PART-II FORMULATION OF FFWS

CHAPTER 4 FRAMEWORK PLAN OF FFWS

4.1 Needs for Flood Forecasting and Warning Services

4.1.1 Objectives of FFWS

Disaster management, including that associated with flooding, is a responsibility of the Government of Bangladesh and is aimed at minimizing loss of human life, property and other economic assets.

The FFWS provides information on flood forecasting and warning to the population with the aim of mitigating flood damage through the following measures:

(1) Evacuation and/or Implementation of Flood Coping Measures by the People

The FFWS provides advanced warning to the population of an impending flood indicating its likely magnitude and lead time, that is time allowance between people receiving information and the occurrence of the forecast flood level. This provides the opportunity for evacuation of those likely to be affected to nominated safer areas where appropriate preparations for their safety have been made. Measures can also be implemented to permit the transfer of movable assets to such areas or even to higher levels within existing residences.

(2) Operation of River Structures

As outlined in **Section 2.5.4**, the JICA Study Team undertook a questionnaire survey of O&M and Hydrology Divisional and Sub-divisional Offices of BWDB on the necessity of a FFWS. It was revealed that the majority supported its necessity and noted that operation of river structures during periods of flooding may not be possible without it. It is considered an essential component of the O&M for river structures and appurtenant facilities.

(3) Operation of Transportation System

FFWS is very important and essential for safe operation of those transportation facilities. In order to eliminate unnecessary economic disturbance due to traffic congestion during flooding, a FFWS would contribute to more efficient traffic control. In such cases, comprehensive management among the agencies concerned is essential.

(4) Earlier Harvesting of Crops

There are many Polders in Bangladesh. Typically harvesting occurs at the end of the dry season or beginning of the flood season and polder embankments should be safe at least until its completion. If floods occur earlier than normal, farmers will generally want to harvest earlier. A FFWS would be most beneficial to farmers in making such decisions on early harvesting.

(5) Social and Economic Activities

Flood can result in major disturbances to social and economic activities. Orderly management should be undertaken by the government based on the FFWS. An inter-agency information system connecting all agencies concerned should also be established for more effective use of warnings from the FFWS.

All the above requirement of FFWS will be taken into account in the planning of FFWS including project evaluation.

4.1.2 Objective Areas of FFWS

As discussed in the previous Chapter, extremely low elevations and ground slopes throughout Bangladesh result in much of the country being affected by flooding.

Although only very limited information defining flood damage is generally available for most years, more detailed records were collated by the authorities following the recent major flood in 1998. This included details on flooded areas, number of affected people and flood damage in monetary terms. This information was used in the current study to identify the objective area for the FFWS.

Based on the records on 1998 flood, the Study Team concluded that there were no significant differences in the likelihood of flood damage between the various Divisions and Districts. Therefore, it was concluded that the entire country of Bangladesh should be considered as the objective area for a FFWS. The Framework Plan for the FFWS outlined in this Study therefore focused on the entire nation with the Feasibility Study component being conducted on the selected optimum plan.

4.1.3 Delineation of Flood Types

It is widely recognized that there are four flood types in Bangladesh, namely 1) monsoon flood, 2) flash flood, 3) tidal surge and 4) local inundation. Local inundation can be considered as a part of monsoon flood.

Although there is no quantitative demarcation of Bangladesh according to flood types, maps showing such areal divisions are available from different sources. Based on these and hydrometeorological data available in BWDB and FFWC, a delineation map of flood types was generated for framework planning as shown in **Figure 4.1.1**.

4.1.4 Required Accuracy of Flood Forecast

In the current flood forecasting and warning services provided by FFWC, the information disseminated includes 1) observed water level, 2) observed rainfall and 3) forecast water level for the following 24 and 48 hour time periods.

The error (required accuracy) of the 24-hour forecast, defined as the difference between observed and forecast water levels, should not exceed:

- 20cm when the change in water level over the 24 hour period is less than 1m or

- 20% of the change in water level over the 24 hour period if this exceeds 1m.

If the error of the forecast water level is maintained within these limits, this will ensure useful and reliable information can be disseminated to recipients.

Monsoon Flood

The accuracy of the current forecasting model is relatively high in the monsoon flood area. The mean absolute error between observed and forecast water levels is less than 20 cm at the majority of forecasting points within the monsoon flood area even for the 72 hour forecast (see **Table 3.5.1**). The maximum absolute errors for most stations do not, however, meet the required forecast accuracy possibly due to input errors in boundary conditions that have estimated before commencing the forecast simulations.

Flash Flood

In the flash flood affected regions, since the time difference between the occurrences of causal (heavy) rainfall and resulting flood is small (often only several hours), accurate and reliable forecasting for areas subject to flash floods is still difficult within the current framework of the observation and analysis system. Therefore FFWC does not issue any forecasting information for stations in flash flood areas.

However, as mentioned **Section 4.1.5** below, some information of future conditions is still necessary in flash flood regions. Such information, which could include current water level and current rainfall intensity over the upstream drainage areas, is still useful for decision-making regarding the need to evacuate and so on. Rough estimates of current rainfall or cloud intensity can be monitored through the BMD radar or NOAA satellite images. The frequent provision to local authorities of observed hydrometric data (water level and rainfall) and knowledge obtained from radar or satellite images is essential.

Tidal Surge

Tidal surge is also recognized as one of the most severe flood disasters in Bangladesh. The quantitative forecast of water level rising due to tidal surge is not covered by the analysis system in FFWC. The behavior of tidal surge depends strongly on the characteristics of cyclones or atmospheric depressions, and also on topographic characteristics of the objective areas. Although the quantitative forecasting of tidal surge has been widely studied throughout the world, it is still under examination.

Since it is premature to make quantitative forecasts of tidal surge in Bangladesh, the response activities or their decision-making should be done based on the storm warning issued by BMD.

4.1.5 Required and Possible Lead Time

Lead Time

Lead time may be defined as the difference between the time when the warning message reaches people and the time when the flood phenomenon occurs at the nominated place.

Required Lead Time

Based on the result of the "Survey on Evacuation Condition and Awareness of Flood Victims", PCM workshops, and interview surveys of O&M staff of BWDB conducted in the early part of the Study, necessary times for the response activity were established as follows:

Necessary Time by Response Activities

Response Activity	Necessary Time for Completion of Activity
Evacuation with minimum necessary belongings	4 hours
Protection of river structure from flood damage	12 hours
Early harvesting of crops	4 ~ 5 days

Possible Lead Time

As shown in the table above, if the flood warning can reach inhabitants 4 to 5 days before, it may provide considerable use for almost all response activities. However, the available or possible lead time differs throughout the country according to the local hydrometeorological conditions.

To assess the available lead times by region, a trial analysis was conducted. In this analysis, the minimum time required for the water level to rise from an elevation 1m below danger level to danger level was calculated at all FFWC stations based on the available historical water level record. This is referred to as the available time for preparedness and provides an indicative measure of the times for people to initiate response actions once the water level reaches 1m below danger level. Comparing the available time with the necessary time indicates those regions of the country that may be more critical in terms of being able to initiate responses.

Figure 4.1.2 shows the minimum available time for preparedness based on the historical records. The area with an available time for preparedness of less than 4 hours is located mainly in the international border area of northeastern and southeastern Bangladesh. It also can be observed that at least 24 hours are available for initiation of response activities over the majority of Bangladesh.

Based on the required lead time from the viewpoint of the recipients of flood warning, target lead time provided by FFWS is considered as 4 days for monsoon flood area and 4 hours for flash flood area. To achieve this target, the acquisition of the hydrometeorological information in the upstream basin area, particularly in India, is essential.

4.1.6 Basic Conditions for Formulation of Framework Plan

(1) Objects to be protected by FFWS

a) Human lives (to minimize the death of people)
b) Movable assets in homestead (to protect household assets)
c) Agricultural produce (to make early harvesting possible)
d) Infrastructure (emergency operation of river structures, traffic control)

e) Social and economic activities

(2) Objective areas of FFWS

a) Entire area of Bangladesh
b) Priority study for implementation of project will be conducted after feasibility study

(3) Social and economic condition as a target year of framework plan

a) Present socio-economic condition to be adopted for the formulation of framework plan
b) Future socio-economic condition including population, GDP, etc will not be considered.

4.2 Component Alternative Development Plan

4.2.1 General

The problems associated with the current FFWS in Bangladesh were extracted and analyzed by components (observation, data transmission, analysis, warning dissemination, and response systems) in the previous Chapter. Based on the findings on the existing FFWS, alternative improvement plans were developed and are outlined below.

The component alternatives were developed considering that they formed an overall combined alternative framework plan. The combined alternative framework plans were largely divided as follows:

1) manual observation system, telemeter system, or combined system of manual observation and telemeter
2) central control system or regional control system

4.2.2 Observation System

(1) General

The existing observation network is currently considered to meet the required coverage for use in the FFWS, as discussed in **Section 3.3**. A number of steps should, however, be implemented to improve the accuracy of the data (both rainfall and water level). These include:

- ensuring all rainfall gauges have adequate clearance from nearby structures or vegetation, and
- installing permanent gauge plates at the higher flow levels at those water level stations with permanent embankments or structures.

In addition, expansion of the existing telemetry network is proposed. This will provide accurate real-time monitoring particularly in those areas subject to flash flooding, where substantial water level changes can occur within 3 to 6 hours. It will also allow more accurate future forecasting in these areas for up to around 24 hours in advance using the flood forecasting analysis model.

For easy understanding of the following descriptions, the alternatives derived from this observation system were defined as follows:

1) Retention of present manual observation system (only data communication system will be improved).
2) Installation of automatic water level and rainfall gauging equipment with telemetric system at all existing FFWC observatories (91 water level and 56 rainfall gauging stations).
3) Installation of automatic water level and rainfall gauging equipment with telemetric system at proposed 23 observatories (data communication system will be improved for remaining manually operated observatories).

In view of reliability, accuracy and consistency of observation, it is clear that option 2) is most preferable provided this large number of automatic gauges is properly maintained. Option 3) defined the case that the number of automatic gauges is reduced with automatic gauges being installed only at locations important from the viewpoints of model requirement and flood characteristics etc. Although there is no improvement in the reliability, accuracy and consistency of observation in option 1), possible errors that could have previously occurred during the data transmission and manual data entry stages would be reduced.

The process of the selection of the 23 stations mentioned in option 3) above is described below.

(2) Criteria for Selection of Telemetric Stations

Four (4) criteria were considered for the selection of the proposed telemetry network as follows:

1) Flood Characteristics [Criteria 1]

In principle, the accurate observation of all flood types recognized in Bangladesh, i.e. i) monsoon flood, ii) flash flood, iii) tidal surge, and iv) local inundation, should be achieved by the hydrometeorological network of FFWC. Given the difference in rates of rise/fall in water levels in those areas subject to different flood characteristics the required observation intervals will also vary. The telemetric system is more useful in those areas subject to short-term floods such as flash flood or tidal surge.

2) Highly Developed Area/City [Criteria 2]

More accurate and frequent monitoring of flood phenomena is necessary in more highly developed areas or areas with larger population due to their greater economic and social importance.

3) Model Requirement [Criteria 3]

Current flood level analyses/forecasts in FFWC are determined using a hydrological and hydraulic software package developed by DHI. Since this analysis system has been judged as suitable for application in the FFWS in Bangladesh (as mentioned in the previous chapter), it is practical that the telemetric stations be selected according to model requirements.

Critical information for model operation included upstream and downstream boundary water levels and rainfall data. The latter are, however, of minimal importance in accurately defining flood levels. The stations to be selected using this criteria were therefore determined according to those stations necessary to adequately define water level boundaries for the hydraulic model.

4) Strategic Locations from Hydrologic Viewpoint [Criteria 4]

Confluence or divergence points of a river network are often recognized as strategic points from the hydrological viewpoint. Although a large number of junctions occur in the river network of Bangladesh (see **Location Map: Rivers of Bangladesh**), a prioritization was applied.

Screening of the various FFWC gauging stations was conducted based on the above criteria. This involved initially screening each station according to the various criteria with a subsequent final selection based on eliminating all except one station if a number were located in close proximity.

(3) Proposed Telemetric Network

Based on this analysis, it was proposed that a telemetric network including 23 stations be established as one of the component alternatives for the observation system. The detailed process of the selection is given in the **Supporting Report**. Automatic water level gauges would be installed at each.

Proposed Telemetric Observatory

Sl.No.	Station Name	Sl.No.	Station Name	Sl.No.	Station Name
1	Panchagarh	9	Laurergarh	17	Mongla
2	Dalia	10	Sarighat	18	Rayenda
3	Noonkhawa	11	Kanaighat	19	Patharghata
4	Kurigram	12	Amalshid	20	Dasmina
5	Sirajganj	13	Chatlaghat	21	Daulatkhan
6	Pankha	14	Bhairab Bazar	22	Panchapukuria
7	Nakuagaon	15	Comilla	23	Chittagong (Sadarghat)
8	Durgapur	16	Dhaka (Mill Barak)		

The location of these stations is presented in **Figure 4.2.1**. They are predominantly located on the boundaries of the existing Supermodel river network. Two stations, Chittagong (Sadarghat) and Panchapukuria, are also situated in the south-eastern region and will be used for both real-time flood level monitoring and modeling of this area in the future by the FFWC.

In order to strengthen the physical accuracy of the model, rainfall observations at shorter intervals are also important especially in the flash flood areas and those areas affected by local inundation (rainfed flood). Installation of automatic rainfall gauges is therefore also proposed at each telemeter site.

4.2.3 Data Transmission System

(1) Needs to be Met by the Communications Network

Establishment of a unified administration and data disseminating structure: Such a network system must allow for the unified management of river-related data and its prompt dissemination to relevant authorities. This will enable such agencies and the general public to accurately comprehend incoming data and thus carry out effective preventative actions without confusion.

Use of data as shared resource: Data collected, stored and processed must be managed in a unified manner with a system that allows effective sharing of such data among all relevant divisions.

Diversification of data for dissemination: The content of data disseminating to relevant agencies and public may not necessarily be identical. It is necessary to differentiate the data provided to each in terms of its level of detail and urgency depending upon the targeted audience.

Improvement of Network Reliability: Disaster prevention data needs to be communicated accurately, reliably and in timely manner. Therefore, data communication networks connected to relevant agencies must ensure that the transmission speed and lines are technologically reliable.

(2) Existing Problems

As discussed in **Chapter 3**, the following major problems were associated with the existing FFWS and telemeter system.

Existing FFWS

- Error or delay in data transmission of manually observed data seems to be caused by human factors.
- Data transmission from the gauging sites to FFWC in Dhaka is based on wireless telephone with voice communication in case of manual gauging stations. This implies possible errors in observations, listening and rewriting.
- Some delay in dissemination of disaster prevention information to relevant agencies and the public occurs because the dissemination only occurs after collection/transfer to the Central office and subsequent analysis.

Existing Telemeter System

- There is a lack of proper maintenance of the existing telemeter system (due to budget constraints, staffing, maintenance, institutions, etc.).
- Telemeter gauging stations (numbering 14) never been utilized for flood

forecasting due to flood damage, sediment accumulation, scouring of structures, and unavailability of spare parts.

- The service and reliability of BTTB and BRTA are poor.

(3) Data Transmission Alternative Plan

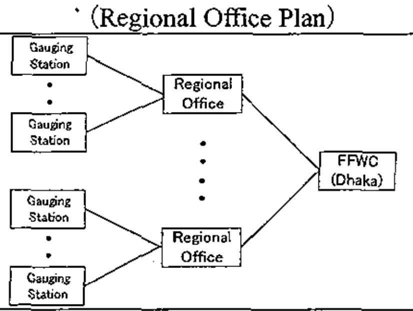
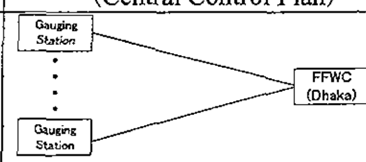
1) Regional Office Plan

Outline of the Plan

Two types of setup for data transmission system can be considered, such as a "Centralized system (Central control Plan)" and a "Distributed system (Regional office Plan)".

The "Centralized system" is suitable for initial development stages of a project or for a small-scale system. It is easy to establish the institution and functions for a Centralized System, however, quick actions and responses are more difficult (refer to **Figure 4.2.2**).

The "Distributed system" is suitable for a large-scale system to act quickly and efficiently. However, it is necessary to develop operational and management capabilities and clear definition of the decision authority and responsibility is needed (refer to **Figure 4.2.3**).

	Distributed system (Regional Office Plan)	Centralized system (Central Control Plan)
Model		
Merit	Quick action at the Regional office for the local condition.	Central control Unified administration of information and technology

The effect of "Regional Office Plan"

- Activation of local community for flood disaster prevention
- Dissemination of information in consideration of local area
- Quick response for flood fighting in consideration of local condition

Condition for installation of "Regional Office Plan"

- Collection of information (observation and other necessary information) to the Regional office
- Clarification of decision authority and responsibility of Regional office

Central office function in case of "Regional Office Plan"

- Collection of nationwide information
- Nationwide management and analysis

- Distribution of information to mass media and relevant organizations

2) Telemeter System Plan

Outline of the Plan

To address data collection errors and delays, a telemeter system will be effective as reliable rainfall and water level data will be automatically (and continuously) collected every 10 minutes.

However, in addition to facility establishment costs, continuous maintenance costs will be required. Therefore, only the minimum number of telemeter stations should be considered.

	Existing System(manual system)	Telemeter System
Model	1: A gauge reader observes the data (staff gauge and rainfall quantity) and relays it to a Radio operator at a Radio Station. 2: The operator at the Radio Station transmits the data to Dhaka through a transceiver. 3: An operator in Dhaka processes the data received from the Radio Station. 4: The collected data are then entered into the FFWS server by a FFWC staff member.	1: Water level and rainfall quantity are sensed and transmitted automatically. 2: Transmitted data are collected and entered into the data server automatically.
Merit	If a river changes section, the location of the staff gauge can be moved. Low cost of O&M	Continuous and detail observation can be obtained with high reliability

Effect of Telemeter system

For flood disaster action: Particularly effective for flash flood areas to assist in disseminating early warnings and forecasting.

For river management: Observation during night and observation of remote gauging stations are possible. This will also reduce the required number of staff.

For river control planning: River control planning and improving the river model are possible by using the more detailed data.

Conditions for installation of telemeter system

- Provision of adequate O&M system (budget +staffing+ organization)
- Development of data entry interface for both telemeter and manual data

3) Digital Communication for Manual Observation Plan

Outline of the Plan

The telemeter system will be installed only at the required gauging stations (as outlined above). For the FFWS, all other gauging stations currently operated by FFWC will continue to be manually observed. To ensure data errors and delays in data input to the analysis system (database) are minimized, an automatic input system will be required. Where mobile phone transmission can be used at the gauging station, the observed data can be transferred and input automatically into the server. Where this is not possible, the observed data can be transmitted through existing radio stations using HF wireless radio communication with the data again automatically input into the data server.

	Mobile data communication	Wireless radio data communication
Model	1: The gauge reader observes the data at the gauging station and transmits by mobile phone using the data sending function. 2: Transmitted data are automatically input into the data server. 3: The analyzing system can use the observed data from data server whenever it requires.	1: The gauge reader observes the data at the gauging station and reads to a Radio operator at a Radio Station. 2: The operator inputs the observed data into the computer via Digital wireless radio at the Radio Station. 3: Transmitted data are automatically input into the data server. 4: The analyzing system can use the observed data from data server whenever it requires.
Merit	Automatically input data into the data server. Prevention of inaccurate data input. Reduces staff. Low cost of O&M	Automatically input into the data server. Prevention of inaccurate data input

Condition for installation of digital communication

- Provision of adequate O&M system (budget + staffing + organization)
- Development of data entry interface for both telemeter and digital communication

(4) Optimum Telecommunication Plan

An optimum telecommunication method was selected for the FFWS system with the adopted system differing based on its location, that is from the gauging station to regional office (selected first) and regional to central office. The telecommunication method selected for dissemination of warnings to Union or NGO was undertaken as part of the Feasibility Study and is discussed in **Chapter 7**.

1) From the gauging station

Selection basis for the alternative plan

At the gauging station, electric power reliability is very low. As a result it was decided to use solar power for which overall power consumption must be minimized. Space constraints at the stations also required that the size of the equipment also be minimized.

The selected alternative plans included:

a) VHF

b) BTTB public network

c) Mobile network

d) INMALSAT

Criteria for selection of optimum plan

Criteria for selecting an optimum communication plan were based on the following.

a) Reliability

- BWDB's own network has greater reliability than that of a private company.
- In case of emergency, the communication quality of a private company's network is not necessarily guaranteed due to communication congestion. This raises the possibility of sometimes failing to transmit data from gauging stations.

b) Low power consumption

- In rural areas where gauging stations will typically be installed, reliability of commercial power is generally low.
- Conversely, solar power is an effective option for power supply.
- Equipment with low power consumption is therefore required in the gauging station.

c) Small sized equipment

- In order to minimize gauging station dimensions, the installed equipment must be compact.

d) Less O&M requirement

- In case of equipment malfunction, BWDB staff must repair immediately.
- It is therefore desirable for BWDB staff to use equipment with which they are familiar and have used.
- It takes considerable time and cost to acquire O&M of new equipment.

Evaluation and Conclusion

The most important criteria for collecting data from the gauging stations is reliability of communication. Therefore, VHF radio should be selected even if the costs are greater. An added advantage is BWDB staff's familiarity with the equipment.

The BTTB public network, Mobile network and INMALSAT, being private company networks, are less reliable. In addition, the annual cost of INMALSAT is too expensive when compared with the other plans.

2) From Regional office to FFWC

Selection basis for the alternative plan

From the Regional office to FFWC, various types of data transfer are important including not only observed data but also database information and voice communication. At both the Regional and central (FFWC) offices sufficient space plus a reliable electricity supply are also available, hence various alternative plans are possible including:

a) Digital HF
b) BWDB's Microwave
c) VSAT
d) GRAMEEN Network
e) BTTB Public Network
f) BTTB Lease line

Criteria for selection of optimum plan

Criteria for selecting an optimum communication plan include the following:

a) Reliability

- BWDB's own network has greater reliability than that of a private company.
- In case of emergency, communication quality of a private company's network is not necessarily guaranteed due to communication congestion. This raises the possibility of sometimes failing to transmit data from gauging stations.
- Since quick action for the flood fighting is important, the reliability of telecommunication system should be ensured especially for the central control system.

b) Transmission speed and capacity

- At the Regional office, it is necessary to have sufficient transmission speed and capacity to forward all collated data from telemeter stations to the FFWC.
- Not only data but also voice transmission should available.

c) Less O&M requirement

- In case of equipment malfunction, BWDB staff must repair immediately.
- It is therefore desirable for BWDB staff to use equipment with which they are familiar and have used.
- It takes considerable time and cost to acquire O&M of new equipment.

d) Less repeater stations

- If the number of repeater station is increased, installation costs rise.
- It is preferable that no repeater stations are required.

Evaluation

The most important criteria are reliability of communication and capability of ensuring O&M.

VSAT, GRAMEEN network and BTTB lease line are possibly less reliable during periods of significant congestion. BWDB's microwave is reliable. However, BWDB staff have only limited O&M experience and its installation is expensive.

The digital HF radio network is BWDB's own network, but communication is less reliable because of fluctuations in radio propagation quality. However, BWDB staff are familiar with the equipment (conditional on propagation quality fluctuations) and there is an existing and good O&M system in place.

The BTTB public network is not optimum for main communication networks. It is, however, used for public communication and with low annual operating costs is considered appropriate as a backup communication network.

Conclusion

In case of the regional control system, the sureness of telecommunication between the central and regional offices is less important than that in case of the central control system, because the regional offices can execute almost all of emergency actions without communicating with the central office. For this reason, digital HF radio is optimum and feasible for communications between the Regional office and Central office. To complement the weak point of digital HF, the BTTB public network was adopted as a backup particularly as it is comparatively reliable in the regional areas.

Contrarily, surer telecommunication system between the regional and central offices may be necessary in case of the central controlled system considering that the central office should conduct emergency activities for local community. To meet this requirement, BWDB's own microwave network was considered for the central control system. Also, digital HF with BTTB public line is proposed as optional plan although its reliability is not high. Because, microwave network is not easy to make proper operation and maintenance generally.

4.2.4 Analysis System

As mentioned in **Section 3.5**, the flood forecasting model implemented by the FFWC performs well within available resources. Since the adoption of an alternative flood forecasting analysis model is not necessary, nor indeed practical, recommendations outlined below are associated with the present system.

(1) Improvement Provided by the Installation of Telemetry System

Flood warnings are currently issued by the FFWC defining both real-time and forecast water levels at selected locations within the country.

The former are based on the network of manually observed water level stations installed and operated by the BWDB. The limited automatic telemetry network comprising a total of 14 water level and/or rainfall stations, installed initially in the mid-1980s and expanded in 1996, is not utilized at all in this process. Only 5 stations remained fully operational as of September, 2003.

Flood forecasting is based on the use of a simulation program installed at the FFWC. Flood levels are forecast for future 24, 48 and 72 hour intervals although they are only issued by the FFWC up to 48 hours in advance. To improve the adequacy of the forecasting, particularly in those areas of the country subject to flash flooding, it is proposed that the automatic telemetry network be upgraded and expanded as outlined in **Section 4.2.2**.

To complement the availability of continuous (hourly) water level data from the automatic stations, it is recommended that the simulation model be operated more frequently. For this purpose use of regional models in conjunction with the Supermodel is recommended.

This will require interface programs to be developed to integrate data between the Supermodel and regional model(s), integrate both manually observed records and data from the telemetry stations into the models and to enable the transfer of data between the two systems. Assessment of associated data trends for forecasting of boundary conditions will also be required.

(2) Improvement to be Undertaken by the Inter-agency Basis

As mentioned in **Section 3.5**, the major obstacles for accurate flood forecasting with longer lead time are:

- limitations in existing topographic information, and
- inaccuracy of boundary estimates for flood forecasting.

These problems cannot be solved by installation of a dense telemetry system in Bangladesh or by applying an alternative forecasting system. To overcome these fundamental obstacles, the following recommendations are made:

a) Topographic Information

The source of the current digital evaluation model (DEM at 300 x 300m) is 1:50,000 topographic mapping generated in the 1960's. To account for changes in infrastructure development in the intervening period, the FFWC is making efforts to update the DEM as site specific information becomes available. The topographic surveys should also incorporate the revised national benchmarks recently resurveyed to update existing 1:50,000 and 1:250,000 topographic maps.

b) Future Boundary Estimation

In order to more accurately estimate future boundary conditions, there are many activities/studies ongoing in Bangladesh. These activities are roughly divided into the following approaches:

- Physical Approach (Hydrological / Hydraulic Approach)

  Future boundary conditions estimated using observed hydrometeorological information for sites outside Bangladesh by means of hydrological/hydraulic simulation models, for example water level correlations, use of radar for estimation of rainfall etc.

- Statistical Approach

  Future boundary conditions are estimated based on statistical approaches using historical hydrometeorological records, for example 'Neural Networks' or 'Artificial Intelligence'.

- Qualitative Approach

  Future boundary conditions are estimated by qualitatively interpreting available hydrometeorological information, such as water levels at Indian stations with those on the international borders, radar and satellite images now received in the FFWC control room etc.

Given the lack of hydrometeorological data from India available to the FFWC and limited development of more sophisticated physical methods such as estimation of rainfall using radar images or the statistical approaches listed above, the FFWC is at present only able to consider the qualitative approach.

Nonetheless, in the future the hydrological/hydraulic approach is considered to be the most suitable and the following recommendations are therefore made:

- Ongoing efforts should be made for the collection of hydrometeorological data outside Bangladesh, especially in India.
- Quantitative estimation of rainfall outside Bangladesh utilizing existing information of meteorological radar, especially in the Meghalaya mountainous area to the north-east where much of the flash flooding originates, is important.
- Regardless of the availability of Indian data, the limitation of current flood forecasting results should be clarified and clearly stated to the local population.

4.2.5 Warning Dissemination System

(1) Inhabitants

Documented procedures for flood warning dissemination to inhabitants already exist, as mentioned in the Standing Orders for Disaster, 1999, and these generally work well down to the Upazilla level. However, the dissemination link between Upazilla and Union is not functioning properly. The proposed alternative is "Current procedure with major upgrading in the lower tiers together with feedback".

In this alternative, the following aspects should be included:

- Flood warning bulletin issued by FFWC must reach all district administrations
- Local BWDB staff who are members of District Disaster Management Committee (DMC) should assist in interpreting warning messages
- Local BWDB staff will monitor the dissemination process in the lower tiers
- Introduction of reward / punishment for the Upazilla level officer responsible for informing Union DMC

- Involvement of local NGOs in the Upazilla and Union DMC
- Arrangement of wireless or mobile phone at Union by participatory contribution
- Introduction of feedback system, for example, once the Union DMC receives information there should be some mechanism to confirm that to Upazilla DMC
- Training of volunteers at village level as currently undertaken in the CPP

(2) River Structures

BWDB operates various river structures such as embankments, polders, pumping stations, irrigation intakes, irrigation canals, etc. Unfortunately, there are no fixed guidelines on routine dissemination of flood warning for all BWDB field operation offices. Also, there is no system to incorporate flood warning in the operation of the various river structures maintained by Roads and Highways (RHD), Bangladesh Inland Water Transport Authority (BIWTA), Bangladesh Inland Water Transport Corporation (BIWTC), Bangladesh Agricultural Development Corporation (BADC), etc. Structures maintained by these agencies include bridges, ferry terminals, ports, irrigation canals, pumping stations, etc. The proposed alternative is "all river structure operation must receive flood forecasting".

In this alternative, the following aspects should be included:

- Flood warning will be provided to the central O&M office of BWDB, which in turn will inform all field operation offices,
- For major structures, flood warning will be given directly to the project operation office,
- After receiving flood warning, BWDB divisional office will also inform field operation offices,
- Flood warning will be provided to all relevant agencies and respective agencies will inform their field operation office, and
- For major facilities such as ports, bridges and major ferry terminals, flood warning will be given directly to the field operation offices.

4.2.6 Response System

(1) Evacuation

There is no fixed setup for appropriate flood evacuation. However, a well-developed system is operating for cyclone warning under CPP. An effective flood evacuation system should be initiated in order to achieve similar benefits with flood warning. DMCs at various levels should take responsibility with overall supervision by Disaster Management Bureau (DMB).

In this proposal, the following aspects should be included:

- Actual responsibility of evacuation should lie with Union DMC,
- Volunteers should be trained to a similar level as those in the CPP to assist in the evacuation process,
- Upazilla DMC should earmark evacuation centers and transportation, and

- Upazilla DMC should arrange security for evacuated dwellings.

(2) Other Non-structural Responses

There is no response management for other non-structural measures such as harvesting, and fish cultivation. A proper response system would reduce the property damage caused by flooding.

In this proposal, the following aspects should be included:

- A response management guideline should be prepared by DMB,
- District DMC should issue response measures for agriculture and fisheries taking into consideration flood warnings,
- District DMC will work closely with the relevant agencies such as the Directorate of Agriculture Extension (DAE) and Fisheries Department, and
- Union DMC should inform the people and monitor the responses undertaken.

(3) Response for River Structures

Even BWDB does not at present use flood forecasting in their operation of river control structures. Other agencies operating river structures also do not incorporate flood forecasting in their operation. A proper response will ensure smooth operation and safety of the structures.

In this proposal, the following aspects should be included:

- A response management guideline should be prepared by all concerned agencies including BWDB,
- The Operation and Maintenance office of each agency should issue response measures for river structures taking into consideration flood warnings,
- Field operation offices of each agency should undertake proper response measures as stipulated in the guideline, and
- District level offices of the concerned agencies should monitor the action taken by the field offices.

4.3 Institutional Alternatives

4.3.1 General

As explained in **Section 2.8**, the present institutional setup has a serious bottleneck in delivering desired services in relation to flood forecasting. To overcome these, three alternatives can be considered. These are:

- Current Organization with some major improvement
- Establishment of regional offices of Hydrology Service, and
- Establishment of regional offices of BWDB.

4.3.2 Organizational Alternatives

(1) Current Organization with Some Major Improvement

At present, there are three data collection circles for surface water, groundwater and morphology. These collect the data and forward to the PFFC circle. In PFFC circle, there are 3 processing branches for those 3 circles.

The FFWC is one branch of PFFC. For flood forecasting, FFWC uses water level and rainfall data from a selected number of stations in the overall BWDB hydrometeorological network. Real time data transmission from these stations is again performed by another branch of PFFC, the C&I division. However, C&I division is also responsible for maintaining electro-mechanical instrumentation for the entire Hydrology.

For smooth operation of hydrology in general and flood forecasting in particular, improvement is proposed as shown in **Figure 4.3.1**. In this proposal, the present mandate of PFFC is divided based on similar work nature. The newly proposed Processing Division will be placed directly under the Hydrology service and will consist of the three present processing branches, Index and publication branch, and Management and services branch. Because of its strategic location, it will be easy for this division to coordinate with the three data collection circles. A new circle will be created, the Flood Hydrology Circle. There will be three divisions under this circle. The present FFWC will become Forecasting division with a mandate of flood forecasting, model update, model validation and low flow forecasting. Part of the present C&I will become Data Transmission division and a new division named data collection division will be created by transferring some personnel from the Surface water hydrology circle. Part of the C&I division will become Instrumentation division placed directly under Hydrology Service, and will be responsible for maintaining electro-mechanical equipment of the three data collection circles.

The mandate of the Flood Hydrology Circle (FHC) will include:

- Collection of all observation data
- Transmission of data to regional office
- Operation of the supermodel
- Issue of flood forecasts with local context
- A mandate to be a member of national disaster management committee
- Monitoring of the warning dissemination process
- Assisting in the evacuation and other response management
- Undertaking dry season monitoring

(2) Establishment of Regional Offices of Hydrology Service

FFWC is now working at central level. In some instances, it is not possible for FFWC to interact closely with the local authorities. To overcome this problem, establishment of regional offices of Hydrology Service is proposed as an alternative.

In this alternative, in addition to the re-organization of the Hydrology service centrally as explained in alternative 1, regional offices of Hydrology service will be established. Under the regional Hydrology Service, the organization will be similar to that operating centrally. The mandate of the regional FHC will include:

- Collection of all observation data
- Transmission of data to regional office
- Operation of the regional flood forecasting model
- Issue of flood forecasts with local context
- A mandate to be a member of regional disaster management committee
- Monitoring of the warning dissemination process
- Assisting in the evacuation and other response management
- Undertaking dry season monitoring on a regional basis

Before full operation, the regional FHC will test run the regional models for at least 2 years. During this interim period, the supermodel will continue operation. Once the regional models function accurately, the supermodel can be operated for monitoring of the entire country.

(3) Establishment of Regional Offices of BWDB

The coordination among different sections of BWDB is not always satisfactory especially at field level. Planning and design are done centrally, major implementation is done by specific project offices and O&M are done by O&M field offices. Furthermore, hydrology field offices work separately from the field offices of O&M. This results in problems with coordination.

In this alternative, there will be a number of BWDB decentralized regional offices headed by a regional director. The office will be responsible for all activities such as planning, design, implementation, operation and maintenance, and hydrology including flood forecasting. The mandate and activity of the FHC under the regional BWDB will be the same as in Alternative 2.

4.4 Combined Alternatives and Selection of Optimum Framework Plan

4.4.1 Candidate Alternatives

(1) Basic Problems Encountering in the Present FFWS

Prior to the assessment of the conceivable alternatives, the basic problems which must be addressed include the following.

a) Insufficient information from India

Bangladesh is located at the confluence of the three International Rivers, the Ganges, Brahmaputra and Meghna. Therefore, hydrological conditions in Bangladesh are largely dependent on hydrometeorological conditions in India. Without hydrological data from India, floods in Bangladesh cannot be forecast more accurately than at present. Hydrological information currently received from India is limited and considered insufficient.

Conceivable solutions to overcome this basic problem are i) Rainfall forecasting using satellite images, ii) Concluding bilateral or regional agreements on hydrological information exchange among all countries and iii) Rainfall forecasting using radar.

Among the above, application of satellite imagery is premature as the technology for rainfall prediction is only now being developed and will take more time for practical application. The second conceivable solution has been seriously addressed by the GOB. However, it is taking considerable time to reach agreement on data exchange. The GOB is now intending to introduce a rainfall-radar system covering some areas in India as well as the entire area of Bangladesh, although a schedule for its installation is not fixed yet.

When realized, all conceivable solutions will contribute to upgrading the accuracy of flood forecasting. In this Study, however, alternative plans will be conceived under existing conditions and those that can be addressed internally within Bangladesh.

b) Insufficient Operation and Maintenance

It must again be emphasized that the present operation and maintenance of the flood forecasting and warning system is very weak in view of the following:

- The existing telemeter system has never been used for flood forecasting. In this regard, the following should be confirmed:
  - Necessity of telemeter gauging stations
  - Recognition by staff working in FFWC and other related offices of the importance and necessity of the FFWS.

  If this necessity is recognized, possible countermeasures by all means regardless of shortage of budget, manpower, equipment, etc should be employed.
- Currently, only 5 telemeter gauging stations (of the original 14 installed) are operational. There are a number of reasons as outlined in **Chapter 3**, including gauges being washed out and/or silted up, unavailability of spare parts, etc. The question then is whether to "just abandon or reactivate either at the same location or an alternative site" with replacement only occurring if really necessary.
- There is no ledger sheet recording the history of operation and maintenance of FFWS facilities. The operation and maintenance may not be conducted properly without ledger sheet. Ledger sheets of telemeter equipment also provide some form of control on availability of spare parts.
- It is difficult to ensure that gauge reader(s) observe water level and rainfall on time as mandated. Reviews of historic records sometimes indicated possible doubtful data. The divisional office should take necessary actions in such cases by monitoring the gauge readers in order to ensure observations are undertaken as scheduled.
- Some equipment rooms of gauging stations are not properly maintained suggesting periodic maintenance is not undertaken.
- Orderly operation and maintenance are a basic requirement for equipment included in a sophisticated telemeter system.

c) More accurate flood forecasts with longer lead-time

At present, BWDB defines the lead time for flood forecasting as 24-, 48- and 72-hours. According to BWDB, the accuracy of 24 hours forecast is about 98%, while 48 hrs and 72 hrs forecasts are considerably less accurate but still good. During the Workshops conducted by the JICA Study Team the participants, of which the majority were farmers, indicated a need for flood forecasting with a longer lead time (more than 4 days) to allow early harvesting of agricultural crops. This would not be possible without more information from India.

Flash floods result in serious damage especially in the north-eastern area (around Sylhet). The GOB has a specific intention to develop a FFWS in this area although the possible lead time may only be a few hours even with the installation of a telemeter system.

Conceivable solutions are i) flood forecasting with a telemeter system combined with rainfall forecasts using radar to reduce time for forecasting and ii) regional forecast operation to reduce time. Furthermore, the authorities and people should be informed of the accuracy of the forecast with respect to lead time and its technical limitations so they can properly judge the necessary actions to be undertaken. In a flash flood river, the forecast lead time will be limited (4-5 hours only). Therefore, the FFWS should clearly define possible forecast lead time by region. These alternative solutions have been taken into account in this JICA Study.

(2) Combined Alternatives

As implied from the above discussion on present condition, problems encountered and conceivable solution, the basis of the combined alternatives is I-Observation system and II-Institutional arrangement (central and / or regional operation systems). The conceivable combined alternatives are given below.

Alternative 1: Centralized Control System (FFWC central office same as current organization with some improvement)

- Alternative 1-1: All manual observation system
- Alternative 1-2: All telemeter system
- Alternative 1-3: Combined manual and telemeter systems

Alternative 2: Regionalized Control System (Regional office under BWDB *or under Chief Engineer, Hydrology*)

- Alternative 2-1: All manual observation system
- Alternative 2-2: All telemeter system
- Alternative 2-3: Combined manual and telemeter systems

In terms of the communication method between the center and region, "Microwave" and "Digital HF with back up of BTTB public line" were selected for Alternative 1 and 2, respectively. However, since the microwave has difficulty in the operation and maintenance, "Digital HF with back up of BTTB public line" for Alternative 1 was also included in the comparative study as Alternative 1'.

4.4.2 Institutional Arrangement

The organization of BWDB is highly segregated. Because of the top-down chain of command, and in spite of implementing work with similar objectives, cooperation among various divisions is not always smooth. Therefore, work congestions occur between related divisions negatively affecting their operations.

The basic administrative role should be "to build the base for livelihood and production and secure the national safety". Administration has a duty to mutually cooperate to realize works beneficial to the nation.

FFWS will never become effective simply by installed additional equipment. The organization should be modified to eliminate the biggest problem associated with the FFWS, that is that flood forecasting and warning is not reaching the public.

1) Decentralization

The basic policy of the Bangladesh Government is decentralization and efficient manpower utilization. The decentralization approach selected as one of the conceivable alternatives in **Section 4.4.1** fully complies with the basic Government policy.

As discussed in **Section 4.4.1**, to overcome the present institutional constraints it is necessary to modify the FFWS to a decentralized operation. To achieve that two approaches can be considered: a) Regional office of BWDB and b) Regional office of Hydrology Service. When the overall picture of river and water resources management is considered, it would be better to merge O&M and Hydrology Divisions. The subsequent unification of the regional river management would provide an effective and efficient river management system to oversee planning, design, as well as maintenance. However, given the closed and top-down organization existing in BWDB the merging of O&M and Hydrology Divisions would be very time consuming. Therefore, the Study Team proposes that regional offices be set up for Hydrology Division.

2) Smooth Operation of Hydrology Service

For smooth operation of hydrology in general and flood forecasting in particular, improvement is proposed as shown in **Figure 4.3.1**. In this proposal, the present mandate of PFFC is divided based on similar work nature. The newly proposed Processing Division will be placed directly under the Hydrology service and will consist of present three processing branches, Index and publication branch, and Management and services branch. Because of its strategic location, it will be simple for this division to coordinate with the three data collection circles.

There will be three divisions under this circle. The existing FFWC will become the

Forecasting division with a mandate of flood forecasting, model updating and model validation. Part of the existing C&I will become Data Transmission division and a new division, Data Collection division, created by transferring some personnel from the Surface water hydrology circle. Part of the C&I division will become Instrumentation division placed directly under Hydrology Service, and will be responsible for maintaining electro-mechanical equipment of the three data collection circles.

In this proposal, it is considered that common organizations such as Instrumentation Division and Processing Division should be placed directly under Hydrology Service for effective and efficient organizational setup.

Although changing an organizational structure is delicate and difficult, a strong willingness that these changes be implemented will be necessary to ensure the future FFWS works effectively.

4.4.3 Comparative Study of Combined Alternatives

Each combined alternative is aimed at improving the existing FFWS. In this section, a technical evaluation of each combined alternative is presented on the basis that each will provide the same level of effectiveness. An evaluation is also presented in terms of organization and cost-effectiveness. This provides an estimate of required investment for service improvement when evaluated from the socio-economic viewpoint.

(1) Technical Evaluation

Criteria for Selection of the Optimum Plan

In order to compare alternative proposals, the technical aspects for each alternative plan were considered in terms of a) Sureness, b) Accuracy, c) Timeliness, and d) Official. These are defined below.

a) Sureness

The FFWS should be highly reliable. The flood warning message must be forwarded with sureness. Warning messages must be disseminated to all concerned under any weather conditions. That is, a reliability of more than 99% should be ensured.

b) Accuracy

Needless to say, the higher the accuracy of the flood forecast the more accurate the warnings provided by the FFWS. However, higher accuracy will only be achieved with higher costs. The JICA Study Team assumed the acceptable error (required accuracy) of the 24-hour forecast, defined as the difference between observed and forecast water levels, should not exceed:

- 20cm when the change in water level over the 24 hour period is less than 1m or
- 20% of the change in water level over the 24 hour period if this exceeds 1m.

c) Timeliness

All components of the forecasting procedure undertaken by the FFWS shall occur as quickly as possible to enable dissemination of the warning message to the various beneficiaries within a certain designated time, such as 4 hours for evacuation of people, 12 hours for preventative works for protection of river structures and 4 days for farmers to allow harvesting.

d) Official-ness

The Government is responsible for disseminating flood warnings. If flood damage occurs due to incorrect flood warnings, the Government shall compensate for such damage. Therefore, flood forecasting and dissemination of flood warning messages may not be conducted by private entities or those without the necessary responsibility. Flood forecasts must be official.

Evaluation

a) Sureness

Selection of suitable observation sites for disaster management

The observation of water levels of rivers at borders of the country and also those located internally is important to accurately define existing river conditions. Only with this information can appropriate disaster management response be initiated. In particular, timely observation and provision of this information are required for flash flood or tidal surge areas and the selection of suitable observation sites in these regions is important.

Sureness in dissemination of information

Sureness of information dissemination is dependent on provision of secure lines of communication to union, the responsible agency for evacuation. In addition, secure communication is also essential with other supporting organizations such as NGOs. For wide-ranging transmission of information to the general public, alarms or emergency public broadcast announcements with loudspeaker would also be effective.

In the case of regional control, information is directly disseminated from the Regional office and staff must act to guarantee its sureness.

For central control where FFWC collects, analyzes and distributes information, it is necessary to have not just central staff in charge of regional communications but also local field personnel (and office) to guarantee sureness of dissemination. In addition, long distance and hot line telephones between FFWC and field office would be essential.

Sureness in collected information

Sureness in collection of information from observatories is dependent on continuous observation and a reliable communication system for transmission of data.

The telemeter circuit is a reliable means of communication guaranteeing transmission even during emergencies (e.g. natural disasters) when public lines are less reliable. It is of course at times such as these that transmission is essential. It is also preferable that the telemeter stations be fixed to structures such as a bridge or a stable dyke. Due to continuous river fluctuation of many rivers in Bangladesh, this is sometimes not possible and stable structures must be constructed at significant cost.

Manual gauge observation, to be comparable to the telemeter recording requires continuous hourly observation by multiple gauge readers. A shelter would therefore be necessary at most gauge stations for continuous recording throughout the night.

b) Accuracy

To improve the accuracy of flood forecasts, observations must be both free of error and also recorded at suitable locations for use in the hydraulic modeling applied in the FFWS.

Accurate observation

Manual observations raise the possibility of reading errors, temporal errors (incorrect time of reading) and communication errors. Approaches to reduce these effects include a double check system using several observers and mobile telephones with a direct data input function. However, automatic recording (and transmission) based on a telemeter system eliminates such errors and the larger the number of such stations installed the higher the observation accuracy of the overall network.

Observation at suitable locations

To improve model accuracy, hydraulic conditions at model boundaries under existing and future conditions must be better defined. For existing conditions, installation of telemeter gauging stations at important boundary locations (defining model boundary conditions) will assist. Upstream data from India are also extremely important for definition of existing and future boundary estimates. But at present such information is generally not available for the most relevant stations from India to be used in this estimation or is not continuously transferred.

c) Timeliness

Lead time required for warning will be unique to the local situation due to its dependence on local flood characteristics. In the flash flood areas where the available lead time is relatively short, continuous telemeter observation and transmission of information could be used to increase the number of times the flood forecasting model is operated and thus improve forecast accuracy at least in the short term. In addition, the improved estimation of water levels/discharges at the upstream boundaries (borders of the country) through acquisition of information from India is important in increasing the accuracy of flood warnings and available lead time in the flash flood areas.

While the regionally-controlled system only requires a circuit to gauging station to regional office, the centrally-controlled system requires a circuit from the gauging station to central office.

In the central system, even if information is obtained, responses to local disaster management are likely to be longer and a 'hotline' between central and field staff is necessary for timely response.

Also the regional office is likely to have a greater appreciation of local conditions. Warning preparation and dissemination activities can therefore be implemented more effectively by the regional offices.

d) Official-ness

For a flood forecasting and warning system to benefit the overall public, it must contribute to the wider disaster management and evacuation procedures of the population. Thus, information must be certain of reaching those affected and must be clearly understood.

A very important aspect of the FFWS is allocating official responsibility to the offices and agencies involved in implementing the various activities. While announcing FFWC information widely through public broadcasting or newspapers can be effective, information distributed through the official network should be adapted to ensure full understanding at a local level. During emergencies, conditions also tend to change continuously at this level and a centralized system would find it more difficult to cope or provide accurate and relevant information. For this reason, regional staff would also be required to remain and act in the local areas.

Countermeasures Necessary for Effective FFWS

Central Control Plan (Alternative 1)

	Alternative 1-1	Alternative 1-2	Alternative 1-3
	Telemeter = 0 Manual = All	Telemeter = All Manual = 0	Telemeter = 23 Manual = Rest
Sureness	*Manual Station* Doubling of gauge readers for 23 gauging stations Automatic entry system with Mobile phone	*Telemeter Station* Stable and expensive structures	*Telemeter Station* Stable and expensive structures *Manual Station* Automatic entry system with Mobile phone
Accuracy	*Manual Station* Double check of reading data for 23 gauging stations Check program for mis-typing		*Manual Station* Check program for mis-typing
Timeliness	*Manual Station* Hourly reading for 23 gauging stations		
	Timely dissemination and activity with field Hot line from Central office to O&M division, Union and other related organizations Enough staff in central office in charge of region		
Official-ness	Confirmation of response activity and collecting local situation and information by O&M division		

Regional Control Plan (Alternative 2)

	Alternative 2-1	Alternative 2-2	Alternative 2-3
	Telemeter =0 Manual = All	Telemeter =All Manual = 0	Telemeter = 23 Manual = Rest
Sureness	*Manual Station* Doubling of gauge readers for 23 telemeter stations Automatic entry system with Mobile phone	*Telemeter Station* Stable and expensive structures	*Telemeter Station* Stable and expensive structures *Manual Station* Automatic entry system with Mobile phone
Accuracy	*Manual Station* Double check of reading data for 23 gauging stations Check program for mis-typing		*Manual Station* Check program for mis-typing
Timeliness	*Manual Station* Hourly reading for 23 gauging station		

(2) Institutional Evaluation

Sureness of information provided is dependant on coordination with the union, which is responsible for evacuation, and with other supporting organizations such as NGOs. Furthermore, it is also important to join in the local disaster management committee to effectively use the provided information and participate in the flood management and evacuation activities.

Whether the FFWS system becomes a true official system depends on how effectively the information provided by it can function for the public's disaster management activities. As the union is responsible for the local residents' disaster management activities, the important key is how effectively the FFWS information can be used in these activities by the Regional office.

For an effective FFWS, data collection and transmission are very important. In the central system, maintenance is time consuming, which may prove fatal during times of emergency. Conversely, maintenance is more efficient from the regional office.

Comparative merits of the centralized and decentralized administration of Hydrology service with respect to FFWS service are given in **Table 3.8.2**.

(3) Cost Evaluation

The technical evaluation clarified the required improvements necessary in the various alternatives to produce similar levels of effectiveness in an improved FFWS. The associated investment costs and operation and maintenance costs for implementing these countermeasures are outlined and compared below.

In case of central control system, Alternative 1 includes the utilization of BWDB's exclusive microwave network for the communication between the regional and central offices. In addition to this, an Alternative 1', in which digital HF with BTTB public line to be utilized for the communication between the regional and central offices, is considered.

In case of regional control system, digital HF with BTTB public line is proposed.

Investment Cost

Condition of evaluation for investment cost

a) Facilities

Central Control Office:	Dhaka
Regional Office:	5 Regional offices
Manual or Telemeter Stations:	108 locations

b) Equipment

Main Server:	National information database from all observatories including both Telemeter and Manual
Regional Server:	Regional information database from gauging stations including both Telemeter and Manual
Supermodel System:	Nationwide flood warning system covering three major rivers
Regional Model System:	Local flood warning system for the regional scale
Monitor:	Terminal for supervising operations
Repeater Equipment:	Radio relay station
Telemeter Equipment:	Equipment of Telemeter Station

Mobile Phone: Mobile phone for digital data transmission from manual gauging station

Digital HF set: Digital HF set for digital data transmission from manual gauging station (where mobile phone cannot be utilized)

Warning Equipment: Point to point Warning Equipment for dissemination (32 sets in each flash flood area)

Data transmission Equipment between the Regional and Central Offices:

Alternative 1: Microwave Equipment (13 repeater stations)

Alternatives 1' and 2: Digital HF with BTTB line

Conclusion of Comparative Study

Investment cost estimates for each alternative plan are indicated as follows.

Investment Cost of Central Control Plan (Alternative 1, with Microwave)

Alternative		1-1	1-2	1-3
Number of Telemeter Stations		0	108	23
Number of Manual Stations		108	0	85
Number of Equipment (unit: Nos.)				
Central Office	Main Server	1	1	1
	Super Model System	1	1	1
	Regional Server	5	5	5
	Regional Model System	5	5	5
Repeater Station			81	27
Telemeter Station			108	23
Manual Station	Mobile Phone	54		43
	HF digital	54		42
Warning Equipment		32	32	32
Investment Cost (unit: Million Taka)				
	Direct installation	951	1,904	1,225
	Administration	10	19	12
	Engineering	143	286	184
	Training	6	12	8
	Contingency	47	118	66
Total Investment Cost (Million Taka)		***1,156***	***2,339***	***1,495***

Investment Cost of Central Control Plan (Alternative 1', without Microwave)

Alternative		1'-1	1'-2	1'-3
Investment Cost (unit: Million Taka)				
	Direct installation	566	1,521	840
	Administration	6	15	8
	Engineering	85	228	126
	Training	4	9	5
	Contingency	26	98	46
Total Investment Cost (Million Taka)		***686***	***1,871***	***1,026***

Investment Cost of Regional Control Plan (Alternative 2)

Alternative		2-1	2-2	2-3
Number of Telemeter Stations		0	108	23
Number of Manual Stations		108	0	85
Number of Equipment (unit: Nos.)				
Central Office	Main Server	1	1	1
	Super Model System	1	1	1
Regional Office	Regional Server	5	5	5
	Regional Model System	5	5	5
Repeater Station			81	27
Telemeter Station			108	23
Manual Station	Mobile Phone	54		43
	HF digital	54		42
Warning Equipment		32	32	32
Investment Cost (unit: Million Taka)				
	Direct installation	646	1,600	925
	Administration	6	16	9
	Engineering	97	240	139
	Training	4	10	6
	Contingency	31	103	51
Total Investment Cost (Million Taka)		***785***	***1,968***	***1,130***

The investment cost of central control plan with microwave (Alternative 1) becomes much higher than the regional control plan (Alternative 2). Moreover, even when comparing the costs for the central control plan without microwave (Alternative 1') and regional control plan (Alternative 2), the differences are not large though Alternative 1' showed lower investment cost.

On the other hand, comparison of alternative plans with different numbers of telemeters indicates that the "all manual" plan is the least expensive, followed by the plan with 23 telemeters. The "all telemeter" plan is very costly.

Operation & Maintenance Cost

The operation and maintenance cost was calculated based on staffing and electricity/communication and depreciation costs for equipment.

<u>Condition of evaluation for investment cost</u>

a) Staffing .

[Basic Concept]

For the regional and central control plans for FFWS, after examining the existing FFWC and C&I staffing, the numbers of staff were determined by considering various tasks at each Flood Hydrology (FH) office including analysis, editing/provision of information, communication equipment maintenance, observatory maintenance, driving, and administration.

[Gauge Reader]

One gauge reader was assumed to be permanently stationed to perform manual observations and take the reading every hour (in line with the data available from the telemeter stations). For this reason, 3 gauge readers will work in rotating 8 hour shifts.

As explained in **Section 4.2,** 23 observation points were considered necessary for the combined alternative. For reliable observation data from these stations, there should be two gauge readers working concurrently. This would ensure continuous and accurate observations with a very high reliability.

[Central Control FFWS]

Even when the central control system is adopted, provision of water level information, flood warning information and so on locally and to promote local activities through the regional disaster management committee are still important. As a result, regional staff was considered necessary in each regional office for the local disaster management activities while dissemination coordinators were required in the central control office of the FFWC for the regional areas.

[Staff Salaries]

Standard salaries were set as follows:

Staff Salary for Cost Estimate

Position	Salary
Superintending Engineer (SE)	Tk. 20,000 x 14 (man-year)
Executive Engineer (XEN)	Tk. 17,000 x 14 (man-year)
Sub-divisional Engineer (SDE)	Tk. 15,000 x 14 (man-year)
Assistant Engineer (AE)	Tk. 10,000 x 14 (man-year)
Technical Staff	Tk. 6,500 x 14 (man-year)
Support Staff	Tk. 6,000 x 14 (man-year)
Gauge Reader	Tk. 5,000 x 14 (man-year)

b) Repair and maintenance cost

It is estimated annual repair and maintenance costs will be 0.5% of total telemeter equipment cost, 10.0% of total computer equipment cost, 2.0% of total civil construction cost and 5.0% of existing gauging station cost.

c) Other O&M costs

Other O&M costs included transportation costs for business trips, communication costs for daily data transmission and warning dissemination, electricity costs for offices and other incidental costs.

d) Depreciation cost for equipment

It is estimated annual depreciation cost will be 10% for equipment, 20% for computers and 3.3 % for the structure.

Conclusion of Comparative Study

Annual O&M costs estimated for each alternative plan are indicated below.

Annual O&M Cost for Central Control Plan (Alternative 1)

Alternative		1-1	1-2	1-3
Number of Telemeter Stations		0	108	23
Number of Manual Stations		108	0	85
Number of Staff	SE	1	1	1
	XEN	3	3	3
	SDE	9	9	9
	AE	14	21	17
	Technical Staff	39	88	45
	Support Staff	35	61	40
	Gauge Reader	223	21.6	90
	Total	324	204.6	205
O&M Cost (Million Taka)	Staffing	26.9	20.5	19.0
	Repair, Maintenance	43.3	47.6	46.4
	other O&Ms	15.0	17.1	15.7
	Sub Total	85.2	85.1	81.1
Depreciation Cost (Million Taka)		140.4	279.3	181.0
Total Annual O&M Cost (Million Taka)		***225.6***	***364.4***	***262.1***

Annual O&M Cost for Central Control Plan (Alternative 1')

Alternative		1-1'	1-2'	1-3'
O&M Cost (Million Taka)	Staffing	26.9	20.5	19.0
	Repair, Maintenance	21.9	26.2	25.0
	other O&Ms	18.4	20.5	19.1
	Sub Total	67.3	67.2	63.1
Depreciation Cost (Million Taka)		83.4	222.5	124.0
Total Annual O&M Cost (Million Taka)		***150.7***	***289.7***	***187.2***

Annual O&M Cost for Regional Control Plan (Alternative 2)

Alternative		2-1	2-2	2-3
Number of Telemeter Stations		0	108	23
Number of Manual Stations		108	0	85
Number of Staff	SE	1	1	1
	XEN	8	8	8
	SDE	17	17	17
	AE	17	17	17
	Technical Staff	46	96	51
	Support Staff	42	67	47
	Gauge Reader	223	21.6	90
	Total	354	227.6	231
O&M Cost (Million Taka)	Staffing	31.5	24.0	23.0
	Repair, Maintenance	24.0	28.3	27.1
	other O&Ms	15.2	16.5	15.5
	Sub Total	70.7	68.8	65.6
Depreciation Cost (Million Taka)		95.4	234.3	136.8
Total Annual O&M Cost (Million Taka)		***166.1***	***303.1***	***202.4***

When comparing the costs for Alternative 1 and 2, the annual O&M costs for Alternative 1 are considerably high. This is due to the additional repair and maintenance costs for the microwave equipment.

However, when comparing the costs for Alternative 1' and 2, the results indicate the annual O&M costs of the central control system are less than those of the regional control system. This is due to the additional maintenance and operational costs of the regional facilities for the latter system.

Economic Evaluation

Expected Effect of FFWS

According to **Section 2.6**, annual average flood damage is estimated to be 12,161 Million Taka. In this assessment, the effect of all countermeasures such as FFWS, flood proofing, rescue and so on were assumed to be from 5% to 10% of annual average flood damage. The reductions due specifically to the FFWS were estimated to be 10% of these countermeasure effects, that is 0.5% to1% of annual average flood damage. The estimated amount of damage avoided through implementing the FFWS was therefore estimated to range from 61 to 122 Million Taka.

Cost of Alternative Plans

Among the alternative plans considered, the maximum costs were calculated as:

- investment cost for equipment = 2,339 million Taka (Alternative 1-2)
- annual O&M cost (excluding dep.)= 85.2 million Taka (Alternative 1-1)

Evaluation

When comparing the annual O&M costs and expected annual effects of the FFWS for the various alternatives the latter are larger, indicating that the currently planned equipment investment is within the appropriate boundary.

4.4.4 Selection of Optimal Plan

Based on the results of the comparative study presented in **Sections 4.4.2** and **4.4.3**, Alternative 2-3 was selected as the optimum plan by the Study Team based on the following factors:

(1) Institutional Aspect

One important issue for the FFWS is that information issued must reach the end beneficiaries. To achieve this, establishment of regional Hydrology offices and participation in the local disaster management committee and local disaster management activities are suggested. In terms of the institutional option, the Study Team proposes the Regional Control system for Hydrology Services (Alternative 2, see **Figure 4.4.1**).

(2) Technical Comparison on Sureness

In case of the regional control system, the sureness of telecommunication between the central and regional offices is less important than that in case of the central control system, because the regional offices can execute almost all of emergency actions without communicating with the central office.

Contrarily, surer telecommunication system between the regional and central offices may be necessary in case of the central controlled system considering that the central office should conduct emergency activities for local community. To meet this requirement, BWDB's own microwave network was considered for the central control system.

(3) Cost Comparison

The Study Team proposed two alternatives concerning the institutional matters and each alternative had three technical alternatives for data collection and transmission. The comparison of both investment and O&M costs was made among the alternatives.

Cost comparison in view of institution (Central vs. Regional)

As a result, the central system (Alternative 1') showed a little lower cost than the regional system (Alternative 2) both in the investment and O&M costs. However, in case of the central system with exclusive microwave network (Alternative 1), both investment and O&M costs became higher than those of the regional system. This shows that the costs (investment and O&M) of the central control system are higher than those of the regional control system if the reliability and effectiveness of FFWS to be secured in the competitive levels both in the central and regional systems.

The Study Team concluded that the regional control system is more preferable.

Cost comparison in view of data collection and transmission

In terms of the investment cost, the all manual system showed the lowest. However, in terms of the O&M cost, the combined (telemeter and manual) system showed the lowest (without considering the depreciation).

For the all telemeter system, the high cost reflects the impact of the expensive structures required to install the telemeter stations. These are indispensable in Bangladesh due to the often high and rapid fluctuations in water levels in the rivers. For the all manual system, the need to provide duplication of gauge readers (to ensure the same effectiveness in data observation and transmission as in the telemeter system) results in increased personnel costs.

It is also clear that in the case of a manual system, accurate water level measurement during the night would be difficult while for an all telemeter system O&M costs are high.

It is therefore proposed that a combined system including both telemeter and manually observed stations be adopted.

4.5 Operation and Maintenance

4.5.1 Organization

The "Operation" and "Maintenance" (O&M) tasks based on the selected optimum plan for the FFWS are categorized in **Table 4.5.1**. This FFWS organization basically consists of a central FFWC system in Dhaka complemented with a network of regional FFWC centers. The associated organizations include existing Surface Water Division and River Morphology Division as well as a newly proposed Instrumentation Division and Processing Division.

(1) Surface Water (Regional)

The proposed optimum plan suggests that Surface Water Division's gauge readers will conduct the reading as currently occurs. In case of the automatic reading with the telemeter, occasional staff gauge reading will also be required for supplemental purposes. In principle, the required number of gauge readers should therefore remain unchanged from the current number. In addition, Surface Water Division will also continue the discharge measurement program and collection and posting of observed data.

(2) River Morphology Division (Regional)

This division will continue its existing program of river cross-section measurement.

(3) Regional FFWC

Each Regional FFWS office will be the base for their respective Data Collection Division, Data Transmission Division and Forecasting Division.

1) Data Collection Division will be responsible for the maintenance of observatories and collection of data. It will also be in charge of repairing sensors and buildings, setting the staff gauges and measuring staff gauge levels.
2) Data Transmission Division will be responsible for maintenance of automatic gauges, telemeter system, communication system and system equipment. It will also undertake HF radio transmission when required.
3) Forecasting Division will provide forecasting and warning at the regional level. It will also undertake river monitoring utilizing local model analysis, provide information for local disaster management agencies via fax and e-mail, and participate in disaster management activities with the local disaster management committee. In addition, it will undertake any modification of Analysis Model software and Hazard Maps and manage and maintain computer system software.

(4) Central FFWC

Central FFWC will also comprise Data Collection Division, Data Transmission Division and Forecasting Division.

1) Data Collection Division will be responsible for the maintenance of observatories and collection of data and regular collation of information forwarded from regional offices.
2) Data Transmission Division will be responsible for maintenance of all electronic equipment including communication system and system equipment. It will also undertake HF radio transmission when required.

3) Forecasting Division will provide forecasting and warning at the national level. It will also conduct river monitoring utilizing the Supermodel analysis and provide information to central government agencies, broadcast stations and newspapers via fax and e-mail. In addition, it will undertake any modification of the Analysis Model (Supermodel) and Hazard Maps and manage and maintain computer system software.

(5) C&I Division

This will succeed the Equipment Manufacture and Maintenance Division of C&I, currently located in Dhaka at Green Road. It will undertake calibration of discharge measurement instruments and manufacture staff gauges for water level observation and rainfall gauges.

(6) Processing Division

It is proposed that this agency will manage the process of transferring the recorded data into the system database and distribute it to necessary agencies. It will also process and transfer all data received from the field via mail including river cross-sections and discharge measurement information. Such information will be used, for example, in any updating of the analysis model.

4.5.2 Staffing

Considering the existing structure of BWDB, staffing needs to be deployed so that the proposed organization can function efficiently and effectively. In particular, the regional FFWC must provide support to local disaster management activities as a member of the local disaster management committee. It also should be capable of undertake the hydraulic analysis based on recorded data accurately and quickly. This will ensure speedy and appropriate decisions by the relevant agencies. This will require that the regional centers be staffed with managers capable of making decisions and engineers with technical knowledge to support disaster management. The proposed staffing schedule for both central and regional centers is presented in **Table 4.5.2**.

Currently, FFWC has executive engineers (XEN) with appropriate decision-making skills who manage the existing organization. Executive engineers (XEN level) with similar capabilities are required to manage regional and central offices of FFWC. Moreover, under XEN management, an appropriate number of assistant engineers and staff are required to ensure the three proposed Divisions within each center are fully functional.

4.5.3 Legal Arrangement

Laws and regulations defining the roles and rights of those involved in river management do not currently exist but are now under consideration. The proposed FFWC system requires participation of the regional center in local disaster management activities as a member of the local disaster management committee. In order to extend such FHC activities, its roles and responsibilities need to be defined by law.

CHAPTER 5 INTERNATIONAL RIVERS

5.1 Constraints on River Management in Bangladesh

In Bangladesh about 93 percent of surface waters originate outside the country. Effective river management, therefore, depends significantly on river management in upstream countries, particularly India, with whom Bangladesh shares 56 rivers. In relation to the scope of the FFWS study, it is critical for Bangladesh to obtain flood-related data from neighboring countries, particularly India and Nepal, and incorporate them into the modeling system to enable flood forecasting with longer lead time and improved accuracy.

The operation of the gates of barrages in India is said to be causing sudden floods in some parts of Bangladesh, though exact details are often not known. Other phenomena and activities in upstream areas also affect flows and quality of rivers and related aspects. It is well known that as a result of the operation of the Farakka Barrage, the water flows downstream in the Ganges during the dry season were reduced. This was associated with falls in groundwater levels, increases in sediment and changing bed profile of the river, and increases in salinity in both surface water and groundwater. More studies are, however, required to determine the exact cause and effect relationships.

Land erosion occurring in Nepal is reported to be causing sediment increases in river beds in Bangladesh. Pollution of river waters is another emerging problem which is beyond the control of Bangladesh if it originates in upstream areas. The recently announced plan of the Indian government to link 37 rivers in India with canals and reservoirs, if implemented without regard to the interests and needs of Bangladesh, is expected to virtually cripple the country's river management.[1]

5.2 Problems on International Rivers

A list of the 56 rivers Bangladesh shares with India plus three rivers the country shares with Myanmar and their locations are found in **Figure 2.4.11**. It is reported that there are dams, barrages, or other water diversion facilities upstream in India on a total of at least 30 of these rivers. On the Ganges as well as other common rivers, BWDB regularly collects data on water level, discharge, sedimentation, groundwater, salinity, among others. These data were analyzed and reported regularly, particularly in the form of a yearbook during the 1980s, but the activities have been abandoned since then due to staff and budget shortages.

[1] The Guardian (UK), 23 July 2003. The Daily Star (Bangladesh), 14 August 2003 and subsequent issues. The Bangladesh Foreign Ministry lodged an official protest against the India's water diversion plan to the Indian High Commissioner in Bangladesh on 13 August 2003. India environmentalists and the eastern states of West Bengal and Assam, who may lose water to the western states, are opposed to this plan. The estimated project cost is around US$200 billion and many are questioning its feasibility.

In the meantime, several studies have been conducted to identify effects of the reduction of the Ganges flows. One of the most recent was carried out by Ainun Nishat utilising data from 1976 to 1992.[2] It should be noted here that regular observation, monitoring and analyses of various conditions on international rivers are the mandate of BWDB and must be reactivated, particularly in light of the limited availability of information and data from India.

5.3 Coordination on International Rivers between Bangladesh and India

5.3.1 The Indo-Bangladesh Joint Rivers Commission

The governments of Bangladesh and India set up a Joint Rivers Commission (JRC) in 1972 with a view toward harnessing the rivers of the two countries for the benefit of both. The initial role of JRC was mostly related to flood management and included such tasks as the development of proposals on advanced flood forecasting and warning and the formulation and implementation of flood control works (the Statute of the Indo-Bangladesh Joint Rivers Commission is found in **ANNEX-IV**). JRC in each country comprises the chairman, who is the Minister of Water Resources, and three Members, two of them being engineers and one representing the Ministry of Foreign Affairs. Under JRC, the following committees and forums have been constituted to monitor or work on different issues:

➢ Joint Committee of Experts (JCE)	Headed by the Secretary, Ministry of Water Resources in each country. Since the conclusion of the 1996 Ganges Treaty, JCE has been focusing on water-sharing of other common rivers.
➢ Technical Standing Committee	Headed by Member, JRC in each country. The Member can appoint four advisors depending on the issues. JRC or JCE can request the Technical Standing Committee to look into certain issues when they arise.
➢ An expert committee on the data for flood forecasting and warning	To discuss additional data and information sharing for flood forecasting and warning. The committee has not met recently.
➢ Joint Committee for the Joint Inspection and Monitoring of the sharing of the Ganges waters at Farakka	To monitor and implement the water-sharing arrangement of the Ganges Treaty.
➢ Local level committees	To identify river-related problems in West Bengal, Assam, Meghalaya, and Tripura, focusing on erosion and bank protection works. Headed by the chief engineer of the regional BWDB office and his/her counterpart chief engineer in India. A number of misunderstandings and problems have been solved through this local mechanism. Unresolved matters are referred to JRC.

[2] A. Nishat, Impacts on Bangladesh of the Ganges Water Disputes, Asian International Waters: From Ganges-Brahmaputra to Mekong, ed. Asit K. Biswas and Tsuyoshi Hashimoto, Oxford University Press, 1996 (Japanese translation published in 1999).

5.3.2 The Agreement and Negotiations on Flood-related Data Sharing

Water level, discharge and rainfall data are being transmitted from certain stations in India to Bangladesh under agreements made at the Indo-Bangladesh Joint Rivers Commission (JRC) in 1972 and subsequent years. (The 1972 agreement is provided in **ANNEX-IV**. Also see **Section 2.4.4.**) Except for occasional delays in the data transmission due to weather and human factors, it is being carried out in accordance with those agreements. In 1996 the Bangladesh JRC made a proposal to the Indian side requesting (a) data from other stations which are located in more upstream areas and (b) continuous transmission of three hourly water level and discharge data regardless of whether the level is at or above the warning stage (**ANNEX-IV**). An expert level forum was entrusted with the task of working out details on this proposal, but the talks have progressed little, although some improvements have been made on additional point-to-point data exchange.

5.3.3 A Regional Flood Information System in South Asia

The proposed "Regional Flood Information System in the Hindu Kush-Himalayan (HKH) Region" (by ICIMOD and WMO) offers an important opportunity for the Bangladesh FFWS to address the data limitation issues.[3] However, the crucial question is the participation of India in the network.[4]

5.3.4 The Ganges Water Treaty

The Ganges Water Treaty signed in 1996 (**ANNEX-IV**) succeeded the original 1977 Treaty with regard to water-sharing of the flows of the Ganges during the dry season from 1 January to 31 May. (Two MoUs bridged the gap between these two treaties to continue the water-sharing arrangement, which ended with the expiration of the second MoU in 1988.) The history of negotiations and implementations of the Ganges water-sharing is provided in **Table 5.3.1**.

Except for some problems encountered in 1997 such as discrepancies of the data recorded at the two observation points (Farakka in India and Hardinge Bridge in Bangladesh), the water-sharing agreement has been working well. One issue that arose with respect to the water-sharing is India's proposal to review Article II (iii), which directs the two governments to undertake consultations if the flow at Farakka falls below 50,000 cusecs in any ten-day period and make adjustments to the water-sharing arrangement "in accordance with the principles of equity, fair play and no harm to either party." India's options include a 50:50 sharing, to which Bangladesh is opposed as it needs 35,000 cusecs as guaranteed in the Treaty. An innovative feature of the 1996 Treaty is a provision requiring the two countries to "conclude water-sharing Treaties/Agreements with regard to other common rivers" guided by

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[3] Details are found at www.southasianfloods.org. The project is supported by the US and Danish governments.
[4] As of writing of this report, India continues to maintain that it will engage only in bilateral dialogue and arrangement and not in any multilateral framework.

"the principles of equity, fairness and no harm to either party"(Article IX). A Joint Committee of Experts (JCE) established in 1997 has been focusing on seven medium rivers toward this goal, giving the highest priority to the Teesta, on which India and Bangladesh constructed barrages in 1986 and 1990 respectively. India proposed a five year study to determine water availability and requirements, to which Bangladesh responded that an interim water-sharing agreement must be in place before such a study takes place.[5] Negotiations have been stalled since then. In the meantime, in an effort to address the long-term issue of augmenting the Ganges flows within Bangladesh, the Government of Bangladesh undertook a pre-feasibility study on a Ganges barrage. This concluded that the barrage project can be implemented as part of a wider integrated water resource management programme to resolve problems in the Ganges dependent areas. The EIRR identified in the study, however, is very low at around 4%.

5.3.5 Bilateral and Regional Cooperation for the Management of Water Resources

Beyond the Ganges Treaty and the general framework that established the JRC, there is no specific legal mechanism between Bangladesh and India to govern and facilitate efforts to manage international rivers. Agreements with co-riparian, upstream countries, particularly with India, are critical for Bangladesh in order to undertake effective river management. The National Water Policy fully recognizes this need and articulates that the government will "endeavor to enter into agreements with co-riparian countries for sharing the waters of international rivers, data exchange, resource planning and long-term management of water resources under normal and emergency conditions of flood, drought and water pollution." The policy is in line with the principle embodied in the customary international law such as the Helsinki Rules of 1966 and the UN Convention of 1997 (see below).

Against the backdrop of the positive political climate in the wake of concluding the Ganges Treaty and the Mahakali Treaty (between India and Nepal) in 1996, an international seminar on the "Water Resources Management and Development in Bangladesh with particular Reference to the Ganges River" was held in Dhaka in March 1998. The delegates agreed: i) to take up a dredging project of the Gorai to provide immediate alleviation of the environmental degradation on the Ganges Dependant Areas (GDA), ii) to conduct further studies on optimal use of the Ganges, and iii) to continue the process of the regional cooperation building on the Ganges and Mahakali treaties. However, except for a study to explore options for the GDA concrete actions have not taken place. The positive momentum in the late 1990s seems to have faded away and been replaced by inactions and mistrust. While a bilateral JRC has not been held since January 2001 despite repeated requests from Bangladesh,

[5] Key records of the JRC meetings on the implementation of the Ganges Treaty, augmentation issues, water-sharing of other common rivers as well as flood-related date are found in Avtar Singh Bhasin, India-Bangladesh Relations Documents: 1972-2002, Volume II: Sharing of River Waters, New Delhi, Geeika Publishers, 2003.

India announced the river-linking plan in 2002, which was again stated publicly in August 2003.[6]

5.3.6 "Second Track" Approaches

With the aim of promoting negotiations at the government level for data and information exchange, water-sharing, and ultimately joint planning and management on common rivers, Bangladesh Unnayan Parishad (BUP), together with the Center for Policy Research (CPR) in India and the Institute for Integrated Development Studies (IIDS) in Nepal have been undertaking research and dialogue since the 1990s. Their activities, which came to be known as "Track II," as opposed to the government level ("Track I") negotiations, have resulted in three publications. The last one describes "GBM Regional Water Vision 2025," jointly developed by the participants including former Indian government officials. Newly proposed initiatives to follow up on this vision as well as other on-going and planned activities at the non-governmental level are summarized in **Table 5.3.2**.

5.4 International Water Law

5.4.1 International Water Agreements

There are more than 260 major international rivers in the world. The United Nations Food and Agriculture Organization (FAO) counted more than 3,600 treaties on international water issues between the years 805 and 1984, the majority of which deal with navigation.[7] After World War II, many treaties were negotiated on non-navigational issues of international rivers such as water allocation, hydropower development, flood control and water quality management. A recent endeavor has identified around 300 international treaties concluded since 1945 on non-navigational issues of water management, flood control, hydroelectric projects, and allocations for consumptive and non-consumptive uses of international rivers.[8] The Transboundary Fresh Water Disputes Project (TFWDP), a comprehensive and interdisciplinary analysis of international surface water conflicts, has created a systematic computer compilation of international water treaties currently including 140 treaties.[9] Principal focuses of these treaties by region and the number of the treaties are summarized as follows:

[6] After a long interval, JRC met on 29 September 2003.

[7] FAO, Systematic Index of International Water Resources Treaties, Declarations, Acts and Cases by Basin, 1978.

[8] A.T. Wolf, International water conflict resolution: Lessons from comparative analysis, Water Resources Development 13, 1997.

[9] Heather L. Beach, Jesse Hamner, J. Joseph Hewitt, Edy Kaufman, Anja Kurki, Joe A. Oppenheimer, and Aaron T. Wolf, Transboundary freshwater dispute resolution: Theory, practice, and annotated references, United Nations University, 2000.

International Water Agreements

Principal Focus	Eurasia	North America	South America	Africa	Total
Water supply	33	3	2	12	50
Flood control	11	2			13
Hydropower	22	11	6	11	50
Industrial uses	2		2	6	10
Pollution	4				4
Navigation	1		2	3	6
Fishing	1				1

5.4.2 Development of International Water Law

Historically, two extreme positions were often claimed by riparian countries: the "doctrine of absolute sovereignty" claimed by upstream riparians that a state has absolute rights to water flowing through its territory; and the "doctrine of absolute riverine integrity" argued by lower riparians that a state has entitlement to the natural flow of a river system crossing its borders. Over time, these positions were moderated with the concept of responsibility and were transformed into the "doctrine of limited territorial sovereignty."

The balance between the principle of "reasonable and equitable use" of the waters of an international river and the "obligation of not to cause significant harm" was developed, with an emerging consensus in the international water law community to put more emphasis on the latter. These concepts were incorporated in the *Helsinki Rules on the Uses of the Waters of International Rivers* adopted by the International Law Association in 1966.

After more than 20 years of deliberations, the basic principles in the Helsinki Rules were developed into a report by the International Law Commission (an advisory body of the UN General Assembly) which became a basis for the *United Nations Convention on the Law of the Non-navigational Uses of International Watercourses.* The Convention, accepted by the UN General Assembly in 1997, codified the principles of "reasonable and equitable use" within each watercourse State "with a view to attaining optimal and sustainable utilization thereof and benefits therefrom" and the "obligation of not to cause significant harm to other watercourse States"(Articles 5 and 7). In the event of a conflict between the two principles, resolution will be based on the requirements of "vital human needs" (Article 10). The Convention also emphasizes the "obligation to cooperate," calling for regular exchange of information (Article 9).

The Convention has not yet entered into force, as the number of countries that have ratified or approved it has not reached the required number of 35. The Convention as it stands today, therefore, does not legally bind any state. However, it represents the accumulation of wisdom and principles developed over time and provides states with general but important guidelines for the development and management of international rivers.

5 4 3 Other Water Treaties in South Asia

There are two other noteworthy international river treaties in South Asia the Indus Treaty between India and Pakistan (1960) and the Mahakali Treaty between India and Nepal (1996)

The Indus Treaty is often cited as an example of sharing a common river with effective facilitation by a third party (the then President Black of the World Bank) This Treaty divided the two river systems between the two countries the western system was given to Pakistan and the eastern system to India A similar arrangement is not possible in the GBM region, where the only solution is to share common rivers

The Mahakali Treaty is for the construction of a high dam on the Mahakali River for flood moderation, irrigation and power generation An important institutional mechanism provided in the Mahakali Treaty is an arbitration procedure with a third party involvement to resolve disputes The Treaty, however, has not been working well as the two governments differ on the interpretation of a provision that sets out the method of water-sharing and as a result the Mahakali project has stalled

In addition to the Indus, Ganges and Mahakali Treaties, India has agreed with Nepal on a cooperative arrangement on flood forecasting and warning India and Bhutan have agreements on a comprehensive scheme of hydrometeorological data collection and transmission and on joint hydroelectric projects However, India has been refusing to date to engage in any multilateral negotiation on international rivers

5.5 Recommendations

5.5.1 Flood Forecasting and Warning

In relation to the current FFWS study, effective flood forecasting and warning in Bangladesh requires acquisition of additional data and information from India and their incorporation into the modeling system of FFWC. It is without saying that under the best practice principles of international water law, riparian countries have an "obligation to cooperate" and should be engaged in "regular exchange of data and information" in a manner which facilitates its utilization by other watercourse states.[10] However, in light of the slow progress of the JRC talks with regard to the proposal made by Bangladesh in 1996 and judging from the records of JRC and expert level meetings and subsequent exchanges between the Bangladesh JRC and FFWC, FFWC is advised to take the following actions

a) To collect all data and information transmitted from India through the point-to-point exchange arrangement on a continuous basis,
b) To incorporate all data and information sent from India, i e those coming through the IMD-BMD arrangement, point-to-point exchange data, rainfall data obtained from the website, and any other relevant information into the modeling system of

[10] Articles 5, 8, and 9, the UN Convention, 1997

FFWC; and

c) To conduct simulations using the available data from India to determine their usefulness and limitations and present the results to the Bangladesh JRC for further negotiations with the Indian side.

In addition, as advised in **Section 2.5.4** above, the operation rules and records of barrages on key rivers in India should be made available and a transboundary water release warning system must be established as essential measures to mitigate artificial flood damage. MOWR is advised to take initiatives to (re)include these issues in the JRC agenda.[11]

While pursuing further dialogue and negotiations at the government level, supplemental efforts at the non-governmental level would be useful for building trust and understanding between Bangladesh, India and Nepal. The "Track II" approach, based on its achievements made so far, as well as other new initiatives can be supported for this purpose with a particular focus on flood management. Detailed technical level dialogue and exchanges involving government engineers of the three countries to the extent possible in unofficial meetings and forums will help promote an environment for similar exchanges at the government level, as experienced in the 1990s leading up to the conclusion of the 1996 Ganges Treaty.

5.5.2 Comprehensive Management Frameworks for the GBM Rivers

In addition to flood management, other issues such as water shortage, water quality, sedimentation, riverbank erosion, ecology and environment need urgent, coordinated attention throughout the river basins. Discussions between Bangladesh and India have so far been focusing on water-sharing and augmentation on the Ganges and water-sharing on another seven medium rivers. Cross-border riverbank erosion issues have been addressed in the Local Level Committees of JRC to some extent.

While the talks on the augmentation of the Ganges date back to the 1970s, no breakthrough seems to be on the horizon yet. In the meantime, attention has shifted to the construction of the Ganges barrages as well as barrages on other rivers within Bangladesh in efforts to address the water shortage issue during the dry season without relying on measures that require international agreements. However, the proposed schemes identified in the draft National Water Management Plan require further, detailed studies. In particular, the Ganges barrage requires an in-depth study to determine its feasibility in view of the very low EIRR (around 4%) identified in the OGDA report.

While undertaking further studies on the proposed river schemes within Bangladesh, efforts aimed at long-term, rational solutions looking at the entire river courses need to be pursued. Negotiations on not only flood-related data sharing and water-sharing

[11] It has come to the knowledge of the FFWS study team that the issue was raised to the Indian JRC as early as in the mid 1970s in the context of monitoring water flows on key rivers during the dry season. The operation rules and records are needed to prepare for and mitigate any artificial flood damage as well.

arrangements but also comprehensive management frameworks for the GBM rivers should be promoted. Such frameworks, reflecting the basic principles of international water law as described in **Section 5.4**, will enable the best possible use and control of water throughout a river basin, ensuring optimization and equitable distribution of economic, social and environmental benefits and costs in the entire watercourses.

The first step needed towards such a direction is to conduct an objective study to determine water balance in the GBM, based on which a master plan can be developed. Simultaneously, free and wider sharing of all relevant information and data on the common rivers and projects and interventions thereof needs be promoted. The experiences of the Mekong Committee to use joint data gathering as the first major cooperative task, which worked to overcome suspicion and build trust among the participating riparian countries, present a good example. The Track II type, non-governmental level dialogue and activities and a skilled and neutral intervention of a third party at the government level would be required to facilitate the process.

5.5.3 Domestic River Management

Domestic river management issues as identified in **Sections 2.4** and **2.5** must be addressed as part of efforts towards international river management. For instance, as mentioned in **Section 5.2**, data on water level, discharge, sedimentation, groundwater, water quality and salinity, among others, should be consistently analyzed, monitored and reported at least on key rivers. This will help identify exact problems encountered in international rivers, which will in turn enhance the negotiating capacity and position of Bangladesh vis-à-vis co-riparian countries.

PART-III FEASIBILITY STUDY

CHAPTER 6 BASIC APPROACH TO THE FEASIBILITY STUDY

6.1 General Approach

This Chapter presents the general approach to the Feasibility Study for the FFWS undertaken in this JICA Study. The work flow chart is given in **Figure 6.1.1** and a brief explanation of the contents of each work item is presented below.

(1) Framework Plan and Selection of Optimum Plan

As explained in **Chapter 4**, the Framework Plan of the FFWS was initially prepared during which a number of alternatives were developed. From these an optimum plan (candidate plan for the feasibility study) was tentatively selected by the Study Team. The acceptability of this plan was subsequently confirmed with the Bangladesh Government through detailed discussions.

The alternative plans focused on two areas, namely I) organizational strengthening, i.e. **Regional Management System** through the establishment of regional offices of FFWS and **Central Management System** with some modification in the current organization, and II) strengthening of the hydrological observation system, i.e. **Manual Observation System, Automatic Observation System,** and **Combined Observation System comprising both manual and automatic networks**.

As outlined in **Chapter 4**, the JICA Study team recommended the **Regional Management System** in conjunction with **Combined Observation System** as being the optimum plan.

This overall scheme was selected as being both practical and realistic after detailed discussion with the Bangladesh Government and taking into account the possibility of re-organization or organizational improvement.

(2) Feasibility Study of the Selected Project Scheme

A Feasibility study was then conducted for the nationwide FFWS. This covered the entire area of Bangladesh and incorporated the following 5 steps:

1) Feasibility Design of FFWS Facilities
2) Feasibility Design of Evacuation System
3) Institutional Strengthening Plan
4) Project Evaluation
5) Selection of Priority Project and its Implementation Plan

I. Feasibility Design of FFWS Facilities

FFWS Facilities should include a) hydrological observation system, b) data transmission system, c) flood forecasting analysis system and d) flood warning and dissemination system. In addition to the study conducted during the Basic Study Stage at the commencement of this Project, the following studies were undertaken in greater detail.

a) Hydrological observation system
- Detailed reconnaissance of the gauge sites specifically for the proposed telemeter gauges
- Feasibility design of the gauging stations to evaluate the most suitable gauge type and equipment

b) Data transmission system
- Digital data transmission system for manual observation system
- Alternative study and design of data transmission system for telemeter system
- Feasibility design of the data transmission system

c) Flood forecasting analysis system
- Review of computer system to determine if upgrading or improvement was required
- Improvement of warning message

d) Flood warning dissemination system
- Detailed study on the measures for flood warning message dissemination
- Improvement of flood warning dissemination system to ensure warnings reach the end users/beneficiaries and the message is clearly and readily understood
- Feasibility design of flood warning dissemination system

II. Feasibility Design of Evacuation System

a) It is assumed feasibility design of the evacuation system will be conducted by DMB, the authority mandated to implement overall disaster management and relief in the country. A Study in this regard is now being undertaken with the assistance of UNDP.

b) The JICA Study provides recommendations for the improvement of the existing evacuation system taking into account the current problems and required changes.

III. Institutional Strengthening

a) In the opinion of the Study Team the most critical issue for the improvement of the FFWS and its more effective operation is related to institutional matters.

b) The Study includes organizational, regulatory and budgetary requirements for operation and maintenance of the FFWS, the latter being extremely important given the current shortfalls in budget allocation and manpower requirements.

IV. Project Evaluation

a) Economic evaluation

The FFWS is an integral component of the basic national strategy for disaster management. Usually, economic feasibility for this kind of project is not conducted. However, in order to promote the FFWS improvement in Bangladesh with the mutual consent of all related agencies, its economic evaluation has been undertaken as a trial case. It is noted that, because of limited data availability, the economic feasibility study was incorporated even though it has necessarily been limited to qualitative analyses with some quantitative assessments, albeit based on a large number of assumptions. Much of the information used in the quantitative analysis was obtained through interview surveys of O&M divisional officers within the BWDB.

b) Social impact evaluation

The social impact of the FFWS is extremely difficult to quantify and was limited to a certain degree to a qualitative evaluation. Again, much of the information used in this evaluation was based on interview surveys of O&M divisional officers of BWDB.

c) Environmental impact evaluation

Basically, FFWS does not result in any adverse environmental impacts. Rather, they are positive, through mitigation of flood damage. Conceivable environmental impacts were taken into account as much as possible in the evaluation.

V. Selection of Priority Project

a) The Framework Plan provides a basic outline for the nationwide FFWS covering the entire area of Bangladesh. The selected candidate project for the Feasibility Study also provided coverage of the same area.
b) Existing restraints on financial capability and available manpower were considered when formulating the proposed project. As a result, the priority project was selected on a regional/divisional basis to ensure its implementation taking into account necessary funding, available manpower, etc.
c) The Implementation plan was drafted based on the studies outlined above.

6.2 Technical Approach

From the technical viewpoint, studies of the following components of the priority project were undertaken with basic designs to feasibility level carried out.

i) Observation System

- Selection of gauge type and adoption of manual observation and/or telemeter gauging stations taking into account site conditions

- Convenience for operation and maintenance

ii) Data Transmission System

- Digital communication system
- Radio propagation analysis
- Inter-agency information system

iii) Flood Forecasting Analysis System

- Computer system in the regional office in the case of regional FFWS
- Upgrading of flood warning message including recommendations for necessary topographic surveys

iv) Flood Warning Dissemination System

- Flood warning system for inhabitants
- Flood warning system for river structures
- Point-to-point warning system

v) Evacuation System

- Evacuation center/shelter
- Recommendation to the DMB for further study on evacuation system

6.3 Institutional Approach

From the institutional analysis presented in **Sections 2.8, 3.8** and **4.3**, it is apparent that BWDB is not functioning properly. BWDB is fully aware of this with the Annual Report of BWDB (2001-2002) stating: *"With the passage of time, the inherent conflicts and contradictions within the system and operational methodology of the Board gradually surfacing as the works progressed and more insight gained. Most of the completed projects were in miserable conditions due to lack of repair and maintenance and delivering (the services) sub-optimally. One of the main reasons was the maintenance of a huge redundant project staff even after project completion leaving little or no resources for project maintenance."* (Chapter 1, page 2).

One of the major problems of BWDB is centralized operation. BWDB is also fully aware of the necessity of de-centralization. The same report also mentions: *"While the concept of water management was shifting its focus globally from central control to demand driven joint management with stakeholders at the grassroots, BWDB failed to update itself by adaptation and continued with traditional top-down modus operandi. This created a big gap between authority and the beneficiaries who were shying away from taking any responsibility of a project in their locality with the result that projects were becoming more and more dependent on meager government resources for upkeep"* (Chapter 1, page 2).

Another major problem of BWDB is segregation of work responsibility. The Annual Report of BWDB mentioned: *"Lack of coherent policy backed by a holistic framework has been responsible for fragmented efforts in the sector causing more harm than* *good*' (Chapter 1, page 2).

In line with the observations of the Study Team obtained through the course of the Study and also of the BWDB, the proposed basic institutional approach will revolve around decentralization and integration of existing work practices.

For the institutional approach, the following components were evaluated.

i) Central Disaster Management System

- Improvement of the organization
- Task and duty of the central office

ii) Local Disaster Management System

- New organizational set-up of local disaster management system
- Task and duty of the regional office

iii) Organizational Setup

- Organization chart
- Required manpower / Number of staff by grade

iv) Law and Regulation

- Mandate of regional office
- Recommendation on improvement of evacuation system to DMB

v) Budget Allocation

- Estimate of necessary annual budget for operation and maintenance of FFWS
- Recommendation on the budget allocation

6.4 Project Evaluation

(1) General

Project evaluation included economic evaluation, social impact assessment and environmental impact assessment as outlined below.

(2) Economic Evaluation

(a) Benefits attributable to the FFWS include the following:
- Saving of human lives
- Protection of movable assets in the household
- Early harvest of agricultural crops
- Mitigation of damage to infrastructure
- Mitigation of traffic congestion

(b) Benefit-cost analysis was undertaken based on IRR and current economic conditions (future economic development was not incorporated)

(3) Social Impact Evaluation

(a) Social impacts associated with FFWS operation were determined qualitatively on the basis of interview surveys

(b) No quantitative analysis was undertaken

(4) Environmental Impact Evaluation

(a) No negative impact to the natural and social environment is considered likely

(b) Positive impact through mitigation of flood damage is considered to be a benefit

(c) Only qualitative evaluation of the impacts was possible