reorganized based on the work responsibility. Since C&I division is the single electro-mechanical division of Hydrology, it should function independently of PFFC Similarly, the work of FFWC is different from the other processing branches and therefore, it should function separately All supporting activities required for flood forecasting should be brought under FFWC.

Adequate O&M budget. Provision should be made for greater budget allocation for the operation and maintenance of BWDB facilities As mentioned in the table in **Section 2.8**, O&M budget allocation to BWDB in 2001-2002, it is only around two-thirds of the requirement. Without extra funding available, it would not be sustainable to introduce a telemeter system in FFWS

Strong accountability. Proper accountability should be ensured for better working efficiency A performance-based reward system should be introduced

Adequate monitoring system Proper guidelines for monitoring should be established. A strong feedback mechanism should be introduced Institutional review should also be done every 5 years

(2) Operation and Maintenance

Formal operational procedure: There must be an operational manual A ledger book must be maintained for each facility This ledger book will record the entire history of the facility and also the inspection and monitoring schedule.

Timely budget allocation: Timely release of funding at the beginning of the financial year is important for appropriate operation and maintenance

Water levy collection A working procedure should be practiced to collect water levies Field operation offices should be allowed to retain that money to utilize for maintenance Water user associations should be organized to improve the levy collection

Filling vacancies in key positions Failure to fill vacancies in key technical positions will harm proper functioning. The posts should be filled urgently. If it is not possible due to government regulations, steps should be taken to fill the post temporarily or relocate surplus staff

Sufficient logistic support Sufficient logistic support is required for accurate operation and maintenance To reduce the cost, sharing of facilities among various units is recommended.

(3) Information Management

Integrated data management The Office of the Chief Engineer, O&M is now preparing a database for all projects It must be completed as soon as possible. Also, all future new projects and changes in existing structures must be included in the database immediately. This should be available to all concerned planning officials.

New topographic information A new Digital Elevation Model (DEM) must be prepared with present topographic information With this, accurate area-wise flood forecasting should be possible

(4) Skill Development

Staff Training. Set rules should be established for regular and periodic staff training including continuing education

Merit based promotion For better efficiency, merit based promotion must be introduced.

Appropriate rotation Staff rotation should be planned appropriately, especially for the top management of Hydrology

Proper incentive Incentive mechanisms should be introduced for increasing motivation of the staff, especially for the staff of FFWC

Applied research More applied research is needed to understand the complex physical phenomena of the river network of Bangladesh in the fields of erosion, siltation, flash floods and river course changes

Multi-disciplinary staffing Multi-disciplinary staffing is important for the flood management field to incorporate social approaches

(5) Inadequate Warning Dissemination and Response

Strong Local Government Institutions The main responsibility of flood warning dissemination and evacuation lies with local institutions To carry this out, there must be strong set ups within the local government institutions In these, BWDB should have a monitoring function There should also be feedback systems

CPP-like setup The Cyclone Preparedness Program (CPP) is functioning very well A similar setup is required for flood response Under the proposed Flood Cyclone Preparedness Program (FPP), volunteers should be trained to carry out warning dissemination and assist in evacuation

Proper warning and response for river structures: All river structures are beneficiaries of flood forecasting services Warnings should be specifically made for the structures and there should be an operation guideline incorporating response based on flood warnings

(6) Planning Issues

FFWS in NWMP There should be overall target and implementation strategies for FFWS in NWMP

Scheme identification from NWMP NMWP provides a program-based approach. Sub-sector studies should be undertaken to identify specific schemes in the light of NWMP

Updating water balance study A nationwide water balance study should be updated periodically This will help comprehensive water sector planning

FFWS in CDMP In the UNDP-financed Comprehensive Disaster Management Program (CDMP), FFWS should be defined clearly

Land use policy A national land use policy is to be prepared for coordinated development planning.

Water code A national water code is urgently required to coordinate water sector development planning.

(7) Increased Private Sector and NGO Participation

Private sector participation Since the flood forecasting and warning services are a sensitive sector, only part of the services can be handed over to the private sector Part of data acquisition, data transmission, and warning dissemination can be effectively handed over to the private sector for better results In the case of data processing, the on-going DANIDA project recommends that IWM will periodically update the model This kind of involvement along with technical input from competent consultants is encouraged Present utilization of the private sector in data transmission can be further increased In the case of warning dissemination, private printed and electronic media is already doing a good amount of work. This can be made more rigorous. Part of data collection can also be handed over to the private sector For example, gauge readers may be appointed on a contract basis to increase their accountability

Participation of NGOs Achievements of NGOs in Bangladesh are considered a success story Involvement of NGOs in flood warning dissemination, evacuation and awareness building will bring better service delivery