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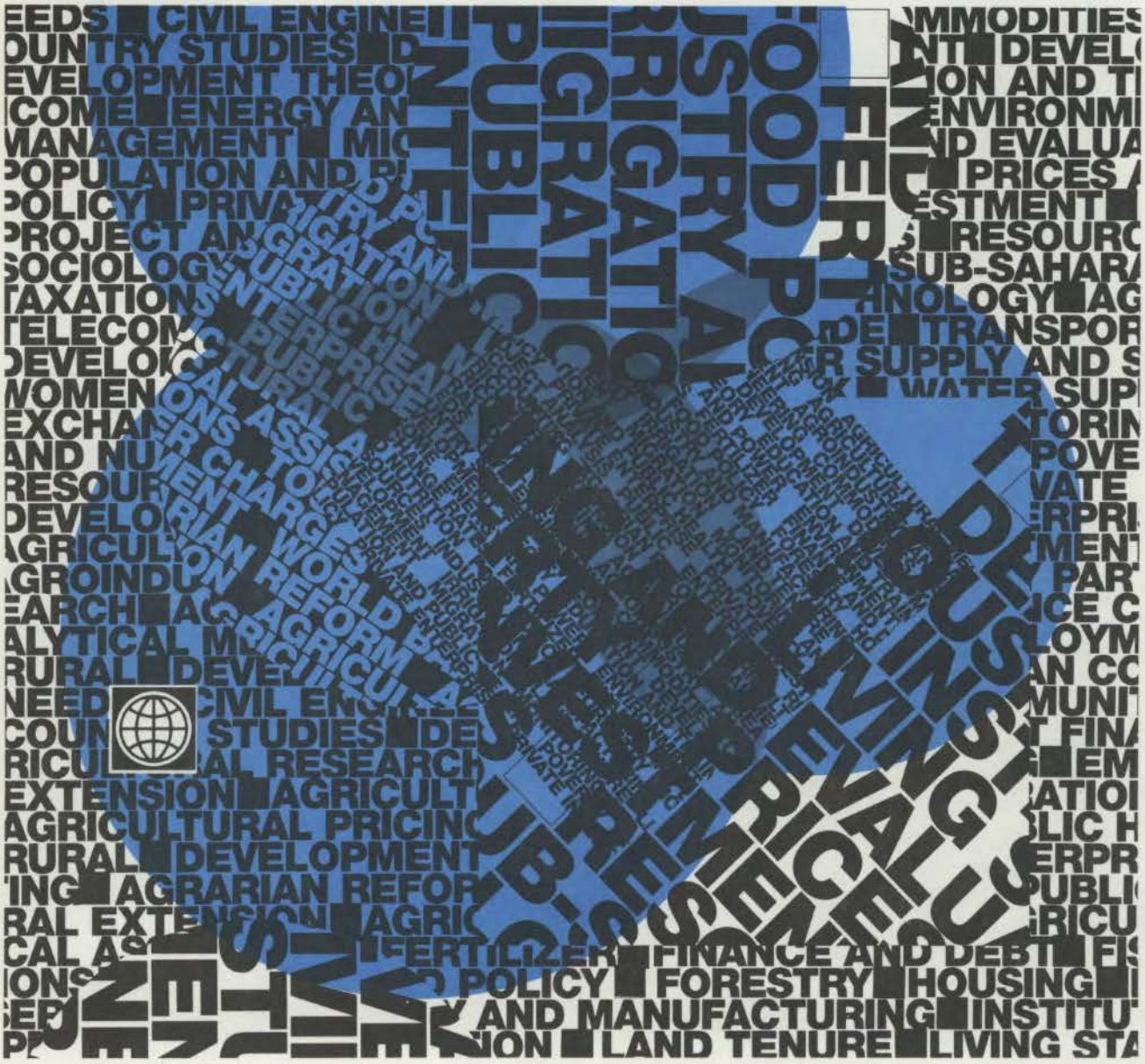
Flood Control in Bangladesh

A Plan for Action

Asia Region
Technical Department



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ABSTRACT

In 1987 and 1988, Bangladesh experienced disastrous floods from the Brahmaputra and Ganges rivers. These events stimulated considerable international interest in helping Bangladesh deal with its flood problem. In June 1989, the World Bank agreed to a request from the Government to help in coordinating the international efforts. This report outlines an Action Plan which would be the first step in the implementation of a comprehensive long-term program for flood control and drainage in Bangladesh. It provided a basis for a conference held in London in December 1989 which secured support for the Action Plan from numerous countries and agencies. The report is now being used as the main reference document for the Action Plan. The report was prepared by Bank staff with considerable contributions from government staff and from experts involved in the various studies.

The Action Plan, covering the five-year period 1990-1995, is to be seen as the first of several stages in the development of a comprehensive system of flood control and drainage works designed to meet the Government's long-term objectives. It would be carried out in parallel with agricultural development and a program of non-structural measures such as flood forecasting, flood warning, flood preparedness and disaster management. The Plan, which will comprise planning studies, supporting activities, high priority projects and first-stage flood projects, will provide a proving ground for setting the foundations of a long-term flood control and drainage program.

This report was prepared by Bank staff working with experts who had been associated with various recent studies of the Bangladesh flood problem. The main contributors are listed below and the sources of financing for their services are shown in parentheses. UNDP, in addition to financing some members of the team, provided funds for office support and report preparation.

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CURRENCY EQUIVALENTS

The external value of the Bangladesh Taka (Tk) is fixed in relation to a basket of reference currencies, with the US Dollar serving as the intervention currency. The official exchange rate on November 1, 1989, was Tk 32.3 per US Dollar.

WEIGHTS AND MEASURES

1 meter (m)	=	3.28 feet (ft)
1 kilometer (km)	=	0.62 mile (mi)
1 square kilomter (sq km)	=	0.39 square miles (sq mi)
1 hectare (ha)	=	2.471 acres (ac)

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
AFPM	Active Flood Plain Management
BWDB	Bangladesh Water Development Board
CIDA	Canadian International Development Agency
DTW	Deep Tubewell
EEC	European Economic Community
FCD	Flood Control and Drainage
FCDI	Flood Control, Drainage and Irrigation
GIS	Geographical Information System
G-7	Group of Seven Industrialized Countries
HYV	High Yielding Variety
IDA	International Development Association
LLP	Low lift Pump
LV	Local Variety
MPO	Master Plan Organization
NGO	Non-Governmental Organization
NWP	National Water Plan
SPARRSO	Spare Research and Remote Sensing Organization
STW	Shallow Tubewell
USAID	United States Agency for International Development
WMO	World Meteorological Organization

CONTENTS

1. BACKGROUND

1.1 The disastrous 1987 and 1988 floods have stimulated considerable international interest in helping Bangladesh deal with its flood problem. In June 1989, the World Bank agreed to a request from the Government to help in coordinating the international efforts. The Bangladesh floods and the role of the Bank were referred to in the communique of the July 1989 G7 economic summit meeting in Paris (Annex A). This report outlines an Action Plan which would be the first step in the implementation of a comprehensive long-term program for flood control and drainage in Bangladesh. Its purpose is to provide a basis for discussion at the London conference in December 1989 to be attended by the countries and agencies interested in participating in such a program. The report has been prepared by Bank staff with considerable contributions from government staff and from the experts involved in the various studies described below.

1.2 In 1987 and 1988, Bangladesh experienced two of the most severe floods on record. Widespread damage was caused to crops, roads, railroads, cities and towns, and more than three thousand people lost their lives. These floods were a major setback to the country's economy, in part because of the heavy expenditures by the Government in its prompt and effective relief efforts and in part by the disruption of economic activities. These floods stimulated the Government to undertake a comprehensive review of flood policy and, soon after the 1988 flood, work began on a Flood Policy Study and a Flood Preparedness Study. These studies, both financed by UNDP, were completed in early 1989. Other countries responded in 1988 by initiating and financing flood studies, including a 'Pre-feasibility Study of Flood Control' jointly carried out by a team of experts from Bangladesh and France, an 'Eastern Waters Study' sponsored by USAID, and a study supported by the Japanese Government. A summary of these studies is presented in Annex B.

1.3 It is over thirty years since the first systematic study of the Bangladesh flood problem was carried out by a UN-sponsored team. This was followed by a Master Plan prepared in 1964 which proposed a large number of projects combining the functions of flood control, drainage and irrigation. Subsequently, some major embankments were built along parts of the main rivers, including the World Bank-financed Brahmaputra Right Embankment. In those pre-Independence days, major water control works were seen as a prerequisite to advances in agricultural production. But, by the early 1970's, the advent of low-lift pumps, tubewells, and the spread of dry-season cropping led to a strategy based more on small-scale, quick-yielding projects rather than major flood control works. Thus, the flood control debate had receded into the background until the floods of 1987 and 1988. Strategies and options for flood control in Bangladesh have been debated for many years. On one side is the argument that periodic flooding in Bangladesh is largely unavoidable because the works needed to eliminate flooding from the rivers are, in some areas, technically and economically infeasible and, moreover, tend to create as many problems as they solve. Those who support this argument believe there is considerable scope to build on the ability of the Bangladeshi farmer to cope with and recover from the annual floods. On the other hand is the widely held view that the country cannot be at the mercy of floods forever and that all the major rivers must eventually be contained so that the floods are safely passed through Bangladesh to the ocean. Those who support this argument believe that this would reduce the risks associated with economic activity on the floodplains and increase the economic growth rate of the country. Government policy is that a high

degree of structural protection must be a key element of the long-term strategy for the development of the country.

1.4 The reports and studies carried out since the 1988 flood reflect to some degree the different approaches to the problem. The UNDP-GOB Flood Policy Study and the French study outline comprehensive structural solutions, together with strengthening flood preparedness, to be carried out over 15-20 years. The French-Bangladesh study examines the possibility of preventing overbank flooding by an extensive system of embankments. The Flood Policy Study similarly proposes extending and strengthening the river embankment system. Both studies recognize the need to combine embankments with other water control measures. Areas enclosed by embankments are prone to flooding by heavy rainfall in the monsoon season and, therefore, major drainage works are also needed. Also, the embankments have to be planned and designed to allow the controlled entry of river water onto adjoining floodplain areas to support farmers' normal cropping patterns, keeping out only abnormally high, early and late floods and to recharge the groundwater. The major flood control works proposed in the studies would be preceded by feasibility and other studies, data collection and pilot projects. USAID's Eastern Waters Study, as its name suggests, takes a broad view of water resource development in the Ganges and the Brahmaputra basins and deals with multipurpose reservoirs, augmentation and allocation of dry-season flows, as well as the flood problem in Bangladesh. The report points to the problems of confining the main rivers and, in general, leans toward the non-structural position. But, the USAID study agrees with the other reports on the value of improvements in the natural drainage system. The Japanese report examines a range of alternatives and is cautious as regards structural solutions, except where needed to protect urban areas, especially Dhaka. All the studies agree on the priority to be given to protective works for urban centers.

1.5 As a first step in meeting its coordinating responsibility, the Bank convened a meeting in Washington on July 11-13, 1989, attended by the leading figures of each of the main studies along with several consultants and Bank staff familiar with Bangladesh. The Government of Bangladesh was represented by a four-man delegation headed by the Joint Secretary, Ministry of Irrigation, Water Development and Flood Control. During the discussions, the participants arrived at the conclusion that the main purpose of the meeting would be to concentrate on an Action Plan for the next five years as the first step in the Government's long-term flood control program. Such a plan would be a mix of projects which are ready to go in the next two or three years, and studies leading to further projects in the near-term and subsequent plan periods. The plan would also include supporting technical, socio-economic and environmental studies. Arrangements to prepare such an Action Plan, put in place during the July meeting, provided for the Bank to be assisted by a team including the key experts who had been involved in the UNDP, USAID, French and Japanese studies. A preliminary draft of an Action Plan report was prepared in July and August, 1989. This was revised and amended in consultation with Bangladesh officials during meetings in Bangladesh, September 8th-23rd, and during a visit to Washington by a Bangladesh delegation, October 12th-15th.

1.6 Chapter 2 argues for a staged approach and highlights some of the issues involved in flood control. The rationale for the Action Plan and a summary of its main elements are presented in Chapter 3. Background material is presented in Annexes A through D. The Appendix to the report elaborates on the Action Plan components and related activities.

2. FLOOD CONTROL AND DRAINAGE: A STAGED APPROACH

Long-Term Objectives

2.1 The severity of the recent floods in Bangladesh has led the Government to look for a flood plan which would, in the long term, provide a comprehensive and permanent solution to the recurrent flood problem and so create an environment for sustained economic growth and social improvement. The Government's objectives for a such a plan are to:

- safeguard lives and livelihoods
- improve agro-ecological conditions to increase crop production
- enhance development of public facilities, commerce and industry
- minimize potential flood damage
- create flood-free land to accommodate the increasing population
- meet the needs of fisheries, navigation, communications and public health.

2.2 In the course of the studies carried out following the 1988 flood, the Government established the 'Eleven Guiding Principles' summarized below:

1. Phased implementation of a comprehensive Flood Plan aimed at :
   - protecting rural infrastructure;
   - controlling flooding to meet the needs of agriculture, fisheries, navigation, urban flushing and annual recharge of surface and groundwater resources.
2. Effective land and water management in protected and unprotected areas.
3. Measures to strengthen flood preparedness and disaster management.
4. Improvement of flood forcasting and early warning.
5. Safe conveyance of the large cross border flows to the Bay of Bengal by channelling it through the major rivers with the help of embankments on both sides.
6. River training to protect embankments and urban centres.
7. Reduction of flood flows in the major rivers by diversion into major distributaries and flood relief channels.
8. Channel improvements and structures to ensure efficient drainage and to promote conservation and regulation.
9. Flood plain zoning where feasible and appropriate.
10. Coodinated planning and construction of all rural roads, highways and railway embankments with provision for unimpeded drainage.
11. Encourage popular support by involving beneficiaries in the planning, design and operation of flood control and drainage works.

2.3 These objectives and principles provide a broad framework for the Government's long-term plan of physical works together with measures to improve preparedness and management of floods described in the UNDP-GOB Flood Policy Study (see Figure 2.1). In physical terms, a long-run objective is to protect large areas from uncontrolled overbank flooding from the major rivers along with measures to evacuate excess rainfall from the protected areas. Physical works would include structures to control inflow to some areas and flood relief channels to intercept and divert flood flows. The north-west and north-central regions (see Figure 2.2) are the parts of the country most susceptible to overbank flooding, mainly from the Brahmaputra, and therefore most of the flood control works would tend to be concentrated in these areas. A large area in the north-east is flooded every year to a considerable depth. There is no practical solution to this monsoon flooding and so the farmers have adopted a system which concentrates on dry-season crop production for which limited protection against early floods can be provided by submersible embankments. Parts of the south-west and south-east are affected by river flooding from the Ganges and the Lower Meghna, but the main problems in these areas are drainage congestion, salinity inflows in the dry season and exposure to cyclones. The south-central part is affected by flooding from the Padma which might be alleviated once the flow of the Ganges, the Brahmaputra, and the upper Meghna is brought under control. Drainage congestion at the confluences adds to the problems of flooding which will also have to be addressed.

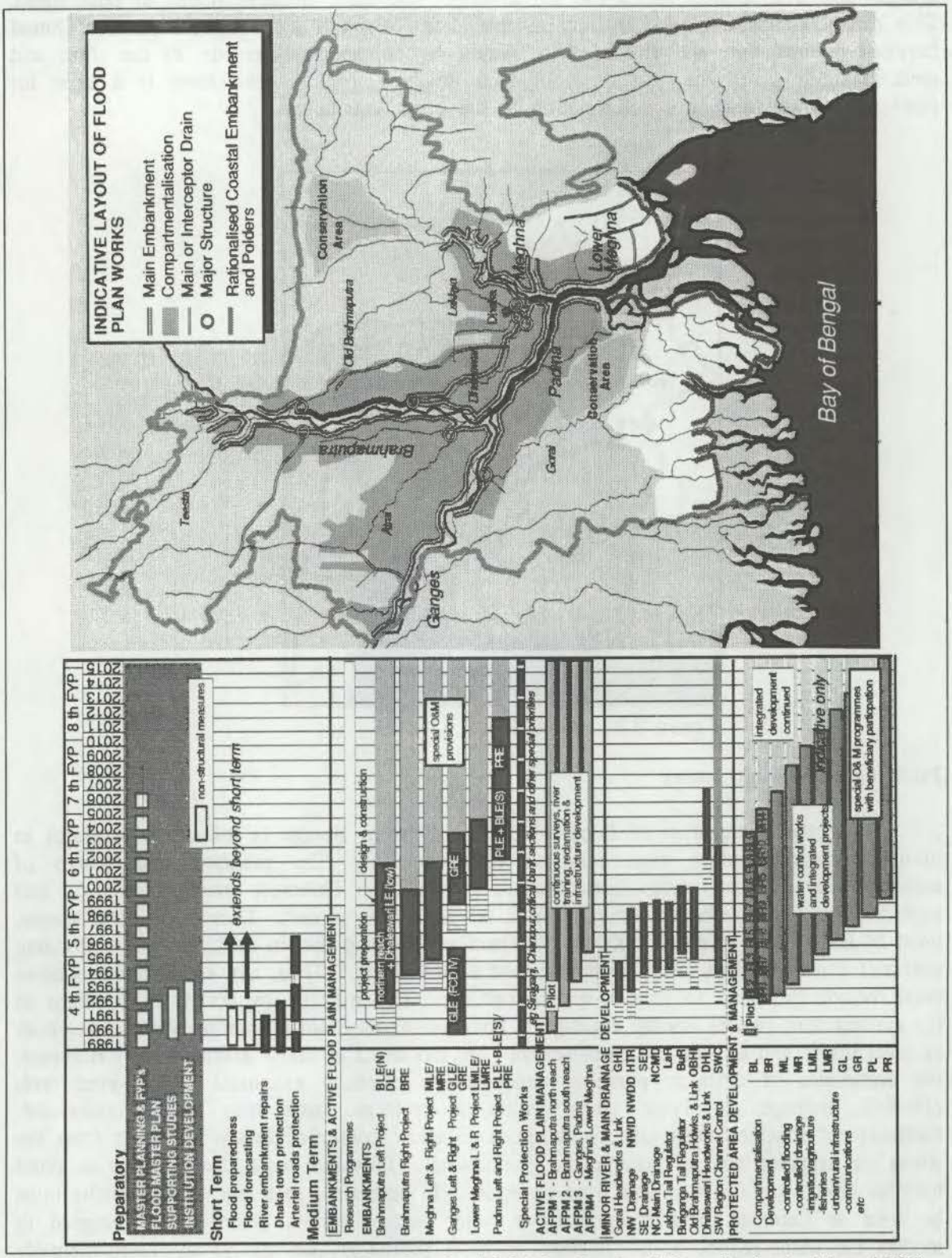
Conceptual Issues

2.4 In the case of most of the world's rivers and river basins, economic justification of flood control rests more on the enhancement of land use than on the reduction of flood damage. This is true in a large measure for Bangladesh; neither the French plan nor the UNDP proposals could be justified solely by the flood damages they would eliminate. There are, of course, localized situations where protection of an urban center from river erosion is justified solely by the need to protect housing, industries, infrastructure, etc. But, as a general proposition, the benefits of flood control must be found in higher economic returns from land, property and infrastructure. An example of this in Bangladesh is the switch from low-yielding broadcast aman to higher-yielding transplanted aman in areas that can be protected from flooding. Aside from gains in crop production, it has been argued that economic activity in Bangladesh is retarded by the threat of floods, but more analysis is needed to quantify this effect. Although there is still scope for expansion of industrial and commercial activities in areas free from flooding, better flood control would provide more room for expansion. Flood control works are also needed to prevent damage to roads and railways. However, priority should be given to designing these works to be, as far as possible, resistant to floods.

2.5 In many river basins, the magnitude and frequency of floods can be reduced by storing flood waters in multipurpose reservoirs. Unfortunately, there are no practical prospects for controlling floods in Bangladesh by reservoir storage. First, the number and capacity of storage sites in the headwaters is limited. Second, the widespread, intense storms which cause the really damaging floods in Bangladesh occur over the plains and piedmont areas which are downstream of the storage sites.

LONG TERM PROGRAM

Figure 2.1



Source: Bangladesh Flood Policy Study. UNDP - Govt. of Bangladesh, May 1989

2.6 It has been suggested that the deforestation that has occurred over the years in the Ganges and Brahmaputra basins has led to larger and more frequent floods in Bangladesh. This theory is not supported by any reliable data. Even if some correlation were found between deforestation and floods, there would be no practical remedy in the short and medium terms given the vast areas of land involved. Nevertheless, there is a need for continued efforts to control deforestation in the upper catchments.

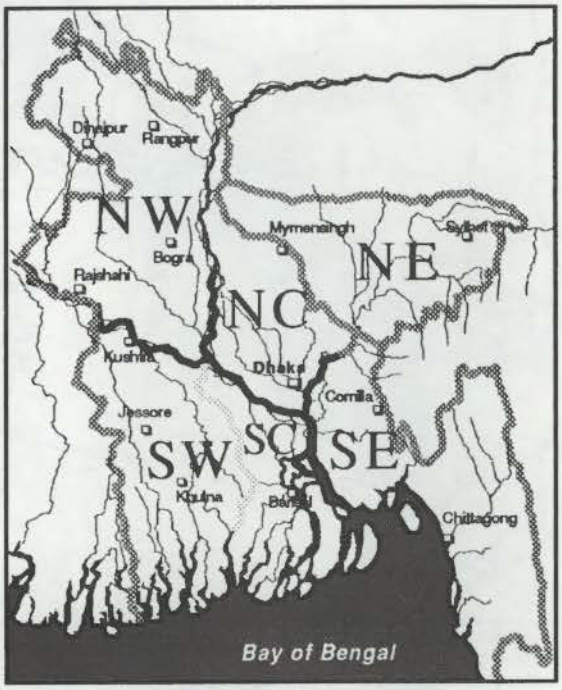


Figure 2.2 REGIONAL UNITS

Planning and Design Issues

2.7 Since the interception of flood waters by upstream storage is infeasible, measures to limit overbank flooding must rely on embankments. The planning and design of embankments in Bangladesh faces various problems. Foremost among these is that embankments tend to obstruct drainage from the areas they protect. During the flood season, most of Bangladesh receives 2,000 to 5,000mm of rain and this in itself can cause flooding unless it can be drained away from the land to the rivers. Thus, any embankment scheme must include provision to remove excess rainfall. This may be by controlled openings in the embankment (where gravity drainage is possible) or by drainage pumps where differences in level inside and outside the embankment are too small to allow gravity flow. However, the economics of drainage pumping needs to be carefully examined. But, even with effective drainage, low-lying lands within a protected area may remain inundated. Embankment schemes must also be designed to allow controlled inflow of water from the rivers for irrigation and to recharge the groundwater. Provision must also be made to avoid harmful effects on fisheries and river transport. In summary, therefore, embankments must be seen as elements of a comprehensive water control system planned and designed to modify the water regime in the interests of more profitable land use in an environmentally sound manner.

2.8 It is the above considerations that have led to the 'compartment' approach proposed in the UNDP - GOB Flood Policy Study and other studies for the development of areas protected by continuous sections of river embankments. In this approach, a section of river embankment forms one side of a block of land enclosed by embankments and provided with the various structures necessary to ensure water control over a wide range of hydrologic conditions. This concept has much in common with the polders which have been built in some parts of Bangladesh; these consist of areas enclosed by embankments which include structures to permit controlled inflow and outflow of water. The experience with polders has been mixed; a few have been successful but others have not worked as intended. The reasons range from design deficiencies, failures to complete the works as designed, and weaknesses in operation and maintenance. Thus, the compartment approach will require a higher standard of planning, design, construction and operation than has generally been practiced to-date in Bangladesh.

2.9 An important planning issue is the location and alignment of embankments. In terms of economics and engineering, the embankments should ideally be placed far enough from the main river channel to avoid attack from the river and to maintain the conveyance capacity of the river. In such cases, the land between the embankment and the river may be used for rice, jute and a variety of dry-season crops which can be protected, if necessary, by a low submersible dike. In this case, the loss of benefits from more intensive wet-season cropping needs to be more than balanced by the savings in construction costs and by the much lower recurrent costs for river training and maintenance.

2.10 The containment of the major rivers of Bangladesh by embankments could lead to significant changes in river regimes which are difficult, if not impossible, to predict by even the most sophisticated modelling and analytical techniques. With embankments, the flow would tend to be concentrated in the main river channels and this could lead to effects such as higher flow velocities and water levels. While this increases sediment transport, it also leads to bank erosion and the need for river training works. In the flood season, the Brahmaputra, the Padma and the lower Meghna are subject to rapid changes in channel geometry; in a matter of days, channels may shift by several hundred meters and scour depths can reach up to 50 meters. Therefore, given the enormous forces involved and the difficulty of predicting the effects of man-made interventions, a structural solution to the flood problem has to be approached with caution. This argues for a carefully-monitored, staged development of these rivers.

Social Aspects

2.11 The considerable gains in crop production in recent years have been due to the initiative and industry of the Bangladeshi farmers coupled with appropriate government policies and supporting services. Since irrigation is largely from small low-lift pumps, shallow tubewells and various man-powered devices, farmers have a high degree of independence in their farming operations. Thus, a basic element of any water control strategy for Bangladesh should be to modify the water regime to provide greater security for individual farmers to display their ingenuity. However, structural solutions to the flood problem will involve large projects calling for improved management and more cooperation among farmers than have been customary in the past.

2.12 The spirited independence of the Bangladeshi farmers and fishermen sometimes manifests itself in a disregard for public infrastructure. In some areas, embankments have been breached (referred to as 'public cuts') by those who see them as harming their interests. There are cases where this is justified because the effect of a structure turns out to be different from its original purpose; this is often a reflection of the difficulty of predicting the effects of physical works on the water regime. But, often, the public cuts have no rational basis and the cutting of an embankment has no effect on water levels. Solutions to this problem must include closer involvement of the beneficiaries and local authorities in the planning, design and management of projects, and better efforts to educate the public.

2.13 The high population density in Bangladesh creates problems of land acquisition for public works. Poor farmers, even when adequately compensated, are reluctant to move since their chances of finding comparable land locally are low. Resettlement, as an alternative to compensation, also presents problems because of the shortage of land. Land acquisition is also subject to considerable delays when richer farmers, who can afford legal help, challenge the authorities. In view of this difficulty, the design of flood control works must, as far as is technically possible, minimize the area of land to be acquired.

Environmental Issues

2.14 A favorable environmental impact is the primary objective of a flood control and drainage project. It seeks to remove the harmful effects of inundation from overbank flooding and rainfall on human lives, crops and infrastructure. As noted in para 2.7, flood control schemes have to be planned, designed and operated to preserve and enhance groundwater recharge, agriculture, fishing and river transport. Floods are often said to have beneficial effects on soil fertility through the sediments deposited on inundated land. This effect is probably overestimated because the nutrient status of river sediments is very low and the nutrients present are probably insoluble. In fact, a common problem in Bangladesh is the loss of land quality due to deposition of sand and silt following a flood. The fertility benefits derived from flooding apparently are produced mainly by nitrogen-supplying algae living in the water.

Staged Development

2.15 The UNDP-GOB Flood Policy and French studies each present a plan for flood protection in Bangladesh through a system of embankments, interceptor channels and internal drainage systems. However, the studies stress that there are a number of technical, social and institutional problems which would have to be solved before such plans could be implemented. For example, the French study devotes considerable space to new approaches to the design of embankments and river training works. The UNDP-GOB study stresses the problem of designing and managing the water control systems in the 'compartments' and presents proposals for active flood plain management. The two reports put forward some new concepts and recommend that pilot projects and studies be carried out before incorporation in major plan components.

2.16 Master plans for river basins often involve a phased approach with lessons learned in the early phases being applied in future phases of the plan. But, seldom are planners faced with a more complex system than that of the rivers of Bangladesh. Certainly there are precedents in Bangladesh and elsewhere in the world for many of the elements of a flood control master plan such as river embankments, river training works, polders, drainage pumping stations, etc. Many of these schemes have highlighted the social and technical complexities of water control in Bangladesh which can provide valuable experience to guide the design of larger scale developments.

2.17 It is apparent, therefore, that the execution of a comprehensive flood control plan for Bangladesh must proceed in stages. This approach would be consistent with the UNDP-GOB Flood Policy, French and Japanese studies which advocate a program of studies and pilot projects to precede construction of major plan components. Individual components would also proceed in stages. For example, an embankment on the left bank of the Brahmaputra could be built in stages from north to south. Close monitoring of the performance of each stage would provide inputs to the planning and design of subsequent stages. This staged approach does not, however, rule out an early start on priority works in the next two or three years. At the same time, studies would be carried out to identify, plan and design projects for execution in a somewhat longer time horizon. This approach is spelled out in more detail in Chapter 3.

Implementation Issues

2.18 The Bangladesh Water Development Board (BWDB) is the agency responsible for the planning, design and construction of major water control works in Bangladesh. It was formed in 1959 as part of the East Pakistan Water and Power Development Authority's Water Wing and spun off as a separate entity in 1972. BWDB and its predecessor agency have an impressive record of construction with some 5,000 water control structures and over 6,000 km of embankment, including the immense undertaking of the Coastal Embankment Project to protect coastal areas from tidal flooding and storm surges.

2.19 BWDB has drawn heavily on bilateral and multilateral sources for technical and financial assistance. For construction, it relies primarily on local contractors. As its workload has expanded, the BWDB has encountered many implementation problems which have resulted in disbursement lags on externally-financed projects of up to 50 per cent. These include:

a) delays in the selection and appointment of consultants and the award of civil works contracts, mainly because of the many entities which have to clear these decisions;

b) a shortage of local funds to pay contractors and consultants;

c) delays in land acquisition, often because of lengthy litigation, but also because of shortage of local funds to effect purchase;

d) delays in approval of any changes in the Project Proforma (PP), especially as a result of cost increases.

2.20 A proposal to help speed up contracting procedures for consultants and to supervize their work effectively is described in Chapter 3. However, the implementation of the Action Plan will require substantial improvements in performance on civil works contracts, and a study of this subject will be a part of the supporting studies for the Action Plan.

3. THE ACTION PLAN

Selection of Action Plan Components

3.1 The Action Plan, covering the five-year period 1990-1995, is to be seen as the first of several stages in the development of a comprehensive system of flood control and drainage works designed to meet the Government's long-term objectives set out in the preceding chapter. It would be carried out in parallel with agricultural development and a program of non-structural measures such as flood forecasting, flood warning, flood preparedness and disaster management. The Plan, which will comprise planning, supporting activities, high priority projects and first-stage flood projects, will provide a proving ground for setting the foundations of a long-term program to meet Bangladesh's objective of achieving a permanent and comprehensive solution to flood control.

3.2 The main components of the Action Plan, selected in consultation with the Bangladesh authorities, address high priority problems, broadly following a logical sequence (from upstream to downstream), that have the best prospects for technical and economic feasibility. Each of the four main rivers was considered. The lands on both sides of the Brahmaputra have high priority where there is need to strengthen and extend existing embankments on both banks and improve water control in the areas protected. The Ganges, up to its confluence with the Padma, has few problems of overbank flooding which are not already being addressed by BWDB, but there is scope for improving flood control and drainage in the area to the south of the river (the south-west and south-central regions). Extensions of embankments along the Padma and Lower Meghna should be deferred until the effects of upstream embankments on river morphology can be monitored and the implications evaluated. However, there is a need to carry out a planning study of the south-west and south-central regions to ensure proper integration of the long-term flood control projects with other ongoing and proposed projects. The Plan also includes the Meghna Left Bank and a study of the north-east region which has a special problem of flash floods from hill rivers. Finally, provision is made in the Action Plan to produce an updated Flood Control Program in 1992 which would define its physical elements, costs and benefits in more detail. This program would be developed in coordination with the National Water Plan.

3.3 The components of the Action Plan, listed in Figure 3.1, are shown in Figure 3.2 superimposed on a plan showing the future embankments and other works proposed in the UNDP-GOB Flood Policy Study. In summary, the Action Plan includes project-oriented studies in all of the country's main regions along with supporting activities to promote better project design and execution and measures of a non-structural nature. The regional studies will be planned and executed to produce technically and economically feasible projects for this and subsequent Action Plans. It should be noted that work is already in progress or is planned for some of the studies proposed in the Action Plan, and it may be desirable

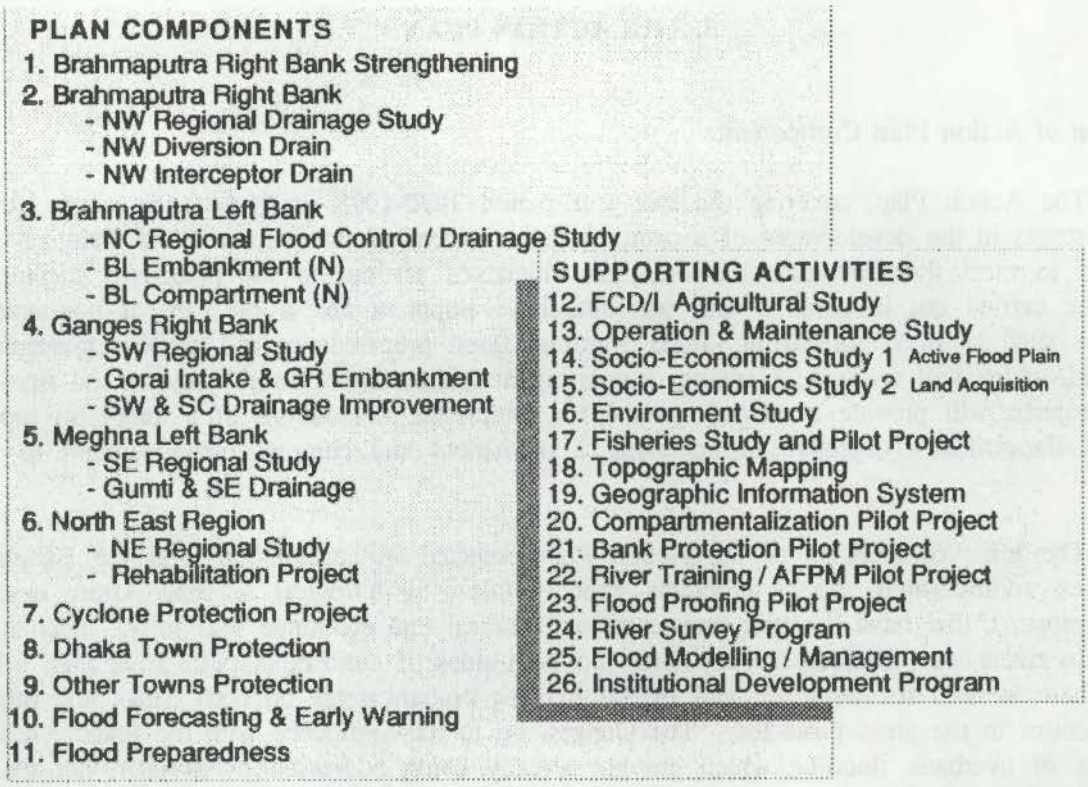


Figure 3.1 ACTION PLAN

in some cases to review and possibly amend the scope of such studies. The relationship of some of the Action Plan components with ongoing studies is shown in Fig. 3.3. In terms of physical works, the Action Plan will initially concentrate on the central features of the conceptual plan, namely the improvement of flood control and drainage along the Bamaputra, one of the world's biggest rivers.

The main features of the Action Plan are:

- strengthening of the Brahmaputra right embankment and improvement of flood control and drainage in the north-west region;
- measures to control flooding on the left bank of the Brahmaputra and the development of the protected area by means of drainage and water control works, particularly in the north-central region;
- measures to control flooding on the right bank of the Ganges, the Padma and the Lower Meghna, and improvements in water control and drainage in the south-west and south-central regions;
- measures to control flooding on the left bank of the Meghna, including improvements in water control and drainage in the south-east region;

- a study of the north-east region leading to a regional water management program;
- rehabilitation of the coastal embankments to protect against cyclones and tidal surges, and to include provision for drainage outlet structures;
- flood protection and drainage works for the Greater Dhaka area, and bank protection for towns such as Chandpur, Sirajganj, and Bhairab Bazar;
- strengthening of the flood forecasting and early warning system;
- development of a flood preparedness program.

In addition, the Action Plan includes the following activities to support the Plan components and the preparation of future projects:

- surveys of the operation and maintenance, agricultural, social and environmental aspects of existing flood control projects;
- provision of topographic mapping, satellite imagery, and geographic information systems;
- pilot projects in compartmentalization, bank protection, river training, fisheries and flood proofing;
- expansion of hydrologic data collection such as discharge and sediment measurements, water level recording, and observations of changes in river regimes on all the major rivers;
- adaptation of existing surface water simulation models to provide inputs to flood management, project design and project operation;
- a study of the institutional arrangements required for implementation of the Action Plan.

3.4 Flood control and drainage works already exist in the areas referred to above and some repairs, improvements and new construction have been taken up since the 1987 and 1988 floods. However, any major new developments will have to be preceded by detailed planning and design studies. But, such studies would be managed so as to identify essential works which could be started by the mid-point of the plan period. Details of the Action Plan components and supporting activities are given in the Appendix to this report.

Brahmaputra Right Bank

3.5 The Brahmaputra Right Embankment (BRE) was constructed in the 1960's and extends for some 230 km south of the Teesta River. The BRE was breached in a number of places in recent years but these breaches have now been repaired. Also, in places, the BRE is prone to attack by the river during and after floods. A study is planned to begin in early 1990 to find solutions to these problems. It is expected that proposals for river training and bank protection will be prepared by mid-1991. The program of pilot projects will also include trials of different methods of bank protection and a trial compartment. Strengthening of the BRE is an important element of the Action Plan. The area behind the BRE, covering most of the north-west region, has some severe flooding and drainage problems. Works which have been proposed to relieve these problems include the North-west Interceptor Drain and the Atrai-Ganges Diversion Drain. These drains would generally follow the lines of existing natural channels. A general study of the north-west region would, therefore, be necessary to explore the feasibility of these drains. The study would also identify ways to relieve water control problems in a broad tract of land lying behind the BRE where additional works to control inflow and outflow of water may be needed.

Brahmaputra Left Bank

3.6 Some 90 km of existing embankments provide some degree of protection to land on the left bank of the Brahmaputra. There is, however, a need for considerable improvement of these works along with drainage and other water control facilities in the protected area which forms the major part of the north-central region. Thus, a detailed study is needed of this area to identify an appropriate flood control and drainage system. The first phase of the study would be planned to provide, at an early stage, plans and designs for works to protect the area extending from the offtake of the Old Brahmaputra to the offtake of the Dhaleswari. These works would include the most northerly of the water control compartments, covering an area of about 50,000 ha. The second phase would cover the area behind the left bank of the Dhaleswari.

Ganges Right Bank

3.7 While the area along the Ganges river west of the Gorai is protected against floods, the area to the east suffers regularly from overbank spill from the Ganges and the Padma, causing damage to agricultural land, as well as to roads and railroads. The water control problems in the south-west and south-central regions are complex: the eastern part is exposed to floods from the Ganges, the Padma and the Lower Meghna; drainage congestion is a serious problem in the south-western part; while the coastal belt suffers periodically from storm surges caused by cyclones; moreover there is the threat of water shortage in the dry season, which aggravates salinity intrusion. A comprehensive regional study would address all these aspects, taking into account ongoing activities and studies done in the past. One of the aims of the study will be to confirm the viability of a continuous Ganges Right Embankment (GRE) and the construction of the Gorai headworks.

Meghna Left Bank

3.8 The area east of the Meghna and Lower Meghna forms a part of the south-east region. The northern half of the region suffers deep flooding from rainwater ponded on the land at high flood stages of the Meghna. Drainage is slow after the monsoon season, especially in the south-center. Flash floods from the adjoining hills frequently damage crops in the east. Coastal areas become saline in the dry season and are deficient in irrigation sources; they are also exposed to tropical cyclones and storm surges. Bank erosion is a problem along the Lower Meghna. A comprehensive regional study is needed to address all these aspects with a view to finding practical flood control and drainage solutions. The study would take into account ongoing and proposed water-control projects in the region.

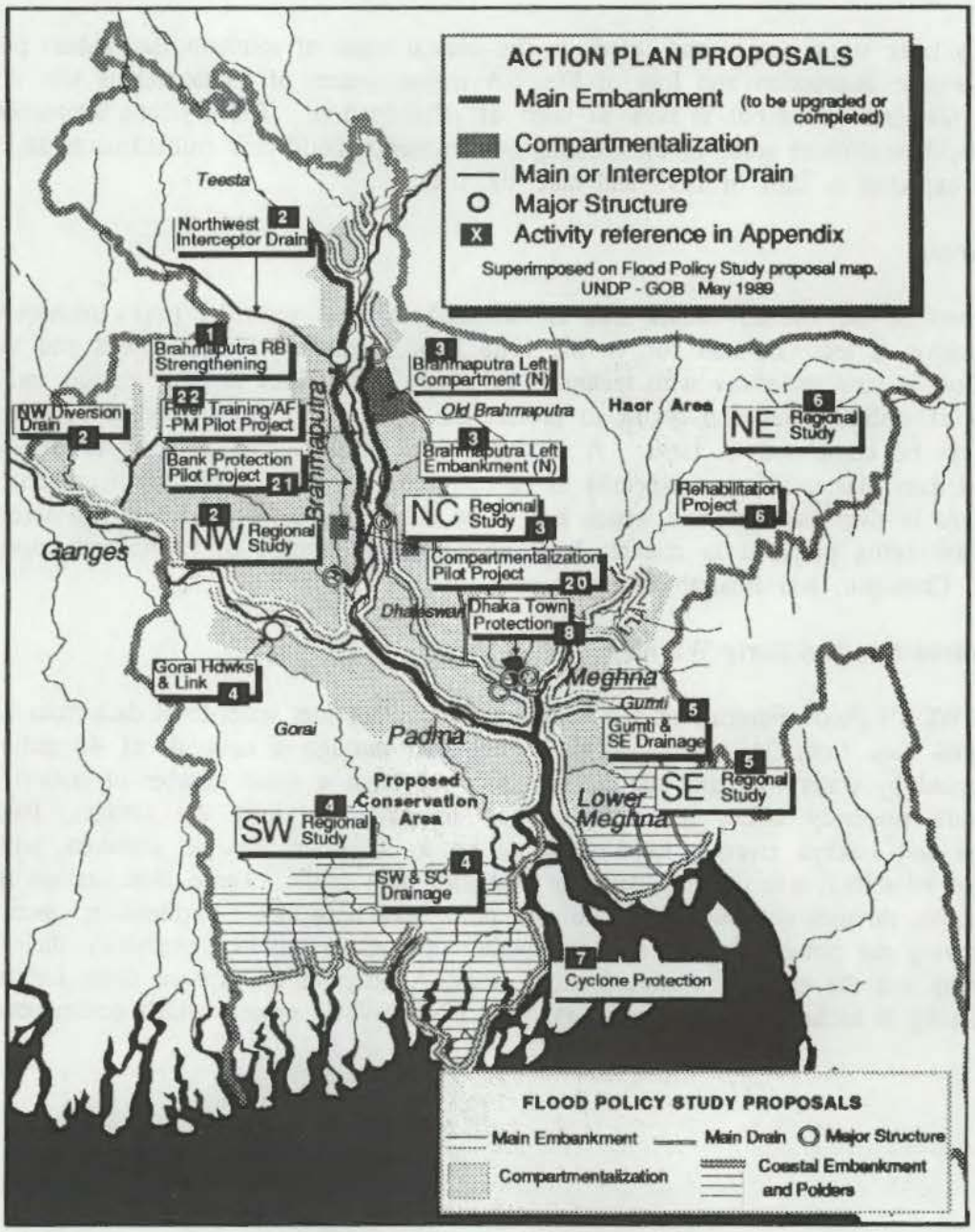


Figure 3.2 LOCATION OF ACTION PLAN ACTIVITIES

North-East Region

3.9 The north-east region provides the most difficult hydrological problems in the country. Northern and eastern areas suffer frequent flash floods from the adjoining hills, while the central area is deeply flooded in the monsoon season, with substantial areas (haors) remaining wet through the dry season. A comprehensive study in this region would aim to provide information on the role of the upper Meghna catchment on flood regimes in other regions as well as to improve flood mitigation measures within the region, taking into account experience gained on existing embankment projects.

Cyclone Protection Project

3.10 Cyclonic storm surges and floods in the coastal areas of southern Bangladesh periodically cause extensive destruction and loss of life. A major system of embankments was constructed in the 1960s and 1970s but is now in need of rehabilitation. The Cyclone Protection Project which would rehabilitate some of the existing embankments, build new embankments and construct roads, is expected to start in 1992 and take six years.

Urban Areas

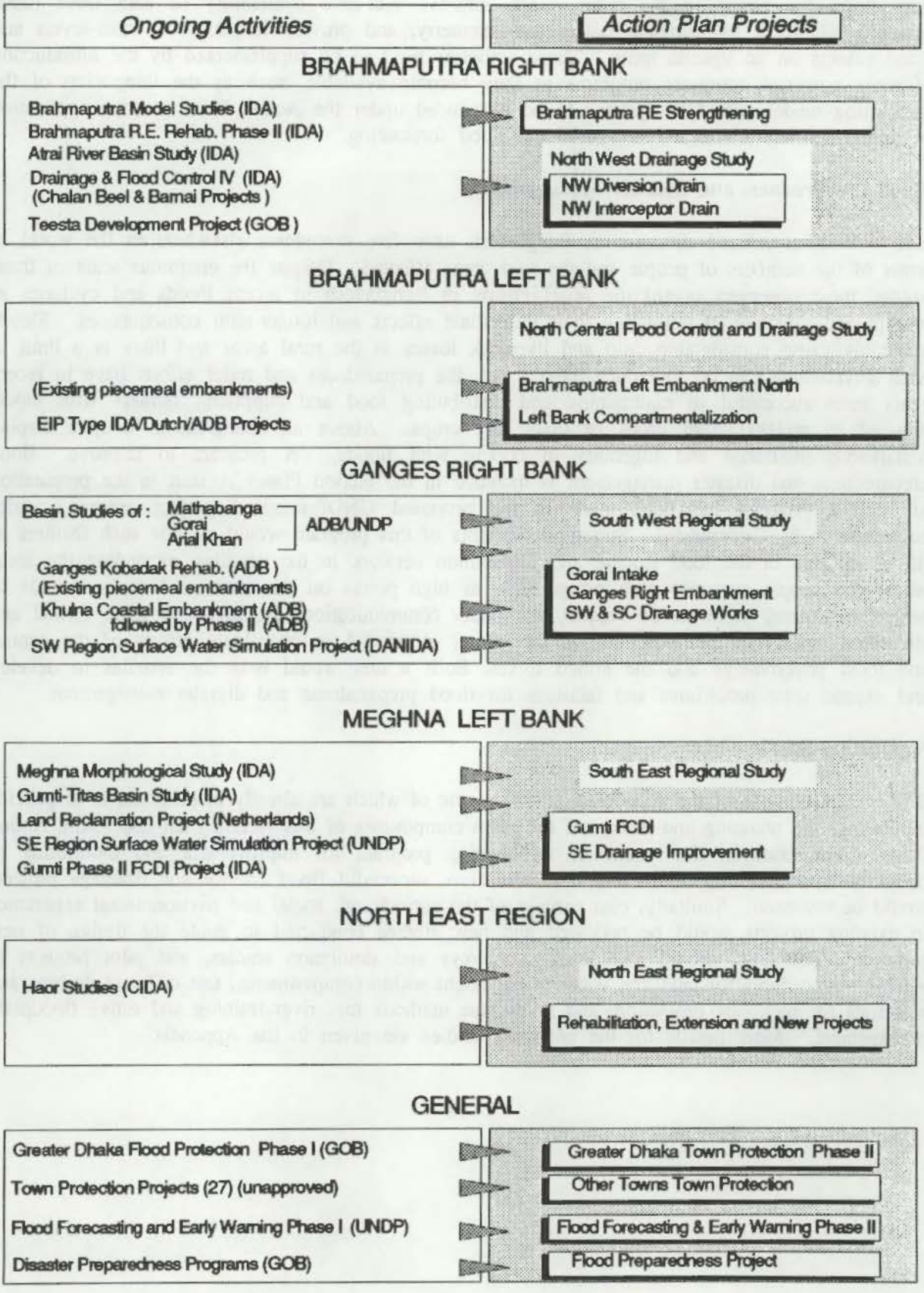
3.11 Parts of the Greater Dhaka area are affected in most years by heavy monsoon rainfall. River flooding is less common but, in the 1988 flood, damage was widespread and severe. A major effort is now underway with technical assistance from Japan to plan, design and construct a system of embankments and drains to protect the Dhaka area from floods. A first phase is expected to be completed in 1990. A second phase, planned and designed in the context of Dhaka's Urban Master Plan, is expected to be completed by 1994. The main problem with the other towns is river bank erosion which has to be solved by bank protection and river training. Projects are being prepared to counter bank erosion of a number of towns and cities such as Sirajganj, Chandpur, and Bhairab Bazar.

Flood Forecasting and Early Warning

3.12 BWDB's Flood Forecasting and Warning Centre monitors water-level data from 35 stations and rainfall data from 34 stations within Bangladesh through a network of 40 radio stations, supplemented by water-level and rainfall data received from a small number of stations in India. The Centre presently issues quantitative flood forecasts for only the Ganges, Brahamputra, Buriganga and Lakhya rivers. Lead times of up to 72 hours can be achieved, with varying degrees of reliability, when timely data are available from India. These forecasts are transmitted to the public through national TV, radio and newspaper networks. Furthermore, there is scope for improving the present density and distribution of stations within Bangladesh, their frequency of reporting and the existing communications links. A program to improve flood forecasting and early warning is included in the Action Plan. A UNDP/WMO project which commenced in May

RELATIONSHIP OF EXISTING ACTIVITIES TO THE ACTION PLAN

Figure 3.3



1989 will introduce a number of measures to upgrade and strengthen the Flood Forecasting and Warning Centre. It aims to introduce the Surface Water Simulation Modelling Program for real-time flood forecasting in the main rivers, improve real-time availability of data from India, establish additional hydrological radars and telemetry, and provide forecasts of water-levels and flood extents on an upazila basis. These activities nced to be supplemented by the introduction of more powerful computer programs as they become available, such as the integration of the forecasting model with GIS systems to be introduced under the Action Plan, and the application of remote-sensing techniques to operational flood forecasting.

Flood Preparedness and Disaster Management

3.13 Weather-induced disasters in Bangladesh have few precedents elsewhere in the world in terms of the numbers of people and the vast areas affected. Despite the enormous scale of these events, most observers regard the relief efforts in Bangladesh in recent floods and cyclones as prompt and effective in mitigating their immediate effects and longer-term consequences. Floods inevitably cause considerable crop and livestock losses in the rural areas and there is a limit to what government can do to reduce them. But, the preparedness and relief efforts have in recent years been successful in maintaining and distributing food and supplying farmers with inputs required to replant kharif crops or plant rabi crops. Above all, Bangladeshi farmers display remarkable endurance and ingenuity in coping with floods. A program to improve flood preparedness and disaster management is included in the Action Plan. A start in the preparation of such a program has been made in the proposed UNDP-financed project presently under consideration by Government. Structural elements of this program would include such features as filling in gaps in the food storage and distribution network in the upazilas, expanding the areas where the people currently seek refuge such as high points on the roads and the surrounds of bridge abutments, more rescue vessels, and better communications facilities. A more formal and structured emergency planning unit at the center is needed to coordinate efforts of the central and local governments and the armed forces. Such a unit would help the upazilas to develop and expand their procedures and facilities for flood preparedness and disaster management.

Supporting Studies

3.14 The purpose of the supporting studies, some of which are already in progress, is to provide inputs into the planning and design of the main components of this Action Plan and future Action Plans. For example, the results of an ongoing program for improvement and monitoring of operation and maintenance in several of the more successful flood control and drainage projects would be reviewed. Similarly, past surveys of the agricultural, social and environmental experience in existing projects would be reviewed and new studies conducted to guide the design of new projects. The latter would include river surveys and simulation studies, and pilot projects to establish procedures for land and water management within compartments, test different designs and materials for riverbank protection, and investigate methods for river training and active floodplain management. More details for the proposed studies are given in the Appendix.

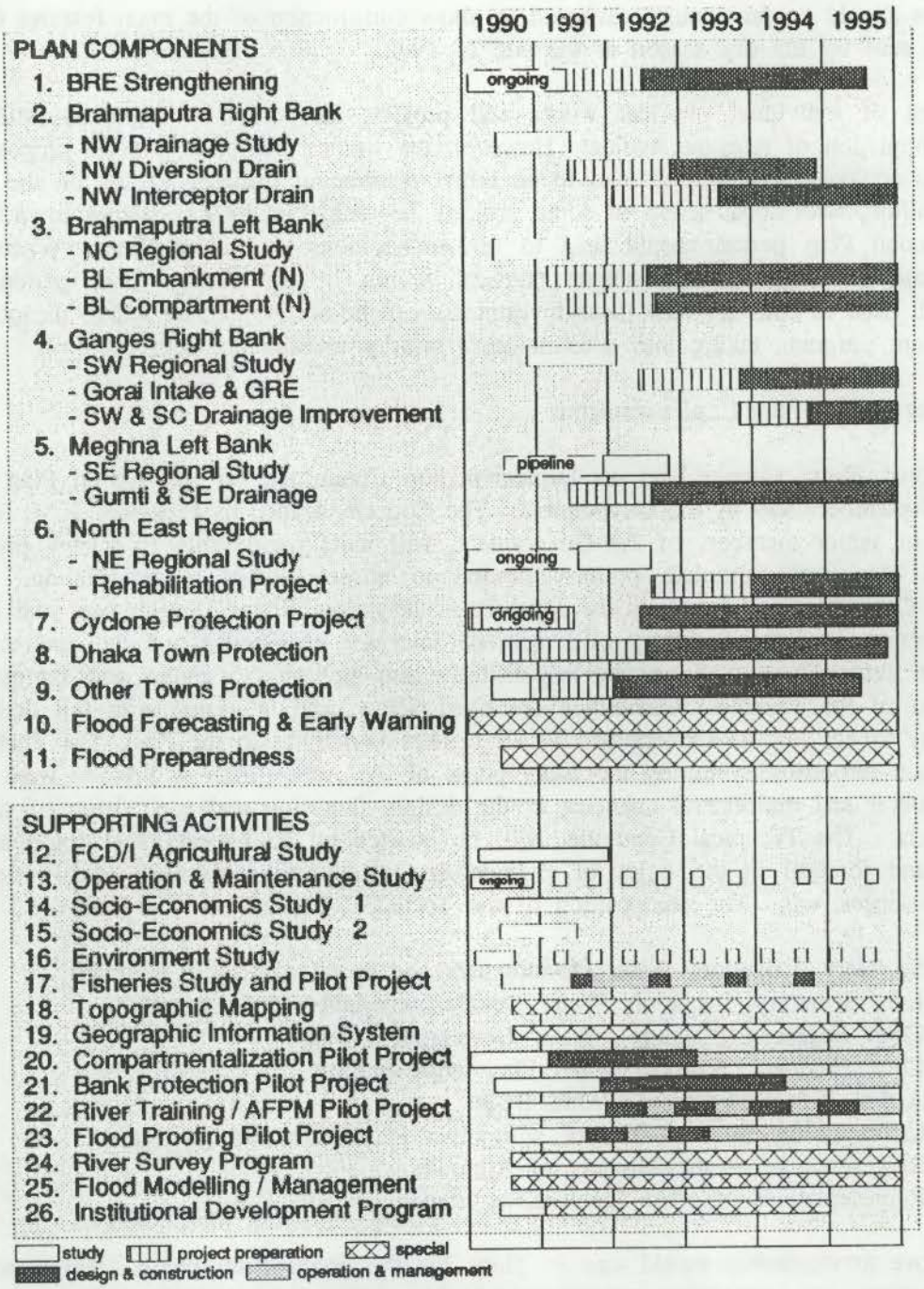


Figure 3.4 IMPLEMENTATION SCHEDULE

Implementation Schedule and Costs

3.15 An implementation schedule is shown above. The first two years of the Plan would be taken up by project preparation and designs. Aside from Greater Dhaka, where work is in

progress, studies should be far enough advanced to allow construction of the main features of the Action Plan to start by the dry season at the end of 1992.

3.16 The cost of individual physical works and projects can only be estimated with any accuracy on completion of relevant studies. However, the studies and pilot projects proposed in the Action Plan could be expected to lead to an initial pipeline of projects costing on the order of US$ 500 million, with construction of some projects beginning in 1992. Studies towards the end of this Action Plan period should lead to further additions to this pipeline. When cost estimates become available for the major physical works in the Action Plan period, the Government will need to consider how these investments can be accommodated within the planned public expenditure program, taking into account other priority investment needs.

Organization for Action Plan Implementation

3.17 A National Flood Council and an Implementation Committee for the Action Plan were established in September 1989 by the Government. The Council, headed by President H.M. Ershad and composed of senior members of the Government, will meet periodically to review progress on the Action Plan and formulate policies needed to ensure timely implementation. The Implementation Committee is headed by the Minister of Irrigation, Water Development and Flood Control and composed of the Secretary of Irrigation, Secretary of Finance and the Secretary of the External Resources Division, it has the responsibility and authority to review and approve the recommendations of the Technical Committee described below, and is vested with full decision-making authority to act for the Government in all matters pertaining to the Plan. The Technical Committee's main responsibility during the study phase of the Action Plan will be to work with the various bilateral and multilateral agencies in the design, financing and supervision of studies and pilot projects. The Technical Committee will be assisted by an Expert Panel composed of experts (local and foreign) in the fields of engineering, agriculture, economics, social sciences, environmental sciences, etc. The composition of the Technical Committee is as follows:

Secretary, Irrigation, Water Development and Flood Control (Chairman)
Joint Secretary, Irrigation, Water Development and Flood Control
Chief Engineer (Planning), Water Development Board
Chief Engineer, National Water Plan Organization
Action Plan Coordinator, World Bank
Chairman of Panel of Experts, with other Panel members as needed.
Representative of the Ministry of Agriculture
Representatives of other agencies, as needed

3.18 The above arrangements would stay in place for the construction phase. However, the appropriate structure and operating procedures of the agency, or agencies, entrusted with construction of the Action Plan works would have to be improved and strengthened to avoid the implementation problems referred to in para 2.19. A task force composed of independent local

and foreign experts would be set up in 1990 to carry out an Institutional Development Study. The task force would identify implementation problems, propose solutions and recommend suitable implementation arrangements to the Government.

3.19 The World Bank would, as requested by the Government in June 1989, assist in coordinating the Action Plan. During the study phase, it would help to promote and coordinate bilateral and multilateral assistance for the Action Plan and assist in the design and supervision of the various studies, pilot projects, etc. A Memorandum of Understanding will formalize the arrangements and define the obligations of the Government of Bangladesh and the Bank in the coordination and implementation of the Action Plan. An understanding will also be reached with the donors supporting the Action Plan to ensure effective coordination and integration of their activities. The Bank will assist the Government in supervising an updating of the Flood Control Program in 1992 and its coordination with the National Water Plan.

ANNEX A

COMMUNIQUE OF THE G7 SUMMIT

Paris, July 16, 1989

It is the matter of international concern that Bangladesh, one of the poorest and most densely populated countries in the world, is periodically devastated by catastrophic floods.

We stress the urgent need for effective, coordinated action by the international community, in support of the Government of Bangladesh, in order to find solutions to this major problem which are technically, financially, economically and environmentally sound. In that spirit, and taking account of help already given, we take note of the different studies concerning flood alleviation, initiated by France, Japan, the USA and the United Nations Development Program, which have been reviewed by experts from all our countries. We welcome the World Bank's agreement, following those studies, to coordinate the efforts of the international community so that a sound basis for achieving a real improvement in alleviating the effects of flood can be established. We also welcome the agreement of the World Bank to chair, by the end of the year, a meeting to be held in the United Kingdom by invitation of the Bangladesh Government, of the countries willing to take an active part in such a program.

ANNEX B

FLOOD STUDIES

INTRODUCTION

1. The severity of the 1988 floods prompted the Government to undertake a comprehensive review of flood policy and flood protection measures. Two studies were carried out jointly. The first was the UNDP financed **Bangladesh Flood Policy Study.** The second was the **Prefeasibilty Study of Flood Control in Bangladesh** funded by the French Government. The Government of Bangladesh carried out a rapid study immediately after the 1988 flood and issued a preliminary document, the National Flood Program (BWDB, November 1988). This document provided the main background for the UNDP and French Government financed studies.

2. Concurrently, the USAID sponsored the **Eastern Waters Study,** which is concerned largely with land and water resource management in the Ganges and the Brahmaputra basins, and the Government enlisted the help of Japanese flood control experts to prepare the **Report on Survey of Flood Control Planning in Bangladesh.**

3. Other activities that have taken place during this period include:

- bilateral discussions with India, mainly through the joint Task Force;
- assistance on specific flood control issues from the Chinese Government;
- various bilateral and multilateral activities on flood related projects and programs

4. This annex is concerned with summarizing the main elements contained in the four main flood studies:

Bangladesh Flood Policy Study (Government of Bangladesh and UNDP)

5. In the light of the severity of the flood in 1988, and of the major flood experienced in certain regions in 1987, the Ministry of Planning of the Government of Bangladesh mobilized a multidisciplinary and multisectoral study team/steering committee to initiate a study which would examine the causes, nature and effects of the floods, recommend remedial measures and establish a comprehensive flood policy. The UNDP agreed to provide a team of international experts to assist the Government study team.

6. The main objectives of the Flood Policy Study were as follows: (a) to evaluate the nature and effects of floods; (b) to examine the effectiveness of flood control options; (c) to formulate a sound flood policy; and (d) to recommend remedial measures and prepare a phased action plan. The 'Eleven Guiding Principles' were developed during the study (see Chapter 2).

7. The Flood Plan reflects several important conclusions emerging from the Flood Policy Study: solutions to be taken up through the Plan are those which can be implemented within Bangladesh. The Flood Policy Study concludes that these solutions are the only effective and durable measures for the short and medium-term. The Flood Plan will be designed to achieve the ultimate objective of contiguous flood protection on both sides of each of the three main rivers. Multi-sectoral development for the protected areas, and maintenance and enhancement of the environment, will be an integral part of the Plan.

8. The Flood Plan includes both structural and non-structural components. Non-structural activities are seen as essential components of a flood plan. Flood Forecasting, Early Warning and Flood Preparedness provisions should be in place at the outset. The nucleus of a flood forecasting system is already established and its consolidation, improvement and extension are being undertaken with UNDP/World Meteorological Organization support. Similarly, community-based flood preparedness activities spanning early warning, evacuation/sheltering, flood fighting and organizing emergency responses should be coordinated by a permanent national office. A contingency plan for 1989 has been drafted and a longer term comprehensive disaster preparedness program is under Government review. Other measures include institutional rearrangements and upgrading, beneficiary mobilization and participation, master planning and supporting studies, operation and maintenance provisions, and appropriate legislation.

9. The study concludes that embankments will form the basis for an effective flood protection program. They are to be built to provide a controlled environment in which social and economic development can be undertaken with confidence. Embankment schemes in Bangladesh must, however, address and resolve the following outstanding issues: (a) potential interference with the environment; (b) impeded drainage of local runoff; (c) morphological changes in main river course; (d) social attitudes; (e) high capital and running costs; (f) constraints in implementation, O&M and management.

10. According to the Plan, protected areas will be divided into locally managed "compartments" to provide water control (controlled flooding and controlled drainage) to protected areas and also to contain the areal extent of flooding in the event of any embankment breach. Compartments will also provide the focal points for flood preparedness and warning activities. Over the plan period, compartments will build up into contiguous flood control systems along the main rivers with wider benefits than a stand-alone embankment scheme and at a pace consistent with institutional capacities. Other components of the Plan include active floodplain management and the development of minor rivers for controlled flooding and drainage to complement the main stem development.

11. Provisional estimates indicate that the proposed flood protection program would cost approximately $3.5 to $4.0 billion and entail annual costs of $250 million. The study recommends proceeding immediately to the preparatory stage centered on a master planning exercise and to the parallel execution of certain high priority works. The master planning exercise will include river development studies (1990-94), area development studies (1990-92), and other general studies (1990-93). The following have been identified as high priority projects which, although part of the overall plan, can be executed and managed independently: (1) Brahmaputra Left Embankment, (2) Brahmaputra Left Embankment Protected Area Development, (3) Northwest Interceptor and Diversion Drains, and (4) Gorai

Head Regulator/Link. Ongoing and short-term developments comprising flood preparedness, flood forecasting, Dhaka town protection, river embankments repairs and arterial roads protection will also proceed.

Pre-Feasibility Study for Flood Control in Bangladesh (Governments of Bangladesh and France)

12. Following the 1987 and 1988 floods, the French Government appealed for a world aid program to address the issue of flood control in Bangladesh, and subsequently financed a prefeasibility study for overall and lasting flood protection for the country. The report provides a long range program of what could be built within several successive five-year plans. Implementation will be broken down into specific projects, each of them consistent with other main objectives of the country.

13. The solution presented in this report for protection against floods is essentially based on the extensive confinement of the main rivers and distributaries by longitudinal embankments. This represents a drastic departure from the previous policy which relied mainly on individual polders. The main features of the flood control scheme are as follows:

- Embankments along the three major rivers, the Brahmaputra-Jamuna, the Ganges-Padma and the Meghna

- Embankments along the main tributaries, the Teesta, Dharla, Dudhkumar, Atrai, Kangsa, Titas and Gumti rivers, in order to counter the floods in these rivers and the backwater effect during high stages in the major rivers

- Embankments along certain distributaries, the Old Brahmaputra, the Dhaleswari and the Arial Khan, in order to alleviate the discharge flowing in the major rivers.

The total length of the proposed main embankments is estimated at 3,350 km, including 1,050 km of existing embankments to be reinforced and 2,300 km of new ones. Embankment height is designed for a 100-year return flood, with a maximum height of 7.40 m and average of 4.50 m.

14. River training works will be provided where necessary to prevent bank and embankment erosion or destruction by bank shifting or bed scouring, and especially to protect specific urban areas such as Sirajganj and Chandpur.

15. The set-back distance between the river bank and the embankment raises an important consideration, with alternative solutions presented in the report. On the one hand, to maintain morphological equilibrium of the rivers so as to protect the environment, and to minimize the cost of river training works, a distance of several kilometers would be necessary. On the other hand, this distance should be as small as possible, in order to protect as much cultivable land as possible. Several solutions have been studied and presented in the report, which stresses the need for thorough complementary technical, economic and social investigations prior to final decisions and feasibility studies.

16. Together with embankments, structures are provided both to control the flooding, as far as it is useful, of the protected areas, and to ensure the drainage of these areas either through hydraulic gravity structures or pumping stations. Protection of eighteen major towns against major floods is also proposed, with a return period ranging from 500 to 1000 years, where possible.

17. The Flood Forecasting and Warning system (FF&W) was also analyzed. Recommendations for its improvement and extension include a general review of the existing system, upgrading an automatic data collection and transmission system, increasing the lead time and forecast accuracy, establishment of a new FF&W Directorate in Dhaka with regional subcenters, and developing a flood warning and action plan at the local level.

18. Financial and economic analysis was carried out on the four alternatives for close or distant embankments (with labor intensive versus mechanized methods). The total construction costs for the four alternatives range form $5.4 billion to $10.2 billion, with annual expenditures ranging from $540 million to $890 million. The major benefits expected from the project include: (a) reduced flood damage, estimated presently at $140 million per year; (b) agricultural benefits, from improved cropping patterns, as a specific result of flood protection; (c) indirect benefits resulting from reduced uncertainty and including higher rates of growth in the non-agricultural sectors and a likely improvement of the overall growth path. The scheme will also have some social costs: it will entail the expropriation of 19,000 - 21,000 hectares which will affect up to 180,000 people. Moreover, in the large set-back solution, about 5 million people living between the main embankments and the bank would not benefit from flood protection and might have to be relocated behind the shelter of the dykes.

Eastern Waters Study (USAID)

19. The Eastern Waters Study was commissioned by the United States Agency for International Development (USAID) in preparation for the American President's Report to Congress "on efforts by the international community and the governments of the region to develop regional programs for the Ganges basin and the Brahmaputra basin that are designed (1) to ensure an equitable and predictable supply of water in the dry season, and (2) to promote better flood control mechanisms to mitigate in the medium-term and prevent in the long-term, floods as severe as the 1988 floods in Bangladesh". The delta of this region, where the severe floods of 1988 occurred, is the outlet for three of the largest rivers in the world, as well as numerous smaller but substantial rivers.

20. The report states at the outset that large flood control projects involving upstream dams or embankments in or near the main channels of the rivers are probably not feasible means of dealing with the flood problem in the near future. Aside from the great expense and possibly serious environmental risk from undertaking such large investments, the report finds little prospect of effectiveness from quick application of the heaviest engineering solutions. Instead, the report stresses that considerable efforts should be made to reduce flood vulnerability, ranging from better emergency preparation and relief services, through international cooperation for flood warning and analysis, modest embankments to protect high-intensity land use or to alleviate low-flood damage, to a range of flood proofing measures. Resources should be allocated to the people of this region to

help them undertake flood proofing measures such as establishing refuge areas, providing better emergency food and medical services, protecting some agricultural areas from shallow-flood drainage, and increasing surface drainage capacities.

21. The recommendations of the report are divided into the following categories: general recommendations; action recommendations; and technical and scientific research recommendations. The report cautions against pursuing overall regional water development programs, emphasizing that the most important and immediate practical measures to be taken are in-country ones. Other general recommendations include intensifying the study and application of groundwater use, international sharing of Bangladeshi and Indian Hydrological and meteorological data, and comprehensive analysis of large engineering projects, and cautions against 'single-solution' approaches,

22. The action recommendations propose immediate pursuit of selected elements of the Government of Bangladesh's Guiding Principles. Of the eleven Guiding Principles, the report is in agreement with seven suggested actions that comprise the soft program of flood proofing which would provide immediate help to the population in dealing with future floods. It is, however, opposed to the four remaining principles which imply massive investments in embankments and river training works. The report views this as a confrontational approach to the floods that is certain to be costly and unlikely to be successful. Other action recommendations include execution of the National Water Plan, intensifying efforts to achieve interregional power development and use, and research coordination between governments, planning bodies, universities and institutes in the region.

23. The report concludes with an outline of further technical and scientific research that needs to be carried out in order to build the strong base of technical and scientific knowledge necessary to design further effective actions for the development of the basin. The achievements in monsoon meteorology now make it possible to take a step beyond weather analysis and to improve monsoon hydrology. Other research areas include the calculation of detailed water balances on the river basins, calculation of sediment balances for the major types of landform in the region, study of the geology and seismology of the Himalayas, potential for underground storage of flood waters, river mechanics interbasin transfer of water, and research in support of flood proofing.

Report of Survey of Flood Control Planning in Bangladesh (Government of Japan)

24. The major objectives of the long-term flood control plan proposed under the study carried out by a Japanese team of flood control experts include: (a) minimizing the potential flood damages, (b) creating flood-free lands to accommodate the increasing population, (c) enhancing agricultural land-use to facilitate the adoption of high-yield crop varieties, and (d) enhancing conditions for effective development of commercial and industrial enterprises. The essential target of the long term flood control plan is to mitigate flooding in the central part of the country by means of appropriate measures against flooding by the three major rivers.

25. The report investigates several conceivable structural measures on the merit of their technical and economic viability. Structural measures such as storage reservoirs are rejected because of the lack of such potential sites. Similarly, dredging of such large

rivers will require large amounts of financing with no significant benefits. Provision of large diversionary channels will be difficult because of extensive land acquisition requirements. On the other hand, although diversion channels of moderate scale are possible with regard to land acquisition issues, such measures it alone will not produce the necessary flood control effect.

26. The report cautions against the construction of long and continuous river embankments without further careful study of the technical feasibility and economic viability of undertaking such large investments. Instead, the report recommends a physical works plan which entails stage-wise implementation such as constructing embankments in limited areas where appropriate, in combination with the existing and/or planned road embankments, so that the flood protected areas can be expanded gradually and in stages. Moreover, provision of a series of polders in the form of cellular blocks will ultimately result in producing effects that are similar to a continuous river embankment, with the interior polders functioning as secondary embankments. In addition, non-structural measures such as a flood forecasting and warning system and flood fighting are indispensable for maintaining the structural measures to serve their intended purposes.

27. The long term flood control plan proposed in the report would therefore be comprehensive, comprising both structural and non-structural measures. The proposed plan will be based on a stage-wise implementation with due consideration to the time and financial requirements involved until the benefits of structural measures could be reaped. The specific structural measures proposed include: (a) rehabilitation of existing embankments and polders; (b) construction of river embankments and polders in stages, and in cases where such construction is technically as well as economically justified; (c) protection of Dhaka and other important cities with a combination of river embankments, polders and raised roads; and (d) limited spur dykes, groynes, revetments and other river training works. Non-structural measures include improvement of the flood forecasting and warning system, improvement of the flood preparedness system, and flood plain zoning.

28. The report concludes with the outline of an Immediate Action Program to undertake priority projects and studies. The first component covers projects that are of national importance, and are ready for immediate implementation with potential realization of quick benefits. These include Flood Protection and Drainage of Dhaka city, Improvement of Flood Forecasting and Warning System, and Strengthening of the Flood Evacuation and Relief Operations. The second component of the Action Program consists of preparatory works required for the implementation of the long term flood control plan, and includes the detailed study of a nation-wide flood control plan, topographic mapping and joint research on flood prevention and preparedness. The detailed master plan survey of flood control measures will cover a period of four years. The first two years will be devoted to the updating of existing topographical maps and the longitudinal and cross-sectional surveying of rivers. The survey proper will be conducted during the final two and a half years of the survey period.

ANNEX C

FLOODING IN BANGLADESH

BACKGROUND

Water Resources

1 Most of Bangladesh is located within the floodplains of the three great rivers (the Ganges, the Brahmaputra and the Meghna), their tributaries and distributaries (Figure C.1). The three rivers drain a total catchment area of about 1.72 million square kilometers in India, Nepal, China, Bhutan and Bangladesh. Only 8 per cent of the catchment area lies within Bangladesh.

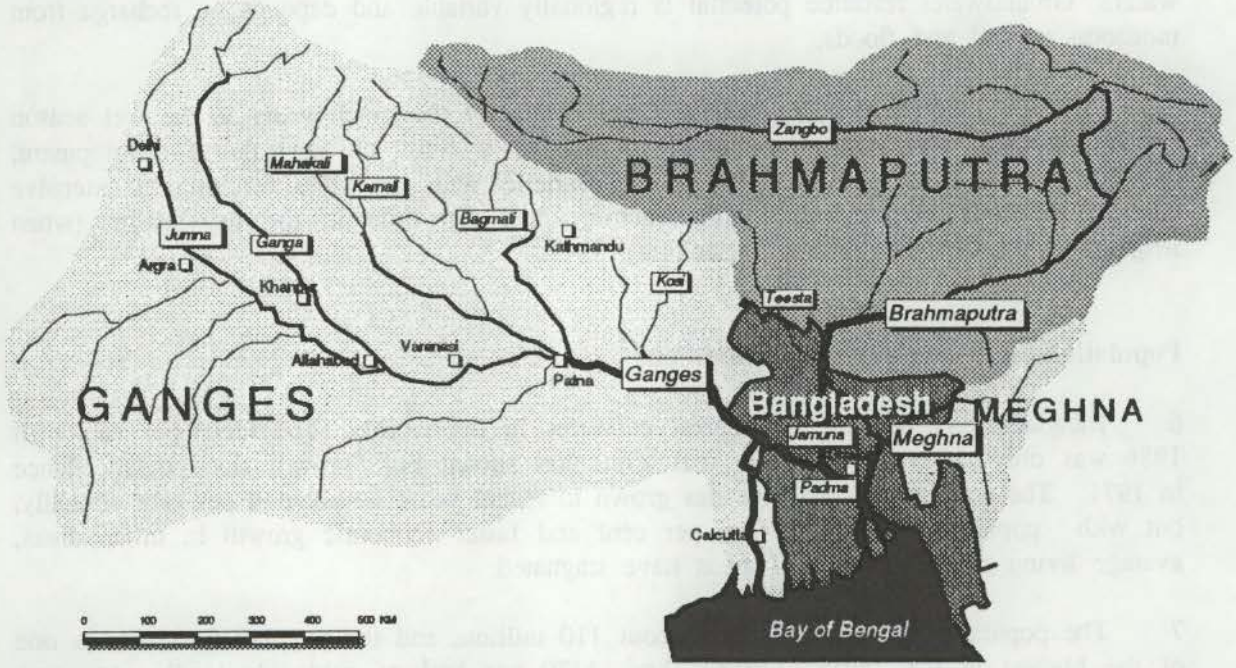


Figure C.1 THE GANGES, THE BRAHMAPUTRA AND THE MEGHNA BASINS

2 From June to September each year, the warm moist air of the monsoon sweeps up the Bay of Bengal from the Indian Ocean producing some of the highest recorded rainfalls in the world over Bangladesh and the upstream catchments of the major rivers, particularly in the Indian states of Meghalaya and Assam. Between 70 and 85 per cent of the annual rainfall is concentrated in the three to four month monsoon season. In Bangladesh, mean annual rainfall increases from about 1200 mm in the west to almost 6000mm in the extreme east. Average annual rainfall in the Himalayas and in the Meghalaya hills to the north of Bangladesh averages about 5000 mm, but reaches 10,000 mm locally. Tropical cyclones can occur in the pre- and post-monsoon seasons. These affect coastal areas and are sometimes accompanied by storm surges.

3 The discharges of the three main rivers are among the highest in the world. Peak discharges are of the order of 100,000 m^3/s in the Brahmaputra, 75,000 in the Ganges, 20,000 in the Meghna and 160,000 in the lower Meghna (Figure C.2). Dry season discharges are only a small fraction of wet season flows.

4 Surface water resources are used extensively for dry season irrigation. In addition, there are groundwater resources in the country which are tapped for irrigation and potable water. Groundwater resource potential is regionally variable and depends on recharge from monsoon rainfall and floods.

5 A major problem that Bangladesh faces is that of too much water in the wet season (when overbank and rain water flooding acts as a limit on agricultural development, necessitating the cultivation of lower-yielding varieties and sometimes resulting in extensive damage to crops, livestock and infrastructure), and too little in the dry season (when irrigation is needed to intensify agriculture).

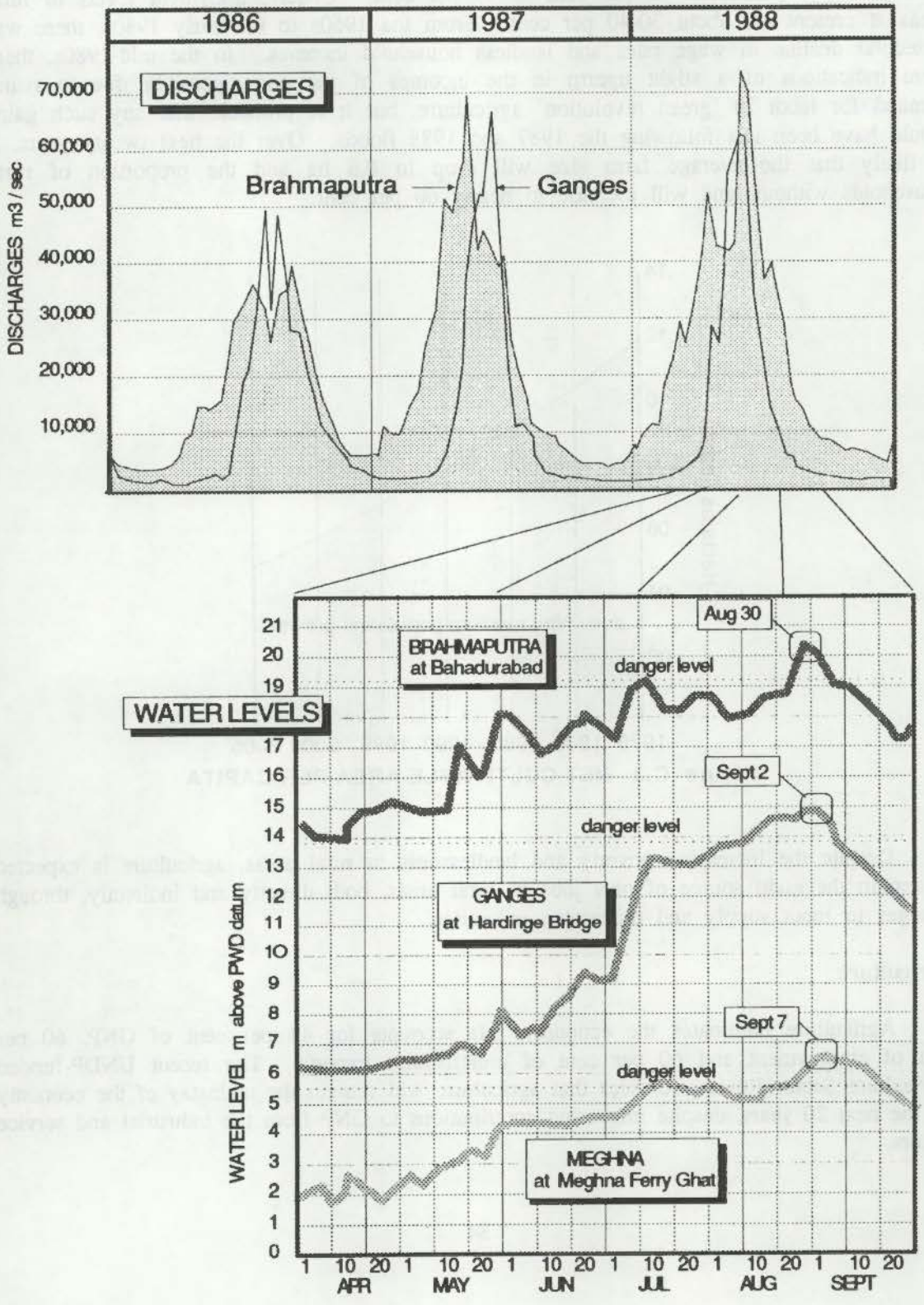
Population and Socio-economic Conditions

6 Bangladesh is one of the poorest countries in the world. The GNP per capita in 1986 was only about $160 and in real terms has shown little growth since Independence in 1971. The economy as a whole has grown in recent years by about 4 per cent annually, but with population growth of 2.5 per cent and faster economic growth in urban areas, average living standards in rural areas have stagnated.

7 The population of Bangladesh is about 110 million, and the population density is one of the highest in the world (770 per km^2, 1170 per km^2 of cultivable land). In some floodplain areas, the population density reaches 1500 per km^2. There are indications that population growth may be starting to decline but, even so, the population is projected to rise to nearly 170 million over the next 20 years. About 85 per cent of the population live in rural areas, but this figure is expected to decline in coming decades with increasing outmigration to urban areas. Migrants to towns are often people who have lost their land and houses as a result of riverbank erosion.

Figure C.2

MAIN RIVER DISCHARGES 1986-1988 AND FLOOD LEVELS 1988



8 Over the last thirty years, there has been a marked increase in poverty in rural areas. Between the 1960s and 1980s, owing mainly to pressure of population, average farm size declined from 1.45 ha to 0.90 ha (Figure C.3) and the proportion of households that are landless rose from about 35 per cent to 45 per cent. Under-employment levels in rural areas at present are about 30-40 per cent. From the 1960s to the early 1980s, there was a secular decline in wage rates and landless household incomes. In the mid-1980s, there were indications of a slight upturn in the incomes of the poor, possibly due to rising demand for labor in 'green revolution' agriculture, but it is probable that any such gains would have been lost following the 1987 and 1988 floods. Over the next twenty years, it is likely that the average farm size will drop to 0.6 ha and the proportion of rural households without land will increase to nearly 60 per cent.

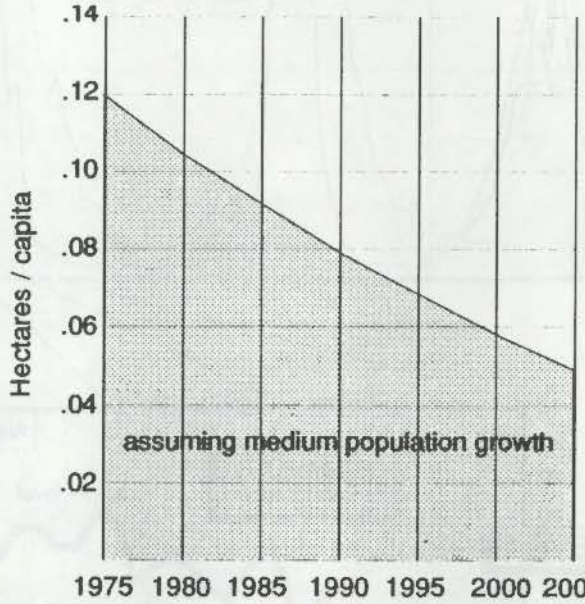


Figure C.3 NET CULTIVABLE AREA PER CAPITA

9 Despite the increasing poverty and landlessness in rural areas, agriculture is expected to remain the main source of new jobs in rural areas, both directly and indirectly, through linkages to input supply and processing industries.

Agriculture

10 Agriculture dominates the economy. It accounts for 45 per cent of GNP, 60 per cent of employment and 60 per cent of merchandize exports. The recent UNDP-funded Agriculture Sector Review foresees that agriculture will remain the mainstay of the economy for the next 20 years, despite increasing contributions to GNP from the industrial and service sectors.

11 Rice is the main crop grown in Bangladesh, covering about 78 per cent of the cropped area. There are three rice growing seasons a year - aus (harvested in the monsoon), aman (grown in the monsoon but harvested after) and boro (grown in the dry season). Aman is the most important (54 per cent of production), followed by boro (26 per cent) and aus (20 per cent). The other main crops are the export crop, jute (5 per cent of the cropped area), and wheat (4 per cent). Some 74 per cent of paddy production is grown in the monsoon season, much of which would benefit from flood protection.

12 Agricultural production has increased considerably since the Partition of the sub-continent in 1947. Up to the early 1960s, most of the growth came from more land being brought under cultivation and more intensive use (e.g., through double-cropping on previously single-cropped land). Since then, Government has made major efforts to raise agricultural output through the introduction of minor irrigation (low-lift pumps and tubewells), high yielding varieties of rice and wheat, and chemical fertilizers. Flood control and drainage projects have enabled farmers to cultivate higher-yielding rice varieties in the monsoon season in some areas and have protected boro crops from early flooding in many areas.

13 From 1973 to 1988, foodgrain production grew at an average of 2.5 per cent annually, which was broadly in line with population growth. Despite this, production fell short of consumption needs. There was a 'food gap' which was met by food aid and commercial purchases. If the country is to become self-sufficient in foodgrain production in the next 20 years, foodgrain output will have to grow at an unprecedented annual rate of over 4 per cent annually.

Infrastructure and Urban Development

14 Over the last 30 years, there has been a significant expansion of infrastructure in rural areas. Before that, the most important form of transport was manual and sail-powered country boats. There was little infrastructure on the floodplains except a small number of railway embankments, rural administrative centers and market towns, and a sparse network of inter-district roads and railways linked by river steamer services.

15 Although inland water transport is still the most important form of transport in rural areas, there has been a very great increase in the number of roads: both national highways built by central government and local council roads constructed under the Rural Works and Food-For-Work programs. In addition, over the last ten years, there has been a rapid expansion in government services at the Upazila centers and in the development of private factories and other commercial activities in small towns on the floodplains.

16 The new infrastructure has done much to stimulate development in rural areas and to improve government's response to floods. However, many roads and embankments have been constructed in ways that disrupt natural drainage channels and they have, in many places, been blamed for exacerbating the impact of floods.

RECENT FLOODS

Types of Flood and Frequency of Flooding

17 While the monsoon dominates the rainfall pattern in Bangladesh, flooding in the country is the result of a complex series of factors. These include huge inflows of water into the country from upstream catchment areas of the major rivers coinciding with heavy monsoon rainfall over Bangladesh, low floodplain gradients, congested drainage in older floodplain areas, the location and effects of the confluences of the major rivers inside the country, and the influence of tides and storm surges in the Meghna estuary.

18 In Bangladesh, four main types of floods occur. These are: monsoon floods from the major rivers; local flooding due to heavy and intense rainfall; flash floods in the eastern and northern rivers; and floods caused by storm surges in coastal areas. These are described in Table C.1

Table C.1 Types of Floods

1. Monsoon floods from the major rivers

Overbank flood spills of the major rivers and their distributaries cause the most extensive flood damage in Bangladesh. With the onset of the monsoon, all the major rivers start rising. The major rivers generally rise slowly over several weeks.

2. Local flooding due to heavy and intense rainfall.

Local flooding is caused by very heavy monsoon rainfall within Bangladesh which generates runoff volumes in excess of local drainage capacity, especially when the main rivers are at high levels.

3. Flash floods in the eastern and northern rivers

These are characterized by a sharp rise followed by a relatively rapid recession. High flood velocities often damage crops and properties.

4. Floods due to storm surges in the coastal area

The coastal areas of Bangladesh consist of large estuarine channels, extensive tidal flats and low-lying islands. Storm surges generated by tropical cyclones cause widespread damage to life and property. Tropical cyclones are most likely to occur during the pre- and post- monsoon periods (April-May and October-November respectively), and have not been known to coincide with monsoon flood peaks.

19 The normal sequence of floods starts with flash floods in the eastern hill streams during the pre-monsoon months of April and May. The onset of the monsoon generally occurs in June. The Meghna and the Brahmaputra rivers normally reach their flood peaks during July and August, and the Ganges river during August and September. Severe flooding occurs if the peaks of the Ganges and the Brahmaputra rivers coincide.

20 Floods may also be categorized according to the extent of the area flooded and the severity of damage they cause. On average, 22 per cent of the area of the country is flooded each year, with up to 60 per cent flooded by a 100-year return period flood (Table C.2). Floods that cover more than 25 per cent of the area of the country generally cause damage to infrastructure and urban areas. When more than 35 per cent of the territory is inundated, floods become catastrophic and loss of life accompanies extensive damage to production as well as to property in rural and urban areas.

Table C.2 Areas affected by floods

Return period (year)	Affected area (% of the country)
2	20
5	30
10	37
20	43
50	52
100	around 60
500	around 70
mean	22

Source: French Engineering Consortium

21 The succession of two catastrophic floods, as happened in 1987 and 1988, is a rare phenomenon, though there was a similar succession in 1954 and 1955. Despite the two catastrophic floods of 1987 and 1988, there is no evidence of any significant trend to increased flooding, either natural or man-made. However, over time, the extent of damage has increased as new development activities have become established on the floodplains.

22 It should be noted that the difference in levels between floods of different return periods is not large. Depending on the river basin, the difference in level between a 10-year and 100-year flood could be less than 50 cm. However, given the topography of Bangladesh, even such small differences in level can be significant in terms of area affected and damage caused.

Causes of the 1987 and 1988 Floods

23 The 1987 and 1988 floods were catastrophic events which led to widespread destruction, misery and loss of life. But they were very different in nature and origins.

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

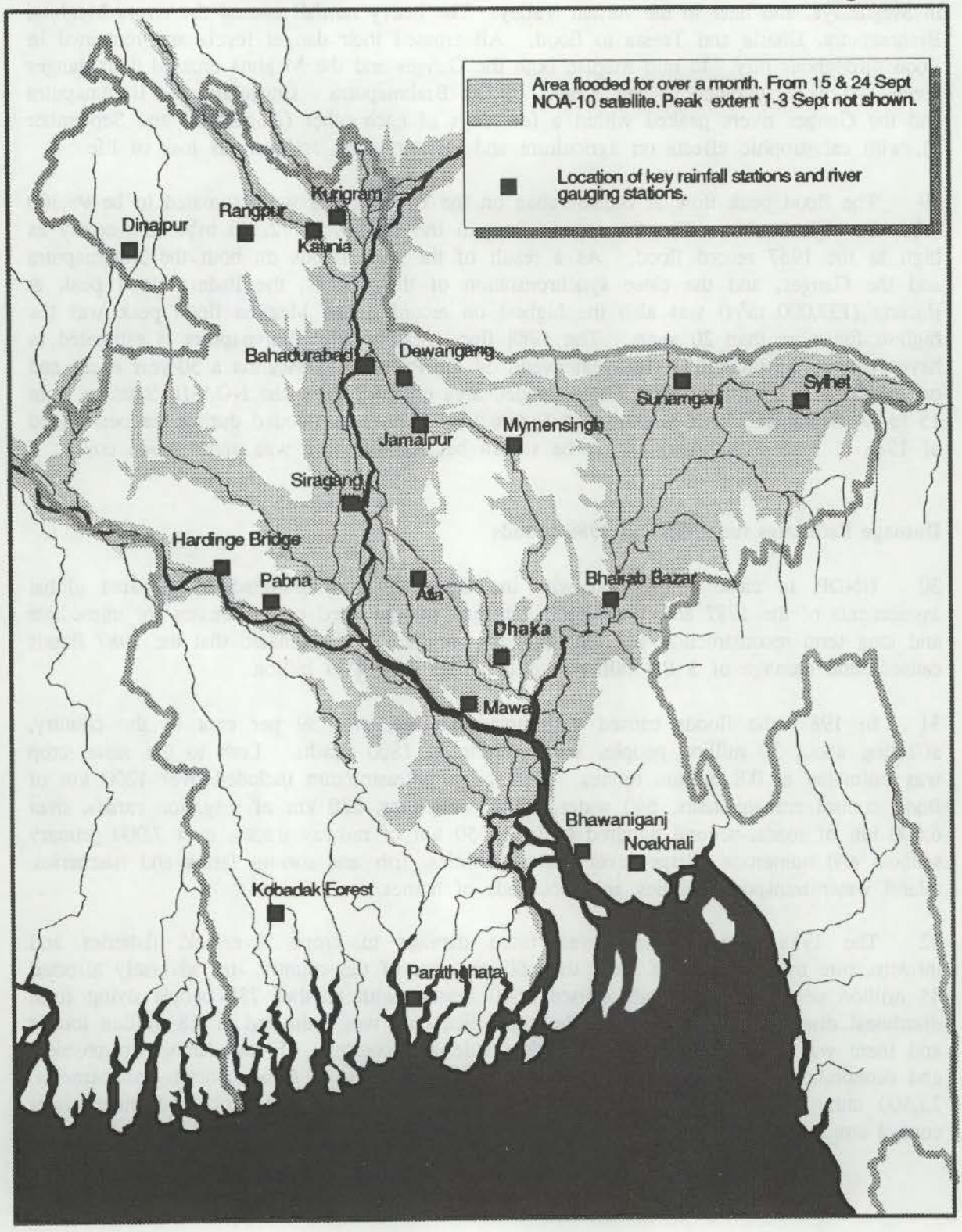
25 Ten-day and monthly rainfalls in 1987 were reported to be 100 to 150 year events over much of the northwest, and the record high 1987 flood peak on the Ganges at Hardinge Bridge was estimated to be 76,000 m^3/s. The flood peak in the Teesta was the highest since records began in the 1950s. The flood peaks in the Brahmaputra (at Bahadurabad) and in the Padma (at Baruria) were 5 to 10-year events. Although high floods were experienced elsewhere in Bangladesh in the course of 1987, they were not on the same scale in terms of damage as those in the northwest region.

26 The exceptionally high river levels in the north-west caused a number of embankments to be overtopped, eroded and breached. In addition, bank erosion caused extensive damage to embankments. Public cuts, mainly by those living outside protected areas, were common. In the lower areas of the northwest, in the vicinity of Chalan Beel, there was a 'knock-on' effect from the upstream floods which was aggravated by flood levels in the Brahmaputra which prevented outflow at the critical time from the main outlet for the northwest, the Hurasagar. Widespread destruction was caused to embankments, regulators, roads, railways, schools, houses, offices and commercial properties, and livestock perished in great numbers. Vast areas of crops in flood-affected areas were entirely lost, and elsewhere yields were seriously reduced.

27 The 1988 floods, in contrast, were caused by intense rainfall during the last 10 days of August over north and northeast Bangladesh, India, Nepal and Bhutan. The most intense local concentrations were in Assam, Meghalaya, Bhutan and Arunchal Pradesh. The flood peak on the Brahmaputra was the highest ever recorded. That on the Ganges was also high, but most significantly, the two peaks coincided, with devastating effects downstream of the Brahmaputra-Ganges confluence. Very large areas along the Brahmaputra, Ganges and Padma were flooded and Dhaka was seriously affected. There was also an exceptionally high flood in the Meghna which added to flood congestion in the Lower Meghna.

FLOODS OF SEPTEMBER 1988

Figure C.4



28 The 1988 flood season started with early flash flooding in the south-eastern hill basins in May-June. This was followed by a storm in early July which caused very heavy rainfall in Meghalaya, and later in the Assam Valley. The heavy rainfall caused the rivers Meghna, Brahmaputra, Dharla and Teesta to flood. All crossed their danger levels and remained in flood throughout July. In mid-August, both the Ganges and the Meghna crossed their danger levels and were followed in late August by the Brahmaputra. Unusually, the Brahmaputra and the Ganges rivers peaked within a few days of each other (August 30 and September 2), with catastrophic effects on agriculture and infrastructure, and serious loss of life.

29 The flood peak flow at Bahadurabad on the Brahmaputra was estimated to be 98,300 m^3/s, the highest ever. The flood peak flow in the Ganges at 72,300 m^3/s was nearly as high as the 1987 record flood. As a result of the high floods on both the Brahmaputra and the Ganges, and the close synchronisation of their peaks, the Padma flood peak at Baruria (132,000 m^3/s) was also the highest on record. The Meghna flood peak was the highest for more than 20 years. The 1988 flood peak on the Brahmaputra is estimated to have been of the order of a 100-year event, on the Padma and Meghna a 30-year event and on the Ganges a 40-year event. The flooded area obtained from the NOA-10 Satellite from 15 to 24 September 1988 is shown in Figure C.4. The area flooded during the peak flood of 1988 (1 to 3 September) cannot be shown because the area was under cloud cover.

Damage Estimates for 1987 and 1988 Floods

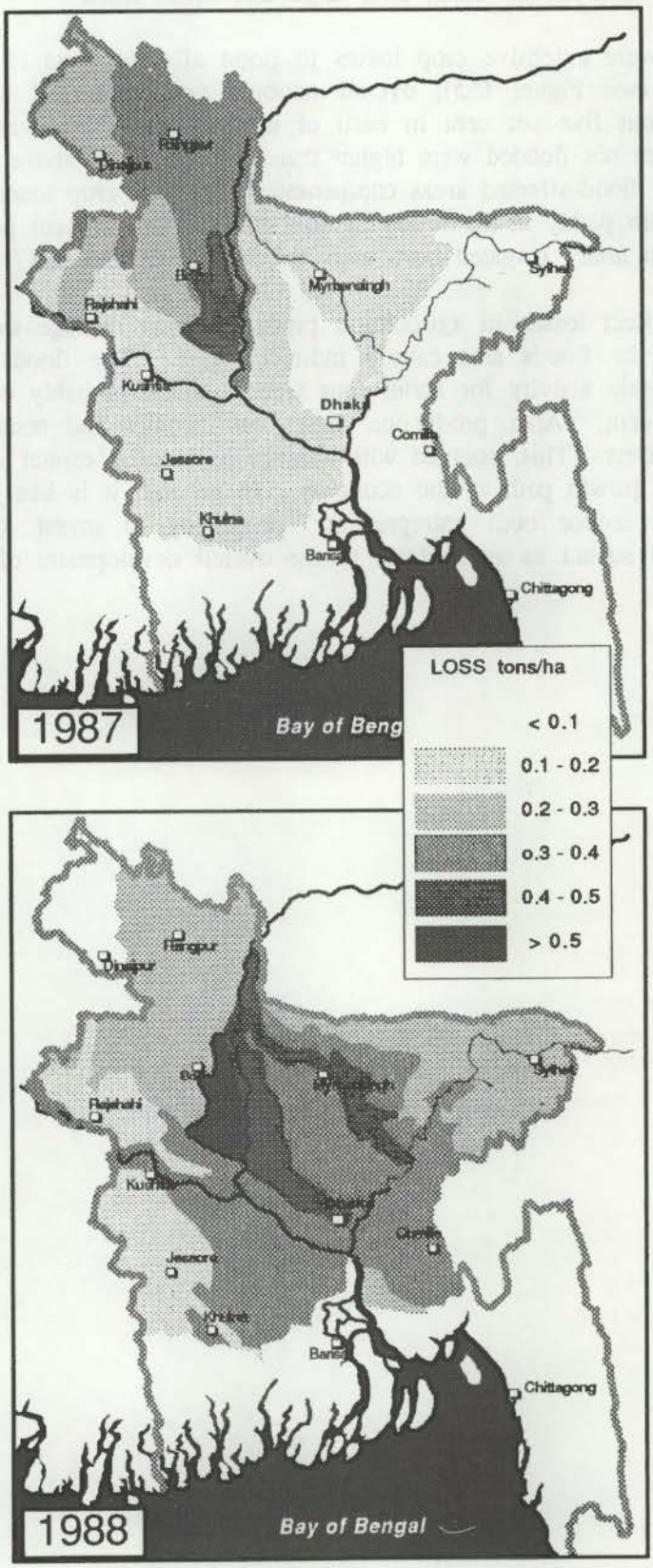
30 UNDP, in close cooperation with the Government of Bangladesh, prepared global assessments of the 1987 and 1988 flood damages and prepared cost estimates for immediate and long term reconstruction and rehabilitation programs. It estimated that the 1987 floods caused total damage of $ 0.5 billion and those in 1988 $1.3 billion.

31 In 1987, the floods caused widespread damage over 39 per cent of the country, affecting about 30 million people, and resulting in 1800 deaths. Loss to the aman crop was estimated at 0.8 million tonnes. Damage to infrastructure included over 1200 km of flood control embankments, 640 water control structures, 220 km of irrigation canals, over 6,500 km of roads, several hundred bridges, 650 km of railway tracks, over 7,000 primary schools and numerous village level health facilities, fish and shrimp farms and hatcheries, inland water transport facilities and thousands of homes.

32 The 1988 floods caused even more damage to crops, livestock, fisheries and infrastructure over an area of more than 60 per cent of the country and adversely affected 45 million people. The floods caused 1600 deaths, with another 735 people dying from diarrhoeal diseases. Net damage to the aman rice crop was estimated at 1.8 million tonnes and there was extensive loss of livestock (cattle and poultry). Flood damage to physical and economic infrastructure was extensive: about 2500 km of flood control embankments, 23,500 units of minor irrigation equipment, large numbers of regulators and other water control structures, 10,000 km of local roads, a substantial portion of national roads, highways

Figure C.5

LOSS OF MONSOON RICE PRODUCTION



and railways, several hundred bridges, over 19,000 educational institutions, 1,468 health centers and 3.7 million village houses. Widespread damage was also reported to fish and shrimp hatcheries, and to industrial units, both large and small scale.

33 Although there were extensive crop losses in flood affected parts of the country in both 1987 and 1988 (see Figure C.5), overall national production fell against expected production by only about five per cent in each of these years. This was because aman yields in areas that were not flooded were higher than normal due to above average rainfall and because farmers in flood-affected areas compensated for aman crop losses by expanding the area of irrigated boro paddy in the following dry season. Government put special effort into expanding the area under irrigated boro after the floods of both 1987 and 1988.

34 In addition to direct losses in agricultural production and damage to economic and physical infrastructure, the floods also caused indirect losses. The floods in both years disrupted normal economic activity for about four weeks, which probably cut the potential GNP by about 4 per cent. Also, production losses cut incomes and resulted in reduced investment in capital assets. This, coupled with damage to existing capital stock, will have affected the long term growth path of the economy. In general, it is likely that the risks associated with floods reduce both entrepreneurs' propensity to invest and households' propensity to save, and so act as an obstacle to the overall development of Bangladesh.

ANNEX D

LAND AND WATER DEVELOPMENT: AN OVERVIEW

1. In this chapter, the present situation of agriculture in Bangladesh and the potential for further development are discussed.

Cropping Patterns in Bangladesh

2. The main factors determining cropping patterns and crop yields on the floodplains of Bangladesh are the monsoon climate, soil properties, the depth, timing and duration of floods, salinity (in coastal areas), the presence or absence of irrigation, access to markets and farm management levels. Local variations in soils, in the timing and duration of seasonal flooding and in the provision of irrigation often lead to complex cropping patterns. Crop yields and production vary from year to year depending on the sufficiency of pre-monsoon and post-monsoon rainfall for non-irrigated crops, the incidence of untimely or high floods and, for dryland rabi crops, the time of recession of floodwater from the land and the incidence of rainfall during the dry season.

3. Table D.1 shows the main cropping patterns by depth of flooding and land types (under normal flooding) and the changes that can occur with irrigation. The impact of flood control and drainage is to reduce the flooding depth and to make it possible to grow higher-yielding cropping patterns. The categorization of land types below is based on that used in the National Water Plan.

Land types	Description	Flood depth	Nature of flooding
F0	Highland	Not flooded	Intermittent or flooded up to 30 cm
F1	Medium	30 to 90 cm highland	Seasonal
F2	Medium	90 to 180 cm lowland	Seasonal
F3	Lowland	Over 180 cm	Seasonal (<9 months)
F4	Low/very lowland	Over 180 cm	Seasonal (>9 months) or perennial

TABLE D.1

Main Cereal Cropping Patterns

Land type	Early kharif	Late kharif	Rabi
Non-irrigated			
F0	B Aus	- [1]	Wheat
	HYV Aus	LV T Aman	-
F1	B Aus	LV T Aman	-
	HYV T Aus	LV T Aman	-
F2	B Aus mixed with	B Aman	Wheat
	B Aus mixed with	B Aman	-
F3	-	B Aman	-
F4	-	-	LV Boro
Irrigated			
F0	-	HYV T Aman	Wheat
	-	HYV T Aman	HYV Boro
F1	-	LV T Aman	Wheat
	-	LV T Aman	HYV Boro
F2	-	T Aman [2]	HYV Boro
	-	-	HYV Boro
F3	-	-	HYV Boro
F4	-	-	LV Boro

Notes: [1] Fallow. [2] Transplanted deep water aman

Abbreviations: B = broadcast; T = transplanted; LV = local variety; HYV = high yielding variety

4. On non-irrigated land, paddy yields and overall output generally decline with increasing depth of flooding (see Table D.2). Yields of transplanted rice normally exceed those of broadcast rice. Farmers on F0 and F1 land with permeable soils generally grow broadcast aus or jute followed by rabi crops; on impermeable soils, they grow local or HYV transplanted aman, preceded in wetter parts of the country by broadcast or transplanted aus. On F2 land, mixed aus and aman or jute is grown followed by rabi crops (eg wheat, oilseeds, pulses). On F3 land, farmers grow deepwater broadcast aman which may be

followed by rabi crops on the higher parts. Local boro is the only crop grown on F4 land. Two or three crops a year are grown on F0 and F1 land in the wetter eastern and central districts, on F2 land and on the higher part of F3 land.

TABLE D.2

Gross Value of Output per hectare by land Type[1] (Taka)

Land type	Irrigated	Non-irrigated
F0	35 500	19 100
F1	29 100	20 200
F2	28 100	15 500
F3	24 100	8 600
F4	12 900	11 300

Note: [1] National Water Plan estimates in 1989 prices. Average of two main cropping patterns on each land type, irrigated and non-irrigated.

5. On irrigated land, boro paddy is the principal crop on impermeable soils on all land types (F0 to F4). High yielding varieties of rice (HYVs) are grown, except in some depressions subject to early flooding, where traditional boro varieties continue to be grown. On impermeable F0 and F1 soils, HYV boro is generally followed by transplanted aman (HYV or local, rainfed or irrigated). Elsewhere, irrigated boro has displaced some rainfed aus and jute on F1 and F2 land and deepwater aman on F2 and F3 land. On permeable F0 to F2 soils, wheat, potato, vegetables and spices are the principal crops grown with irrigation.

6. Floodplain cropping patterns are often complex. Most floodplain villages include several soil and land types and farmers' fragmented holdings lie scattered across them. Additionally, farmers generally grow several crop varieties in order to suit local micro-environments, to reduce risks of crop damage and to spread their labor use and market opportunities.

7. Flood control and drainage can be provided for two alternative purposes. Where pump or tidal drainage can be provided, the objective is to reduce the depth of flooding so as to convert the greater part of the protected area to F0 and F1 land and thereby enable intensive cropping practices to be used in the rainy season (and, with irrigation, in the dry season also). Elsewhere, with 'controlled flooding', the objective is to eliminate high and untimely floods so as to provide greater security of crop production in the rainy season under 'normal' flooding conditions. Embankments (including submersible embankments) are needed in some areas to protect boro paddy from early floods.

8. The country has been divided into six regions based on differences in flooding characteristics (see Figure 2.2). Table D.3 indicates the considerable differences which exist between regions in the distribution of land of different depth of flooding types. These regional differences, together with differences between them in annual rainfall, the length of the rainy season and the length of the cold winter season, considerably influence regional cropping patterns and potentials. Important differences between regions are outlined below.

TABLE D.3

Distribution of Cultivable Land Type and Region
(Area in Mha)

Region	Cultivable area	F0	F1	F2	F3	F4
North West	2.451 (100)[1]	1.307 (53)	0.797 (33)	0.194 (8)	0.153 (6)	-
North Central	0.909 (100)	0.308 (34)	0.267 (18)	0.168 (18)	0.160 (1)	0.006
North East	1.664 (100)	0.481 (29)	0.301 (18)	0.361 (22)	0.508 (30)	0.013 (1)
South West	1.666 (100)	0.545 (33)	0.713 (43)	0.281 (17)	0.120 (7)	0.007 (0)
South East	1.313 (100)	0.386 (29)	0.474 (36)	0.300 (23)	0.134 (10)	0.019 (2)
South Central	1.026 (100)	0.234 (23)	0.599 (58)	0.128 (13)	0.032 (3)	0.033 (3)
Active flood-plain	0.533 (100)	0.253 (47)	0.137 (26)	0.126 (24)	0.017 (3)	-
Bangladesh	9.562 (100)	3.514 (37)	3.288 (34)	1.558 (16)	1.124 (12)	0.076 (1)

Note: [1] Figures in parentheses indicate percentage of cultivable area in the region.

9. **The north-west (NW)** region comprises the area between the Brahmaputra-Jamuna and Ganges rivers. It includes 13 sub-regions: the active Teesta, Brahmaputra and Ganges floodplains; the high and low Ganges meander floodplains; the Teesta and Karatoya-Bangali floodplains; the old Himalayan piedmont plain; the lower Atrai basin (Chalan Beel); and the Barind Tract. About 86 per cent of the cultivable land is F0 and F1 land. The main

flooding problems in the NW are caused by river floods on the active Teesta, Brahmaputra-Jamuna and Ganges floodplains, by the backing up of water in the low-lying Atrai basin and by flash floods on the old Himalayan piedmont plain and the Teesta and Atrai floodplains. Breaching of the Brahmaputra right bank embankment can also cause severe flooding on the Karatoya-Bangali floodplain and parts of the Teesta floodplain. Transplanted aman is the principal crop affected, but boro, aus and deepwater aman paddy and jute are occasionally damaged by early floods. About 29 per cent of the NW region is irrigated, predominantly by tubewells.

10. **The north-central (NC)** region comprises the area between the Old Brahmaputra, Jamuna and Meghna rivers. It includes nine sub-regions: the active and meander floodplains of the Jamuna, the Old Brahmaputra and Ganges rivers; the low-lying Arial Beel; and the predominantly upland Madhupur Tract. F0 and F1 land together occupy about 63 per cent of the cultivable land and F3 and F4 land 19 per cent. The main areas subject to damaging floods are the active river floodplains, the Ganges meander floodplain and the southern part of the Jamuna floodplain. Transplanted aman is the principal crop affected by floods in north; in the center and south, aus, deepwater aman and boro paddy and jute are affected by early floods. About 40 per cent of the NC region is irrigated, partly by low-lift pumps and traditional methods, partly by tubewells.

11. **The north-east (NE)** region comprises three main subregions: extensive piedmont floodplains in the north and east; the low-lying Sylhet basin in the center; and part of the Old Brahmaputra floodplain in the west. F0 and F1 land occupy 47 per cent of the cultivable land, F3 and F4 31 per cent. The main flooding problems are caused by flash floods in the north and east, deep and sometimes early flooding of the Sylhet basin, and both river and rainwater floods on the Old Brahmaputra floodplain. Flash floods can damage boro, aus, deepwater and transplanted aman, depending on the season in which they occur. Early floods damage boro paddy in the Sylhet basin and on the Old Brahamputra floodplain. About 22 per cent of the NE region is irrigated, mainly by low-lift pumps and traditional methods.

12. **The south-west (SW)** region comprises the area south of the Ganges and Padma between the western border and the Arial Khan and Swarupkati rivers. It includes five subregions: parts of the Ganges active, meander and tidal floodplains and of the Gopalganj-Khulna beels. F0 and F1 land together comprise 76 per cent of the cultivable land in the region, and F2 land 17 per cent. Flooding problems are caused mainly by drainage congestion in interior floodplain areas and over-bank spill from the Ganges. Additional problems are provided by dry-season salinity and exposure to cyclones and storm surges in the south, by perennially wet peat areas in the Gopalganj-Khulna beels, and by relatively droughty conditions in the north. Transplanted aman is the main crop affected by floods. About 16 per cent of cultivable land in the SW region is irrigated, partly by gravity canals in the Ganges-Kobadak project, elsewhere by low-lift pumps or tubewells.

13. **The south-central (SC)** region comprises the area west of the Padma and low Meghna rivers as far as the Arial Khan and Swarupkati rivers. It includes six sub-regions: parts of the Ganges active, meander and tidal floodplains, of the old and young Meghna estuarine floodplains and of the Gopalganj-Khulna beels. F0 and F1 land together comprise 81 per cent of the region, and F2 land 13 per cent. Flooding problems are caused mainly by river flooding along the Ganges-Padma channel and by drainage congestion in the interior.

Additional problems are caused by exposure to cyclones and storm surges in the south, dry-season salinity in the extreme south and by perennially wet peat areas in the Gopalganj-Khulna beels. About 10 per cent of cultivable land in the SC region is irrigated, mainly by low-lift pumps in the south (eg., in Barisal Irrigation Project) and to some extent by tubewells in the north.

14. **The south-east (SE)** region comprises the area east of the middle and lower Meghna rivers to the eastern border and the coast. It includes eight sub-regions: old and young Meghna estuarine floodplains; middle and lower Meghna river floodplains; the complex Chittagong coastal plain; piedmont plains; and the eastern hills. Excluding the hill areas, F0 and F1 land occupy 65 per cent of the cultivable area and F2 land 23 per cent. The main flooding problems are caused by flash floods in areas adjoining the eastern hills, which may damage boro, aus or transplanted aman depending on their time of occurrence. River floods occasionally damage aus and deepwater aman on the Meghna river floodplains and local flooding damages crops on the Meghna estuarine floodplain. Storm surges occasionally damage transplanted aman, more rarely aus, in coastal areas. About 40 per cent of cultivable land in the region is irrigated, mainly by tubewells, but partly by low-lift pumps in the Chandpur Irrigation Project and on the Chittagong coastal plain and by gravity irrigation in the Meghna-Dhonagoda Irrigation Project.

Agricultural Development

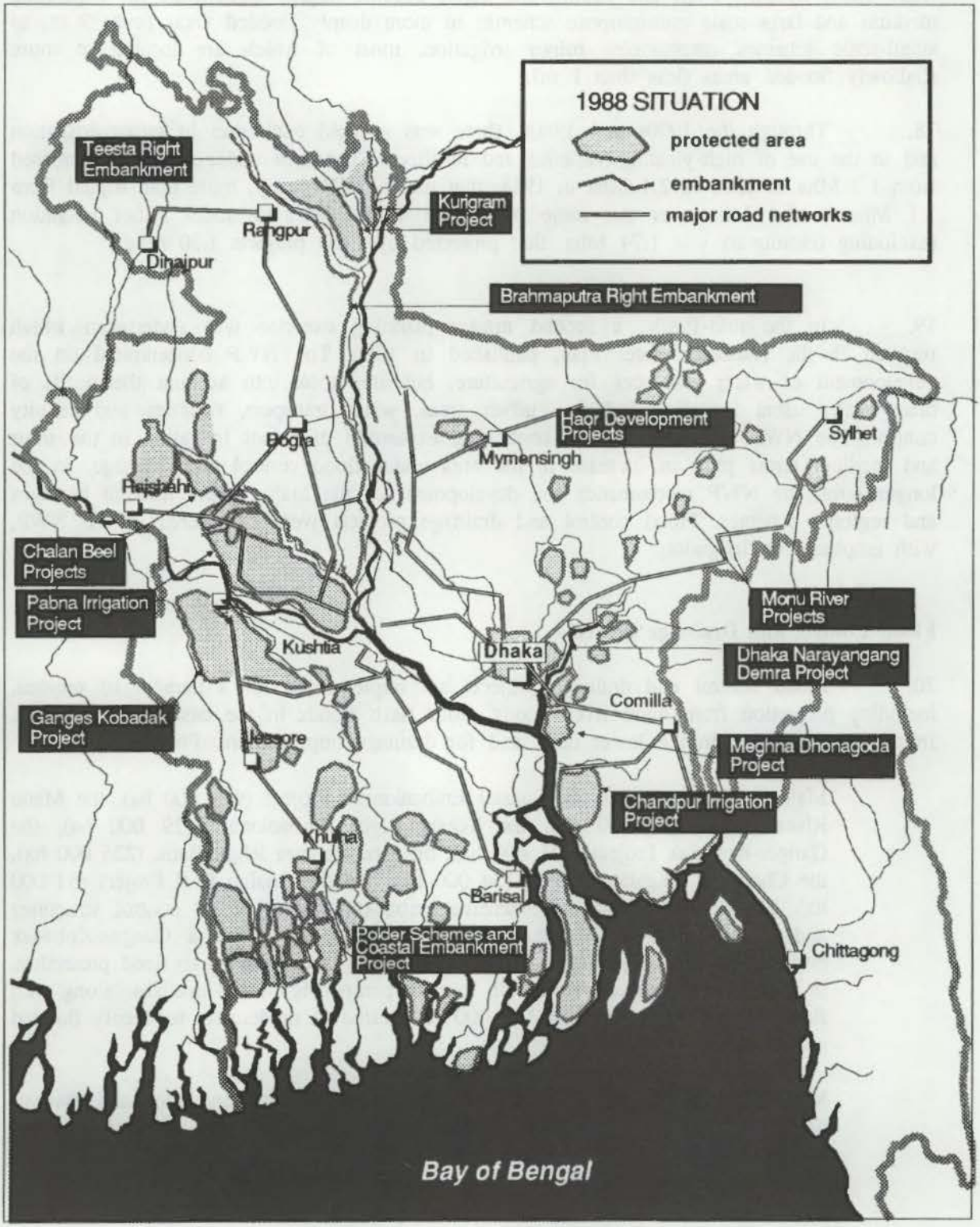
15. Major government efforts to increase agricultural production started in the early 1960s. The importance of improved water control to agricultural development was recognized from the outset. Among the first organizations established were those that were later to become the Bangladesh Water Development Board (BWDB) and the Bangladesh Agricultural Development Corporation (BADC).

16. In 1964, a Master Plan for water resource development was developed which envisaged the development of 50 flood protection and drainage projects (some with gravity irrigation) covering about 5.8 Mha of land. Three types of polders were envisaged: polders with gravity drainage, tidal sluice drainage and pump drainage. Projects included in the 1964 Master Plan which have been completed include: the Coastal Embankment Project (949 000 ha) completed in 1980; the Brahmaputra Right Flood Embankment (226 000 ha) completed in 1968; the Dhaka-Narayanganj-Demra irrigation scheme (4 000 ha) completed in 1968; the Ganges-Kobadak Project (Phases 1 and 2), providing wet season irrigation to 141 000 ha, which was completed in 1970; the Manu River Project (22 500 ha); the Teesta Right Embankment Project (39 000 ha); the Barnal-Salimpur-Kolabasukhali Project (25 500 ha); the Chalan Beel Project (53 000 ha); the Tarnal-Pachuria Project (20 000 ha); the Satla-Bagda Project (29 000 ha); and the Chandpur Irrigation project, an FCDI project completed in 1979. The main FCD and FCDI projects in Bangladesh are shown in Figure D.1.

17. In 1972, soon after Independence, the World Bank published a comprehensive Land and Water Sector Study. This study was based on the experience gained in the 1960s and on new hydrological and agro-ecological data that had become available. The recommendations of the study, called for a significantly different pattern of development from that envisaged in the 1964 Master Plan. A rapid increase in food production through the implementation of small, quick-yielding projects, including minor irrigation and small-

MAJOR FLOOD CONTROL PROJECTS

Figure D.1



scale FCD projects, became the main focus of government water development policy. BADC, IRDP (later BRDB), BKB and commercial banks became largely responsible for expanding medium and large-scale multipurpose schemes in more deeply flooded areas (over 2 m) to small-scale schemes emphasizing minor irrigation, most of which are located in more shallowly flooded areas (less than 1 m).

18. Through the 1970s and 1980s, there was a rapid expansion in minor irrigation and in the use of high-yielding varieties and fertilizers. The area under irrigation increased from 1.2 Mha in 1973 to 2.4 Mha in 1988; that under HYV paddy, more than tripled from 1.1 Mha to 3.4 Mha over the same period. In 1985, the area under minor irrigation (excluding traditional) was 1.74 Mha, that protected by FCD projects 1.30 Mha.

19. In the mid-1980s, a second master planning exercise was undertaken which resulted in the National Water Plan, published in 1986. The NWP concentrated on the development of water resources for agriculture, but also took into account the needs of other water users including industry, urban areas, water transport, fisheries and salinity control. The NWP recommended the continuing expansion of minor irrigation in the short and medium terms plus an increase in the area under flood control and drainage. In the longer term, the NWP recommends the development of the major rivers through barrages and regional schemes. Flood control and drainage projects were considered in the NWP, with emphasis on irrigation.

Flood Control and Drainage Projects

20. Flood control and drainage projects are implemented for a number of reasons, including protection from main river floods, from flash floods in the east of the country, from saline intrusion in the lower delta and for drainage improvement. Projects include:

- Major projects such as the Coastal Embankment Project (949 000 ha), the Manu River Project (22 500 ha), the Teesta Right Embankment (39 000 ha), the Ganges-Kobadak Project (141 600 ha), the Brahmaputra Right Bank (226 000 ha), the Chandpur Irrigation Project (54 000 ha), and the Chalan Beel Project (53 000 ha). These projects include extensive embankments and water control structures and, in the case of Meghna-Dhonagoda, Manu, Muhuri and Ganges-Kobadak projects, gravity irrigation covers about 185 000 ha in addition to flood protection. In Bhola, Chandpur and Karnafuli, low lift pump irrigation is available along with flood control for an area of 140 000 ha located in moderately to deeply flooded areas.

- Medium-scale projects such as the Satla-Bagda, Chenchuri Beel and Barnal-Salimpur-Kolabasukhali projects implemented under the Drainage and Flood Control Projects (DFC I to DFC IV) financed by the World Bank. These projects typically benefit areas of 10 000 to 30 000 ha and involve flood control and drainage with limited irrigation development.

- Small-scale projects such as those implemented under the Early Implementation Projects (supported by Netherlands and Sweden), the Small-scale Irrigation Project

(Asian Development Bank) and Small-scale Drainage and Flood Control Project (World Bank/Canada). These started mainly as flood control and drainage projects in shallowly flooded areas. Projects were designed to be implemented quickly, to have low investment costs per hectare and to benefit areas of 1 000 ha to 10 000 ha. In recent years, upazilas have started to implement very small-scale projects (generally under 500 ha) with the assistance of the Local Government Engineering Bureau.

21. Flood control and drainage projects have accounted for about half of the funds spent on water development projects since 1960. Despite this, the benefits have been less than planned. There are a number of reasons for this, including cost and time overruns (due to a number of factors such as land acquisition) and problems in the operation and maintenance of projects. There is a tendency to see projects as being finished when the physical works are complete. Insufficient attention is paid to ensuring adequate water control. Problems in the operation and maintenance of projects have also been common, as is indicated by the frequent cutting of embankments by the public and malfunctioning of regulators and water control structures.

22. There have been few adequate evaluations of flood control and drainage projects and it is thus difficult to estimate their impact on production, incomes and employment, or to assess the operational and other problems involved and the best ways to overcome these. Evaluations of the Chandpur Irrigation Project (a major FCDI project) and the Early Implementation Projects indicate that benefits can be considerable, but are often less than planned because of operational problems. Big projects like Chandpur, however, often bring indirect benefits (eg to transport, culture fisheries) which are difficult to quantify

Minor Irrigation Development

23. The development of irrigation started in the 1950's with the exploitation of surface water using low lift pumps which irrigate, on average, about 10 ha. By the mid-1970's, 0.6 M ha were irrigated with surface water and most of the easily accessible resources had been developed. Groundwater development started with deep tubewells (capable of irrigating about 30 ha) in the 1960s and continues today. The further exploitation of groundwater with individually owned shallow tubewells (irrigating, typically, 4 ha each) started in the late 1970s and by 1985 this had become the dominant mode of groundwater irrigation. In 1985, shallow tubewells (STW) irrigated an estimated 0.520 Mha, deep tubewells (DTW) 0.420 Mha, low-lift pumps (LLP) 0.720 Mha, major FCDI project 0.32 Mha and traditional methods 0.350 Mha. Over the last 20 years, the area under traditional irrigation declined from about 0.6 Mha to 0.4 Mha; that under mechanized/modern irrigation increased from under 0.1 Mha to nearly 1.8 Mha.

24. In the mid-1980s, there was concern about an apparent falling off in demand for new irrigation equipment and in the average area irrigated by tubewells and low-lift pumps. Following the 1987 and 1988 floods, however, demand for irrigation, especially STWs, has increased as farmers tried to compensate for the crop losses.

25. Irrigation has been the leading factor in agricultural development. Irrigation has made possible expansion of HYV boro and wheat cultivation. In low-lying areas, HYV boro often replaced broadcast aman leading to increases in yields per ha from 1.5 tonnes to 4.5 tonnes; on higher land, HYV boro often replaced broadcast aus or transplanted aus with increases in yields from 1.2 tonnes to 4.0 tonnes/ha. Irrigated development also typically led to increases in agricultural employment of 30 to 50 per cent per hectare. Post-project evaluations indicate that rates of return on minor irrigation projects are generally in the region of 20 to 40 per cent.

Potential for Growth

26. The UNDP Agriculture Sector Review emphasizes the considerable potential for agricultural growth in Bangladesh. Yields of rice, wheat and other main crops are lower than in other countries in the region, as are the use of irrigation, fertilizer and other inputs. Bangladesh has generally productive, alluvial soils and a climate that permits plant growth throughout the year. With improved water control (through flood control, drainage and irrigation), the development of new varieties of rice and other crop varieties suited to the varied agro-ecological conditions in the country, and improved input supply and extension, Bangladesh can greatly increase agricultural output.

Scope for Intensification of Dry Season Agriculture

27. There is considerable scope for the further expansion of dry season agriculture over the next 15 to 20 years. The National Water Plan estimates that the area under irrigation could be almost tripled from about 1.8 Mha to 5.5 Mha (from 26 to 76 per cent of the net cropped area). This would be achieved through:

- groundwater development to irrigate 2.3 Mha with shallow tubewells, deep-set shallow tubewells and deep tubewells;
- surface water development to irrigate an additional 1.2 Mha by low-lift pumps, withdrawal schemes from main rivers and major irrigation schemes (FCDI).

The expansion in the area under irrigation would greatly increase HYV boro production.

28. After the end of the National Water Plan period in the year 2005, a further development of 1.5 Mha of irrigation would be possible but would involve major projects, such as barrages, to divert stream flow from the main rivers and possibly the integrated development of major FCDI projects.

Scope for the Intensification of Wet Season Agriculture

29. There is also considerable scope for the further development of wet season agriculture through more widespread supplementary irrigation of monsoon season crops (especially transplanted aman), the development of new FCD and FCDI projects and by the more effective operation of existing and future major schemes. The National Water Plan estimated that an extra 1.8 Mha of protection (raising the total net benefited area to 3.1 Mha) could be implemented by the year 2005, but this did not take account of possible major projects along main rivers which would increase this potential area considerably.

30. As was noted earlier, flood control and drainage projects make possible increased agricultural production by reducing the risk associated with monsoon agriculture and, where pump or tidal drainage can be provided, making the cultivation of HYVs possible in the monsoon season as well as, with irrigation, in the dry season. Although there have been few evaluations of FCD and FCDI projects, there are a number of examples of projects that have been successful. The Chandpur Irrigation Project, for example, is a successful tidal and pump drainage project that made possible the cultivation of HYV aman on land where lower-yielding broadcast aman was previously grown; the Early Implementation Projects are examples of generally successful smaller schemes which reduce the risk to farmers associated with the cultivation of traditional cropping patterns.

31. To achieve potential changes in cropping patterns and increases in production from flood control and drainage projects, such projects need to be designed carefully and operated effectively. Likely problems in scheme operation need to be anticipated during planning and taken into account in project design (eg, inclusion of ring bunding within polders to protect lower land; provision of minor irrigation on higher land). Projects also need to be operated and maintained effectively which requires participation of the beneficiaries and possibly local government in management. Effective operation and maintenance will be even more important in the case of the compartments envisaged for 'controlled flooding' (see Chapter 2).

32. Attention must also be given in project design and operation to reducing any negative social impacts of FCDI and FCD projects and to minimize any negative environmental impacts. Land acquisition procedures need to be improved and provision made for occupational training and skill development for those whose land is acquired. Projects should be designed, as far as practicable, to minimize any negative impacts on fishing or boating households and on the fisheries resource.

33. Floodplains are critical for capture fisheries in Bangladesh. Floodplains and beels provide the habitat for a highly productive open water capture fishery and spawning grounds for major river fisheries. This productivity is dependent, however, upon natural hydrologic patterns which can be disrupted by flood control and drainage projects. Care needs to be taken in the planning and operation of such projects to minimize any detrimental impacts on fisheries (eg through the provision of structures to allow entry and exit of fish at appropriate times).

34. To make the most effective development of agriculture based on flood control, drainage and irrigation projects (including minor irrigation), improvements in farming technology, including more intensive use of inputs, will be essential. A number of new varieties of paddy and other crops are under development and may be ready for introduction within the next decade. These include improved varieties of deepwater aman and new varieties of HYV aman which are photoperiod-sensitive and suitable for late transplanting after the recession of floodwater. Privatization of input distribution (eg fertilizers, pesticides) has improved overall access to them by farmers, though problems still remain in more remote areas. Over the next two decades, a high priority must be given to agricultural research, extension and input supply. The UNDP-financed Agricultural Sector Review discusses these issues. There should also be a closer integration of activities of agencies concerned with the development of flood control and drainage and those concerned with

agricultural, fisheries and livestock development in the planning and implementation of FCD and FCDI projects.

Overview by Region

35. **The north-west (NW)** region has high potential for the further development of surface water irrigation from the rivers Brahmaputra, Teesta, Darla and Dudhkumar. Besides, the region has further potential of groundwater development by tubewells, particularly on the extensive areas of F0 and F1 land. This would be for HYV boro and aman cultivation on impermeable soils and for irrigated rabi crops (eg wheat) on permeable soils. Flood control along the Brahmaputra-Jamuna is essential to the securing of kharif crops: aus, jute and transplanted aman in the north and center, deepwater aman in the south. The same is true along the Ganges. To gain full benefits from such major embankments, improved water control through smaller projects behind the main embankments is needed. In the Chalan Beel, flood control embankments to protect the HYV boro crop could be further developed, though the problem of evacuating rainwater in the rainy season requires a solution.

36. **The north-central (NC)** region needs flood protection, especially in the south and center of the region, for further improvement of crop production in the rainy season. Controlled flooding would increase security of aus, deepwater aman and jute crops, which might encourage farmers to invest more in fertilizers and improved seeds. Like the north-west region, this region offers high potential for surface water irrigation from the Brahmaputra and its distributaries. In addition, development of groundwater irrigation is envisaged for HYV boro cultivation and for supplementary irrigation of aman, especially in the north.

37. **The north-east (NE)** region is hydrologically the most difficult region to develop due to the very high rainfall in the region and surrounding hill areas, deep flooding in the haors in the Sylhet basin and low river gradients below the exit from the region. Controlled flooding as in the NC region may be feasible in the western part of the old Brahmaputra floodplain. Elsewhere, further development of submersible embankments (in the center and east) and embankments against flash flooding (in the north and east) will be needed to secure the boro crop and, in places, the aus and transplanted aman crops.

38. **The south-west (SW)** region requires channel improvements to relieve drainage congestion in interior areas and embankments with sluices to control flooding by saline water in coastal areas so as to secure the transplanted aman crop and expand shrimp farming. The region has potential for further irrigation development for dryland rabi crops on permeable ridge soils and HYV boro on depression clays. There is significant potential for surface water irrigation development from the Ganges in this region which would at the same time ensure some relief from salinity to the industries in Khulna in the dry season. Supplementary irrigation of aus, aman and jute would also be beneficial.

39. **The south-central (SC)** region also experiences severe hydrological problems (see para. 13, above). In the north, controlled flooding following protection from the Ganges and Padma floods would secure jute and mixed aus and aman crops. In the interior parts of the north and center, channel improvements together with embankments (perhaps submersible) could increase the area suitable for secure HYV boro, dryland rabi crops, jute, aus and aman

crop production. In the south, embankments with sluices are needed to provide protection against tidal flooding, occasional storm surges and, in the extreme south, saltwater flooding. Such facilities would help secure transplanted aman and HYV boro/aus cultivation. The region offers excellent potential for surface water irrigation development through diversion of Ganges waters There is also further potential to expand tubewell or low-lift pump irrigation in most areas in order to increase HYV boro/aus production and, in the north, high-yielding dryland rabi crops.

40. **The south-east (SE)** region is the most intensively cultivated region of Bangladesh. It has potential for further irrigation development. Surface water irrigation development could be achieved with new projects similar to the Chandpur Irrigation Project and with water diversion from the middle Meghna river through the existing network of man-made khals. Controlled flooding on land adjoining the middle Meghna would bring benefits similar to those in the NC region. Embankments to protect against flash floods would benefit boro, aus and aman crops in the east of the region in Comilla, Noakhali and Chittagong districts.

APPENDIX

ACTION PLAN DETAILS

INTRODUCTION

The Action Plan comprises twenty six elements divided into two groups :

- Plan Components
- Supporting Activities

This appendix contains a general description of each element, including preliminary schedules and approximate costs for studies, project preparation, pilot projects and other activities leading to the implementation of the Action Plan. At this stage no cost estimates for main works are given. The preliminary schedule for the Action Plan, a map showing location of works and a table of indicative costs are included in the Appendix.

It is expected that as the Action Plan proceeds further projects will be generated by the studies and additional studies will be identified.

ACTION PLAN

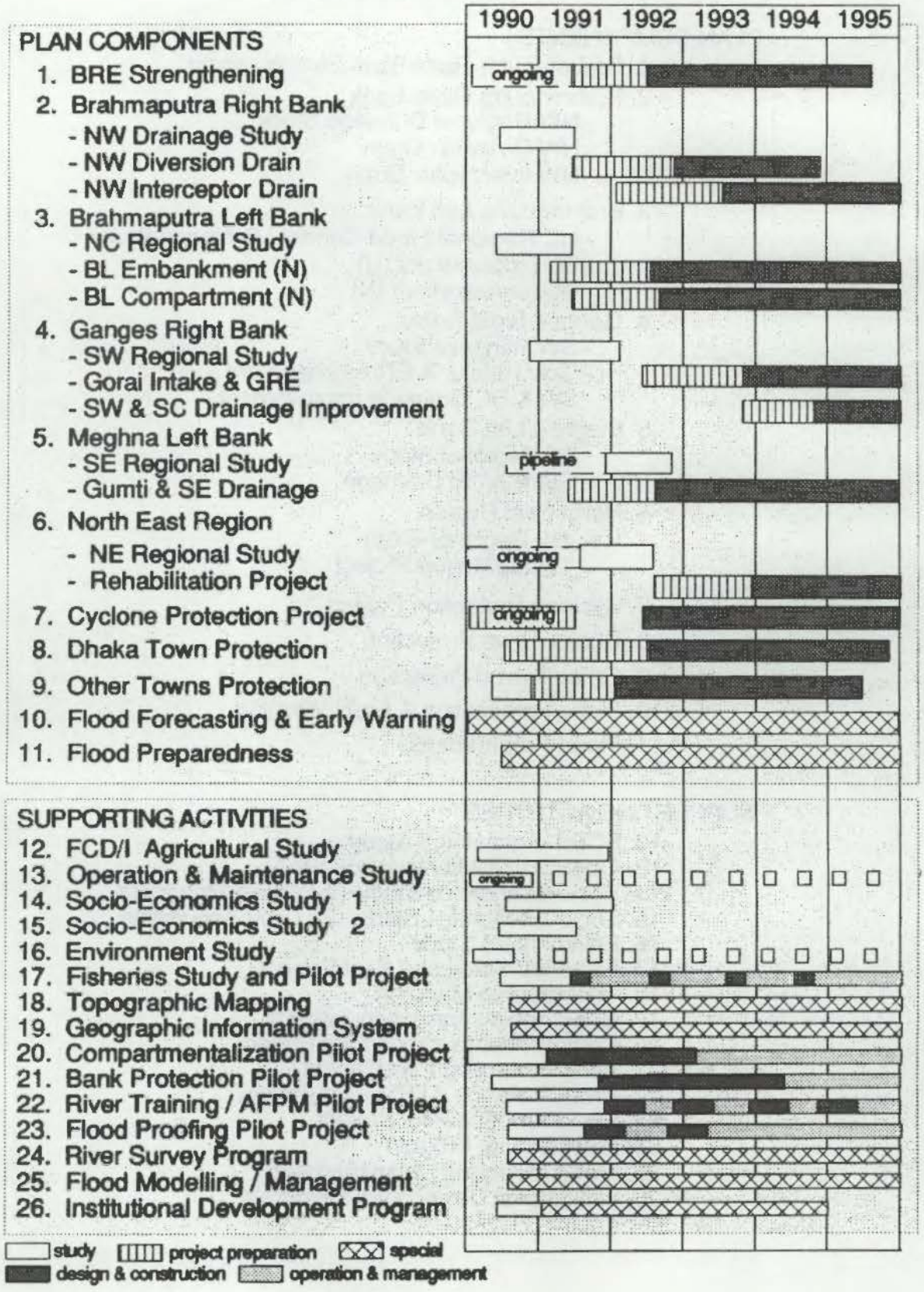
PLAN COMPONENTS

1. Brahmaputra Right Bank Strengthening
2. Brahmaputra Right Bank
   - NW Regional Drainage Study
   - NW Diversion Drain
   - NW Interceptor Drain
3. Brahmaputra Left Bank
   - NC Regional Flood Control / Drainage Study
   - BL Embankment (N)
   - BL Compartment (N)
4. Ganges Right Bank
   - SW Regional Study
   - Gorai Intake & GR Embankment
   - SW & SC Drainage Improvement
5. Meghna Left Bank
   - SE Regional Study
   - Gumti & SE Drainage
6. North East Region
   - NE Regional Study
   - Rehabilitation Project
7. Cyclone Protection Project
8. Dhaka Town Protection
9. Other Towns Protection
10. Flood Forecasting & Early Warning
11. Flood Preparedness

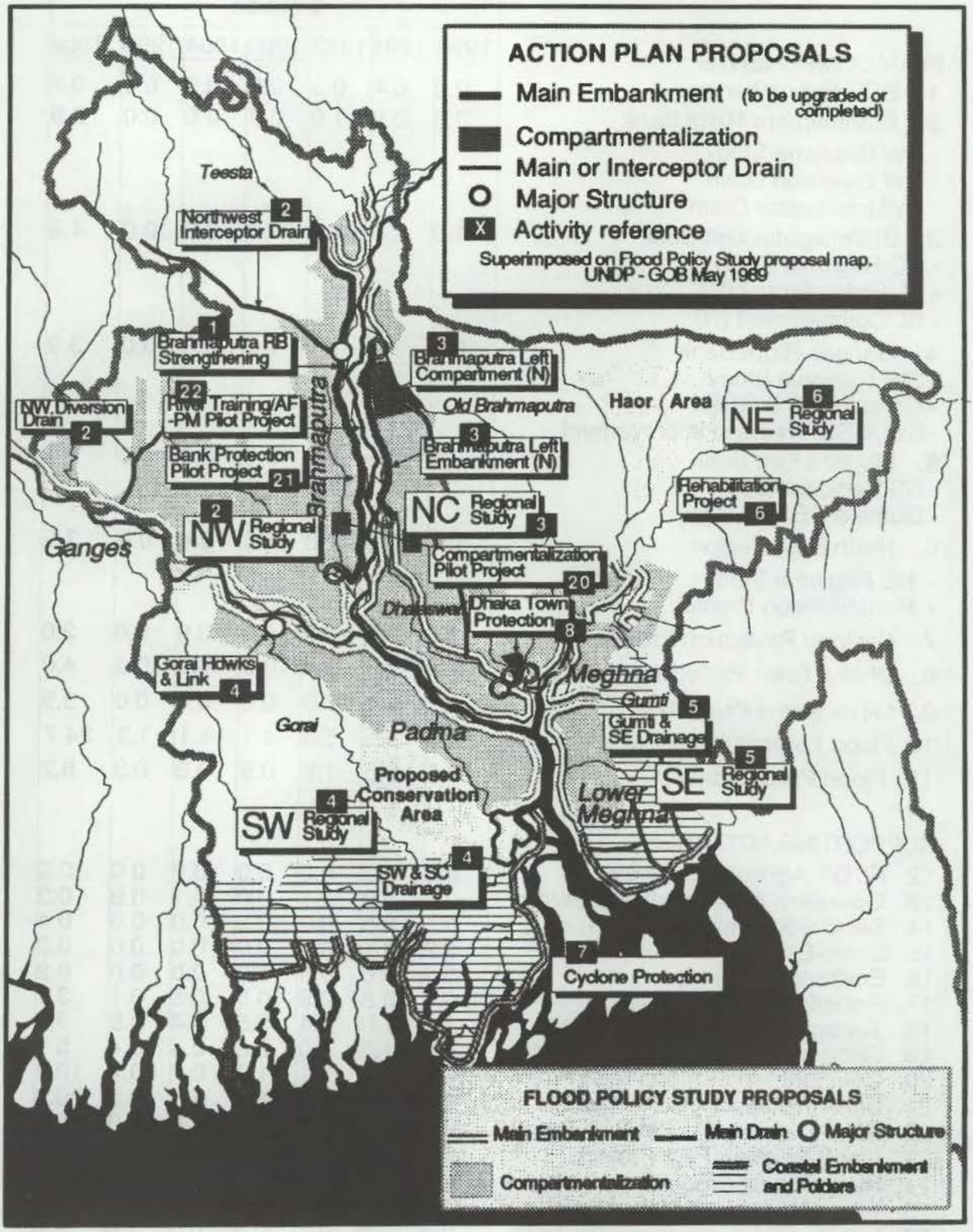
SUPPORTING ACTIVITIES

12. FCD/I Agricultural Study
13. Operation & Maintenance Study
14. Socio-Economics Study 1 : Active Floodplain
15. Socio-Economics Study 2 : Land Acquisition
16. Environment Study
17. Fisheries Study and Pilot Project
18. Topographic Mapping
19. Geographic Information System
20. Compartmentalization Pilot Project
21. Bank Protection Pilot Project
22. River Training / AFPM Pilot Project
23. Flood Proofing Pilot Project
24. River Survey Program
25. Flood Modelling / Management
26. Institutional Development Program

IMPLEMENTATION SCHEDULE



LOCATION OF ACTION PLAN ACTIVITIES



INDICATIVE COSTS OF SURVEYS, STUDIES, PILOT PROJECTS ETC

	$ million						
PLAN COMPONENTS	1990	1991	1992	1993	1994	1995	Total
1. BRE Strengthening	0.0	0.4	0.3	0.0	0.0	0.0	0.7
2. Brahmaputra Right Bank	0.6	0.9	1.0	0.3	0.0	0.0	2.8
- NW Drainage Study							
- NW Diversion Drain							
- NW Interceptor Drain							
3. Brahmaputra Left Bank	1.0	2.5	1.1	0.0	0.0	0.0	4.6
- NC Regional Study							
- BL Embankment (N)							
- BL Compartment (N)							
4. Ganges Right Bank	0.1	1.7	1.1	1.0	0.0	0.0	3.9
- SW Regional Study							
- Gorai Intake & GRE							
- SW & SC Drainage Improvement							
5. Meghna Left Bank	0.0	0.5	1.8	0.6	0.0	0.0	2.9
- SE Regional Study							
- Gumti & SE Drainage							
6. North East Region	0.0	0.6	1.0	1.6	0.4	0.0	3.6
- NE Regional Study							
- Rehabilitation Project							
7. Cyclone Protection Project	1.5	0.5	0.0	0.0	0.0	0.0	2.0
8. Dhaka Town Protection	1.0	2.0	1.0	0.0	0.0	0.0	4.0
9. Other towns Protection	1.1	2.4	0.0	0.0	0.0	0.0	3.5
10. Flood Forecasting & Early Warning	1.8	7.5	5.9	4.1	4.1	1.3	24.7
11. Flood Preparedness	0.5	2.5	1.8	0.8	0.3	0.3	6.2
SUPPORTING ACTIVITIES							
12. FCD/I Agricultural Study	0.3	0.3	0.0	0.0	0.0	0.0	0.6
13. Operation & Maintenance Study	0.1	0.0	0.1	0.0	0.1	0.0	0.3
14. Socio-Economics Study 1	0.1	0.3	0.0	0.0	0.0	0.0	0.4
15. Socio-Economics Study 2	0.2	0.1	0.0	0.0	0.0	0.0	0.3
16. Environment Study	0.2	0.0	0.0	0.0	0.0	0.0	0.2
17. Fisheries Study	0.4	0.8	0.8	0.5	0.5	0.1	3.1
18. Topographic Mapping	1.1	1.0	0.4	0.5	0.4	0.5	3.9
19. Geographic Information System	1.0	1.5	1.0	0.8	0.4	0.4	5.1
20. Compartmentalization Pilot Project	0.5	3.5	3.7	1.7	0.7	0.7	10.8
21. Bank Protection Pilot Project	0.7	2.0	7.0	15.6	4.0	0.0	29.3
22. River Training / AFPM Pilot Project	0.6	1.0	1.2	1.2	1.0	1.0	6.0
23. Flood Proofing Pilot Project	1.0	1.0	1.5	0.5	0.5	0.5	5.0
24. River Survey Program	4.1	9.4	1.1	1.1	1.1	0.5	17.3
25. Flood Modelling / Management	1.2	0.8	0.2	0.2	0.1	0.0	2.5
26. Instutional Development Program	0.6	0.5	0.5	0.5	0.5	0.0	2.6
TOTAL	19.7	43.7	32.5	31.0	14.1	5.3	146.3

These components constitute the main part of the Action Plan. The programs comprise the following activities:

STUDIES

There are six regional studies , each leading to a program of works. Therefore each has a different emphasis depending on the regional problems and priorities. The studies which will establish broad feasibilty will vary between 9 and 15 months depending on available and on-going studies and on regional complexities. The costs which are only indicative are based on man month inputs for expatriate and local consultants.

PROJECT PREPARATION

A series of implementation programs will result from the regional studies. Projects have been provisionally identified, confirmation of these or other projects depend on the outcome of the regional studies. Project preparation, the next step, will include technical feasibility, economic and social justification, environmental impact etc. supported by general surveys and fieldwork. Costs of project preparation are on the same basis as the regional studies but more approximate.

CONSTRUCTION

The construction phase will start with detailed design, topographic surveys, site investigations and the preparation of contract documents. From the start of these activities to the start of actual construction will take at least one year. Except for possibly Brahmaputra Strengthening and the Northwest Diversion Drain, construction can be expected to continue into the Fifth Five Year Plan period. No costs are given for the construction phase.

SPECIAL ACTIVITIES

Flood Forecasting & Early Warning and Flood Preparedness are special non-structural programs that will be consolidated during the Action Plan period and continued in subsequent periods.

BRE STRENGTHENING

1

An embankment on the right bank of the Brahmaputra was constructed in the 1960's. Since then it has been breached in a number of places, mainly due to bank erosion by the river. The remedy has been to provide retired embankments, but in some places, for example at Sirajganj town, groynes have been constructed to arrest erosion. Other causes of failure include piping under the embankment, bank slippage due to seepage through unstable material and wave action. Poor maintenance has resulted in inadequate sections, a problem aggravated by the almost continuous squatter habitations along the BRE.

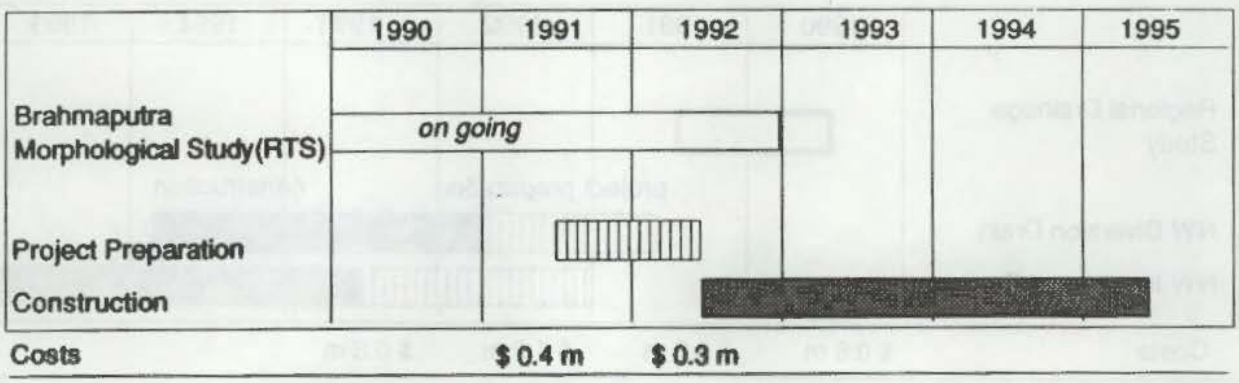
A major study of the causes of embankment failures and identification of remedial measures (Brahmaputra River Training Study-RTS) is scheduled to start in December 1989. Threatened embankment reaches with priority for strengthening will be identified and preliminary designs and costs for appropriate bank protection and river training works prepared. This study would be coordinated closely with the following Action Plan activities :

- Compartmentalization Pilot Project
- Bank Protection Pilot Project
- River Training
- River Survey Program

The strengthening works proposed under RTS will be supplemented by the additional water control embankment structures identified in the Action Plan's North West Drainage Study (3). This will be a regional study which will investigate the feasibility of major drainage diversions as well as controlled flooding and drainage in the protected area.

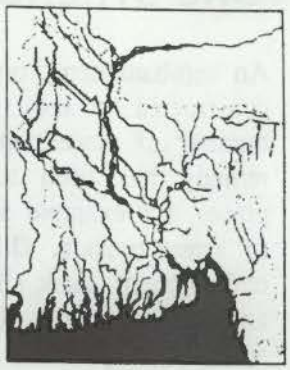
The recommendations from RTS and the North West Drainage Study should become available to enable a start on project preparation for BRE Strengthening in 1991. Detailed design starting in mid-1992 would incorporate the first results of the pilot projects.

The estimated cost of project preparation is $ 700,000. RTS costs ($3m) are being covered by an ongoing IDA credit.



BRAHMAPUTRA RIGHT BANK

2



The North West region suffers regularly from floods. These originate from the Brahmaputra and Teesta when their embankments breach, from its tributaries (especially the Atrai) and from direct rainfall. An area that is particularly hit by floods is the Chalan Beel. During the last decade, a number of polders have been constructed but their embankments are regularly breached.

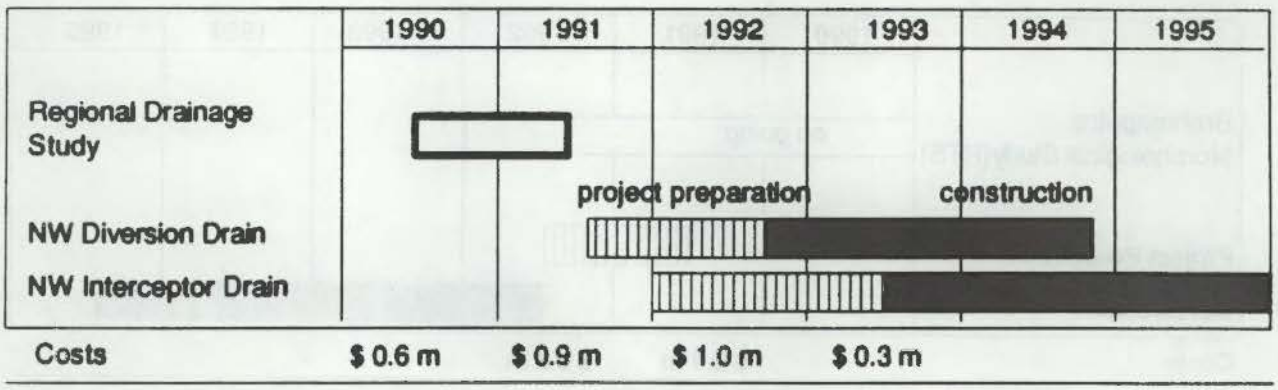
Studies of the Atrai basin and of the Chalan Beel and its polders which have recently been commissioned will include plans for tackling some aspects of the drainage problem. In the recent UNDP-GOB Flood Policy Study, radical proposals to improve the overall drainage of the Brahmaputra right bank were developed. These comprised a major drain from near Dinajpur to the Brahmaputra following the Karatoya Valley, which would intercept the headwaters of the Atrai and other south-flowing rivers, and a diversion drain connecting the lower course of the Atrai to the Ganges, following the Baranai valley. The proposals also included controlled flooding and drainage in the area protected by the Brahmaputra Right Embankment using the compartmentalisation concept.

An overall regional drainage study is needed to examine these drainage proposals in the light of recommendations to improve the Brahmaputra Right Embankment and its structures. This study would make full use of the data, models and results produced in the on-going studies. If the general feasibility is confirmed, full feasibility/project preparation can proceed.

Approximate costs are :

- Regional Drainage Study $ 1,200,000
- Diversion Drain Project Preparation $ 600,000
- Interceptor Drain Project Preparation $ 1,000,000

The diversion drain would be the first to be implemented because of its size and relative simplicity. Construction of the Interceptor Drain might start toward the end of the Action Plan period.



BRAHMAPUTRA LEFT BANK

3

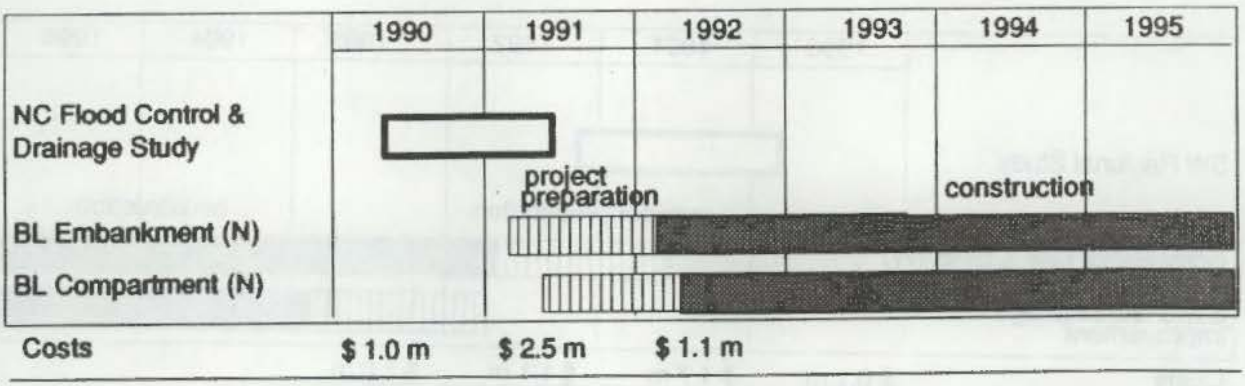
The left bank of the Brahmaputra has high priority for flood control and drainage. About 8,000 sq km of low-lying land bounded by the Brahmaputra, Old Brahmaputra and Dhaleswari rivers are vulnerable to flooding. The flooding of this area (the North Central Region) is caused by rainfall, drainage congestion and spillage from minor rivers and from the Brahmaputra itself. Existing embankments are not effective against major river floods because of inadequate sections, gaps and bank erosion; drainage is impaired by numerous road embankments and restricted waterway sections.

An overall study of flood control and drainage of the North Central region will be undertaken as a first step. This study will examine various alternatives and identify the most suitable pattern of future water control development. Strengthening of existing embankments, constructing new ones to fill in the gaps, building appropriate embankment structures for controlled flooding and drainage, remodelling the main drainage systems and compartmentalization can be expected to feature in the regional plan. The overall justification for the plan will be established taking into account the environmental and socio-economic effects. The study will also address the operational and organisational aspects. The Study would take fifteen-months and cost $1.8 m.

The probable outcome of the regional study would be feasibility studies for:

- a 150 km embankment from the Old Brahmaputra to the Dhaleswari incorporating existing embankments, new stuctures and a link embankment to Jamalpur, together with a detailed study focussed on the upstream section (50 km)
- a compartment covering about 50,000 ha in the northernmost part of the protected area including major water control/drainage structures and main drainage development and taking into account all linkages with agriculture, fisheries, navigation, roads and railways.

These studies would follow on from the regional study and are expected to cost approximately $ 1.0m each. Technical studies could start before completion of the regional study. Detailed site investigations, surveys, design and preparation of contract documents could start in early 1992, with actual works starting a year later.



GANGES RIGHT BANK

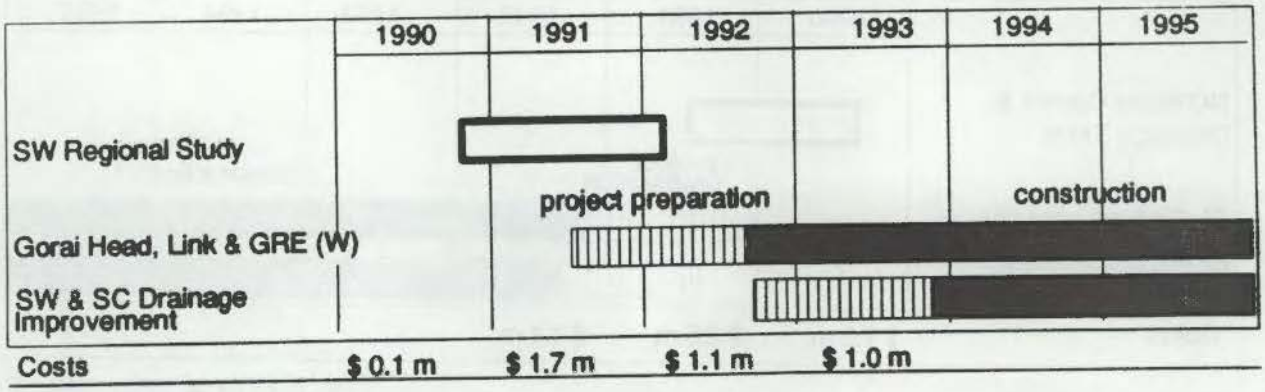
4

Macro scale water management problems in the South West Region and south-central are extremely complex. Floods are caused by overbank spillage from the Ganges, Padma, Lower Meghna and their distributaries, by rainfall which collects in the lower beels and by drainage congestion which is becoming increasingly serious in the southwestern part of the region. Saline water intrusion is an increasing and very serious threat, while cyclones have a devastating effect on infrastructure, agriculture, and the entire socio-economy of the southern part of the region.

Some embankments exist along the Ganges and Padma right banks but these are very few and far between and most are under-sectioned. Drainage is impaired by numerous road embankments and restricted waterway sections. The silting up of the present offtake of the Gorai has stopped the dry season flows needed to restrict the ingress of seawater in the south. The extensive coastal embankments require repairs, upgrading and possibly further extension. Water management and drainage congestion in the numerous polders requires radical improvement.

Various studies to improve the situation are complete, on-going or about to start. The Action Plan aims at coordinating all activities related to flood protection and macro drainage. It is therefore necessary to undertake a regional study to bring together, and where appropriate integrate, all aspects covered by the above studies, particularly because of the complex interactions. The study should cover the whole south west region including the Sunderbans forest reserve which is suffering from saline intrusion. The activities will include review of past studies and coordination of on-going studies,undertaking any additional surveys, development of flood protection and macro water control and drainage plans together with the formulation of first priority projects including terms of reference for their feasibility studies. Consideration should be given to an environmental project in the Madaripur Beel conservation area. The regional study would take about 15 months at an estimated cost of about $1.2m.

One of the priority projects likely to emerge from the SW Study would be the new Gorai Head off take downstream of the existing off take, to provide dry season flow to counter saline intrusion, possibly linked to part of the Ganges Right Embankment. Feasibility studies of these works starting in 1991 at an approximate cost of $1.3m could result in a start with construction in 1994. Project preparation for SW and SC drainage improvements would start in 1993.



MEGHNA LEFT BANK

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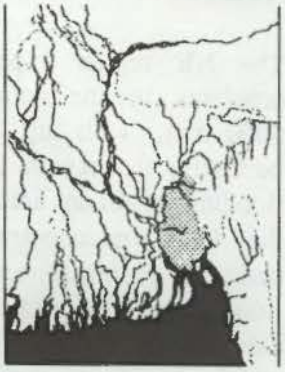


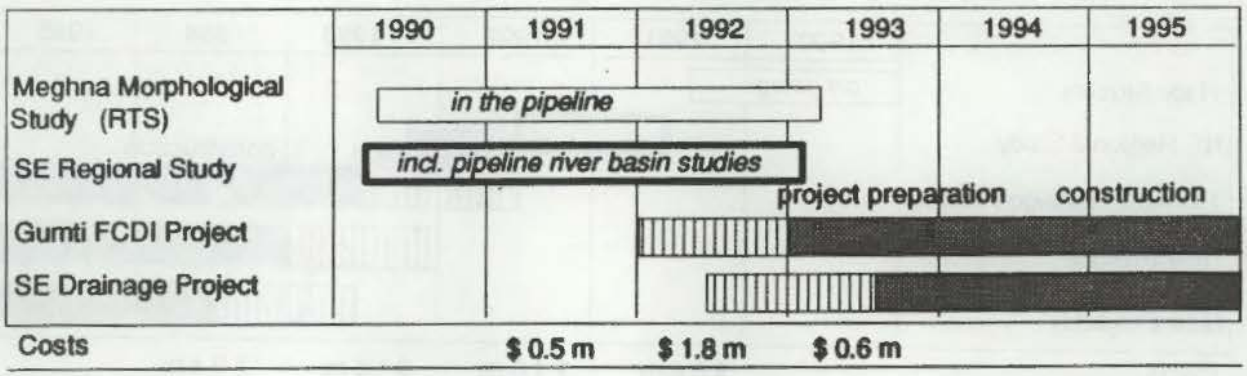
The most densely populated part of Bangladesh lies in the flood plains to the east of the Meghna and Lower Meghna. Agricultural development, although well advanced, is vulnerable to regular floods; these come from the Meghna, from flash floods from the hills to the east and from direct rainfall. Because of the flat topography drainage is extremely difficult; drainage into the Meghna or Lower Meghna is not possible during the flood season due to high river levels, and drainage southwards to the Bay of Bengal is hampered by siltation of outlets. Embanking the main rivers and the rivers from the east will clearly remove a significant source of flooding, but the provision of effective drainage is probably the most important factor.

The Chandpur Irrigation Project has a proven flood control and drainage system. Constructed in the 1970's, it is protected by a continuous embankment and provided with an effective pumped irrigation and drainage system. However, the embankment along the Lower Meghna is occasionally threatened by erosion and has been retired over some length. To the north, the Meghna-Dhonagoda FCDI scheme has suffered serious breaches in recent floods.

A regional study of the area east of the Meghna and Lower Meghna will address the hydrological problems of the region, taking into consideration on-going activities, - these including:

- the Meghna morphology study (RTS.. as for Brahmaputra)
- the IDA financed morphological study of the Gumti - Titas Basin
- the Dutch financed Land Reclamation Project
- MPO's SE Region Surface Water Simulation Project
- the Gumti Phase II FCDI project.

The study will identify/formulate projects for implementation in the Action Plan. These will probably include a project for the flood control and drainage of the land south of the Gumti basin and other projects that are in the pipeline. The study would take about 9 months and cost about $ 0.9m, to be followed by preparation of two projects costing about $1.0m each.



NORTH EAST REGION

6

The NE region experiences some of the most severe flooding problems in the country. Average monsoon rainfall of 2000 to 5000 mm, with up to 11,000 mm on the Meghalaya plateau bordering the region in the north, results in flash floods and deep flooding of basin areas. River floods also occur occasionally along the Old Brahmaputra channel to the south-west. Flooding and drainage problems are aggravated by the uncontrolled inflow of floodwater from adjoining Indian hill regions and by the low elevation of the Sylhet Basin in the centre of the region, much of which stays wet through the dry season. Flash floods also bring down huge sediment loads which, when deposited, impede drainage and reduce the quality of agricultural land. All three major rice crops (aus, aman and boro) are exposed to frequent flood damage, and the great depth of flooding prevents wet season crops from being grown over much of the Sylhet Basin.

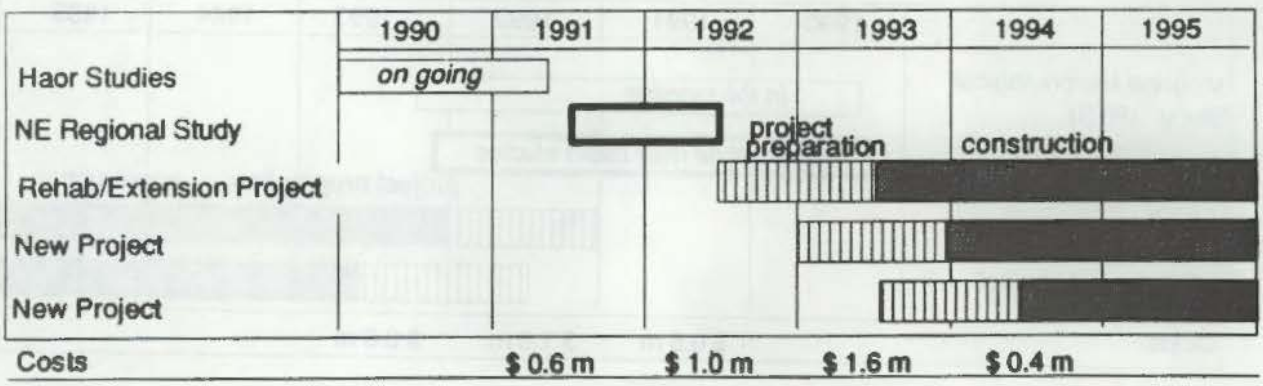
Two solutions to the problems of flash floods have been sought:

- the construction of submersible embankments around individual haors (depressions) to protect the main boro crop from early flash floods;
- the construction of flood embankments along rivers crossing the eastern piedmont plains to protect adjoining agricultural land and urban property. However, frequent breaches and rising river bed levels are major problems to be investigated.

A regional study will address these problems, with a view to:

- identifying gaps in hydrological and topographical information that need to be filled;
- assessing the role of the region's hydrology in relation to that of the NC and SE regions;
- reviewing/identifying structural and non-structural methods of mitigating flood damage and losses;
- evaluating performance of existing schemes, examining measures to improve effectiveness and identifying rehabilitation and new flood protection/relief works.

A NE regional study (already initiated by CIDA) leading to a regional water management program and costing about $ 1.2 m. would be followed by feasibility studies for projects that could be initiated in the later stages of the Action Plan. Assuming three projects, a provision of $ 2.4 m is made for project preparation.



CYCLONE PROTECTION PROJECT

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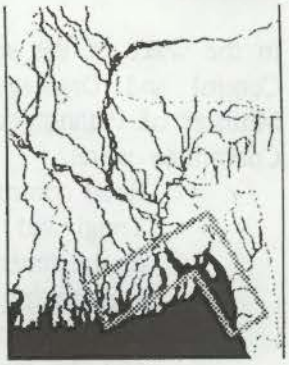
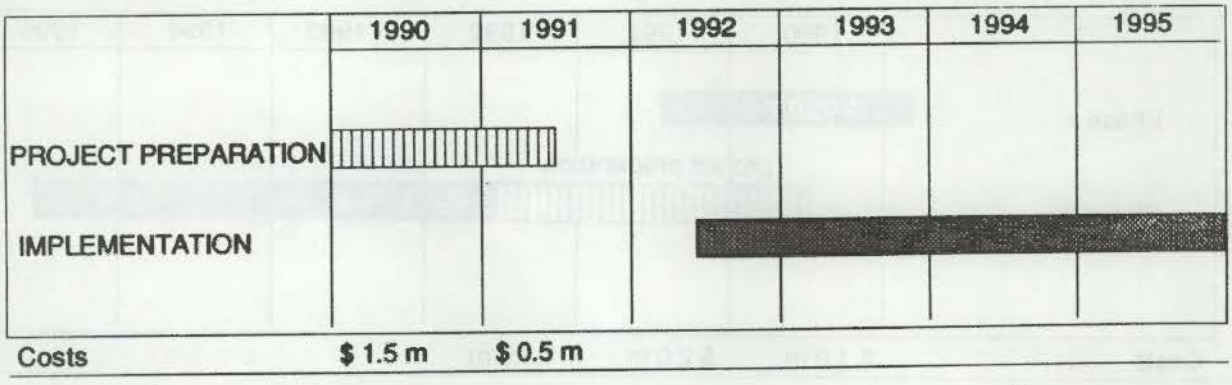


Frequent cyclonic surges and floods in the coastal areas of southern Bangladesh cause extensive destruction of crops, housing and infrastructure. They also can result in extensive loss of life, as happened in 1970 when an estimated 170,000 people lost their lives. A major system of coastal embankments was built in the 1960s and 1970s in Chittagong, Noakhali, Patuakhali, Barisal and Khulna districts. These embankments have become badly damaged over time and are in need of rehabilitation.

The planned project would rehabilitate 300 km of existing embankments out of a total of 1200 km; construct 190 km of new embankments; construct or repair about 600 hydraulic structures; operate and maintain structures for a period of two years after completion; afforest embankment slopes and berms, to help reduce damage to protection work; construct 480 km of feeder road; and undertake a numerical modelling study to determine design levels, embankment profiles and the location and type of protection works. The primary aim of the project would be to minimise damage by future cyclones over an area of 1.4 million ha (1.0 million of which would be agricultural land), including several heavily populated urban and rural areas, thus safeguarding the economic development of coastal districts.

The coastal embankment component would be implemented by the BWDB and the feeder roads by the Roads and Highways Department and the Local Government Engineering Bureau (LGEB).

The total project cost is estimated at $ 100 million, of which US $ 70 million and $ 30 million would be for the coastal embankment and roads component respectively. IDA would contribute about $ 80 million to the project. Project preparation, which is being undertaken by consultants appointed by the EEC, will be completed in mid-1991. Project implementation is expected to begin in mid-1992 and to take six years.



DHAKA TOWN PROTECTION

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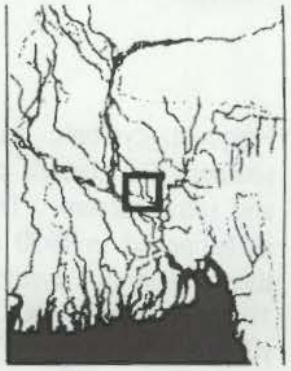


In the wake of the serious floods of 1988, a committee for 'Flood Control and Drainage of Greater Dhaka" was formed with the Minister of Planning as its chairman. The terms of reference of the Committee were:

- flood control for Greater Dhaka Metropolitan Area, Mirpur, Tongi and Narayanganj;
- establishment of link roads for these towns and surrounding industrial areas;
- formation of lakes and a drainage network within Dhaka and the modernisation of the city's sewerage system.

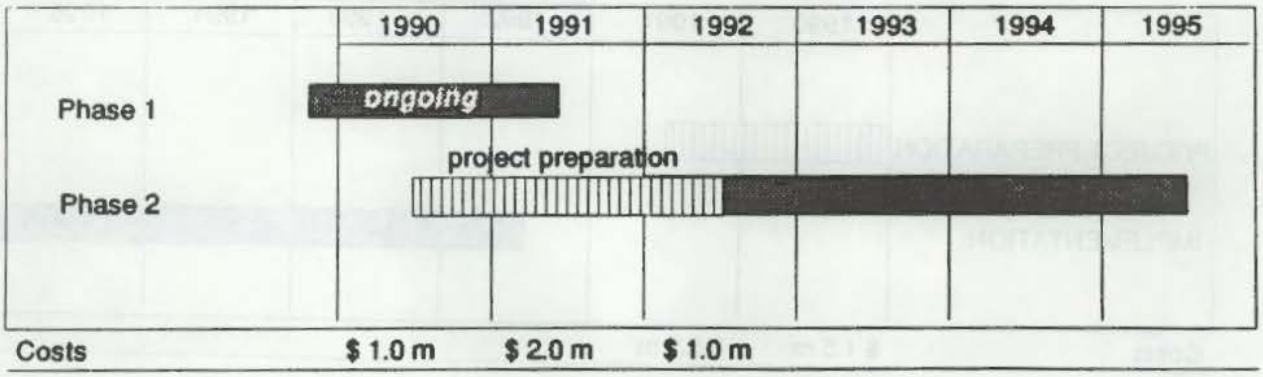
Several studies have been undertaken in the past. These established that the major cause of the flooding are internal drainage congestion and overland flooding from peripheral rivers.

The estimated cost of the works as proposed by the present Committee is approximately $ 110 million. The first phase of the works is under construction and would be completed by 1990; all the works are programmed for completion by 1993. The works will be planned and designed in the context of the Greater Dhaka Master Plan to ensure that they are consistent with future development activities. The proposed works include:

Phase I: Dhaka West Area :Cost $ 27 m
- embankments from Tongi Railway Bridge to Shimir Tek
- road raising and flood wall to Buriganga Bridge
- embankment at Dhaka International Airport
- clearing of khals in the city
- repair and restoration of the sewerage system
- temporary flood control structure

Phase II: Dhaka East Area :Cost $ 42 m
- road/embankment from Demra to Tongi Bridge
- installation of five pumping stations

Narayanganj West: embankments and regulators. :Cost $ 9 m
Narayanganj East: embankments and regulators. :Cost $ 14 m
Tongi : embankment, raised roads & walls, regulators and pumping stations. :Cost $ 9 m
Savar : (similar works to those at Tongi). :Cost $ 7 m



OTHER TOWNS PROTECTION

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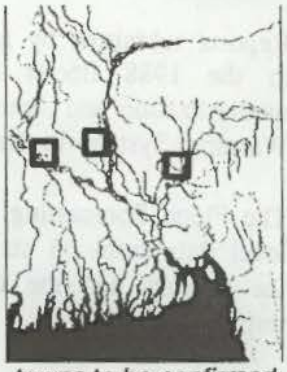


towns to be confirmed

An important component of a structural long term program for flood control in Bangladesh would be to protect the towns which are most susceptible to flood damage and river erosion.

It is accepted that the protection of Dhaka is essential. However, other town protection schemes will be divided into two phases. Firstly, a technical feasibility study would be undertaken incorporating assessments of the severity of erosion and/or inundation at selected riverain towns and the viability of different solutions. The study would also include detailed proposals for protection measures at several priority sites.

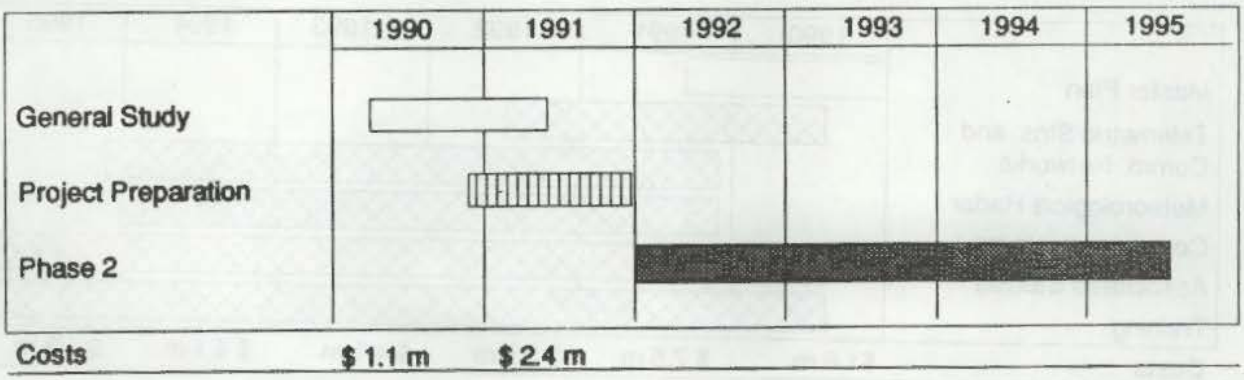
Studies for the selected towns would cover population distribution, town layout, communication networks, services, industrial and residential areas and other key features taking into account future development plans. For each, the source of flooding and the natural drainage characteristics and associated structures would be evaluated. The technical viability of different forms of flood protection would be assessed including embankments, river training, bank protection, gravity or pump drainage.

Close coordination will be maintained with the Bank Protection Pilot Project, River Survey Program and with the on-going/planned Brahmaputra and Meghna morphology studies.

The second phase would comprise detailed studies of three selected towns, possibly one on each of the three major rivers. The studies would result in designs and tender documents and would lead to construction within the FFYP.

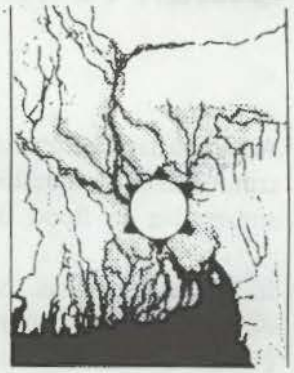
Feasibility studies/project preparation are assumed to take one year and cost about $ 1.5 m.

Project preparation, including technical feasibility assessment and technical studies, is assumed to take 15 months and cost about $ 2 m.



FLOOD FORECASTING & EARLY WARNING

10



Reports submitted by Japan, France, UNDP and the USA in response to the 1988 floods all conclude that measures for the overall modernization and strengthening of the existing Flood Forecasting and Warning System in Bangladesh are required.

The Flood Forecasting and Warning System at present monitors water level data from 35 stations and rainfall data from 34 stations inside the country and the coverage and quality of the data need to be improved.

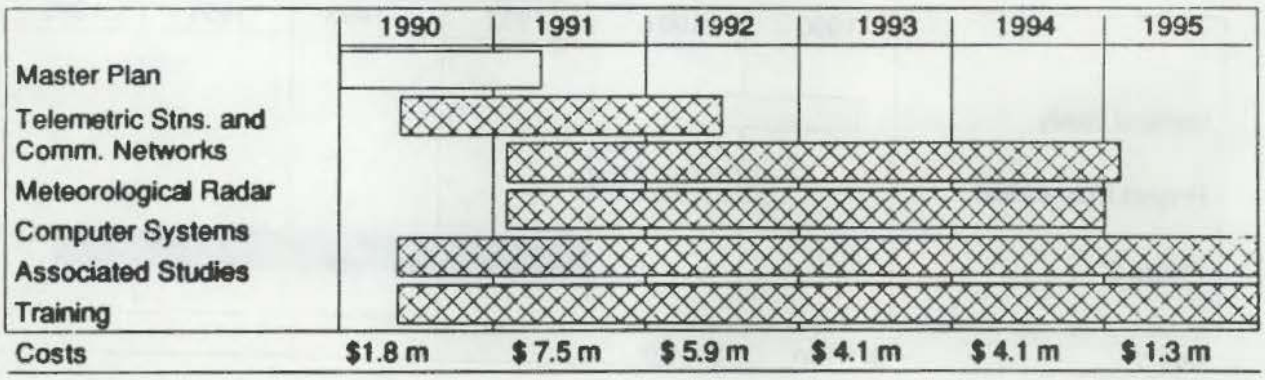
The objective of the proposed project is to strengthen and integrate the existing flood forecasting and warning system by:

- Improvement in the telemetric system, to upgrade data collection, accuracy and lead time.
- Installation of additional meteorological radar.
- Installation of a system for transmission of radar and satellite data and some flood data supplied by the Indian Government to a central computer system in the Bangladesh Meteorological Department (BMD).
- Installation of a data management system (a central computer system including software) to forecast the behaviour of both the main rivers and the eastern flashy rivers with sufficient lead time.
- Installation of an integrated communication network for flood warning, including warning systems to upazila level and below.

In response to the recent major floods, the Government of Bangladesh plans to upgrade the Division of Flood Forecasting into a fully fledged Directorate of Flood Forecasting and Warning (DFFW) under the administration of the Water Development Board with regional sub centres in four districts in the country.

A three year UNDP-WMO project which started in May 1989 will assist the DFFW with calibrating the existing weather radar, upgrading computer and communication syatems and adapting the Surface Water Simulation Model to flood routing and forecasting.

Experts provided by Japanese technical assistance are also working with DFFW to plan and implement the upgrading of the Flood Forecasting and Early Warning System.



FLOOD PREPAREDNESS

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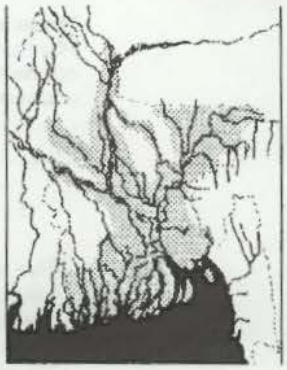
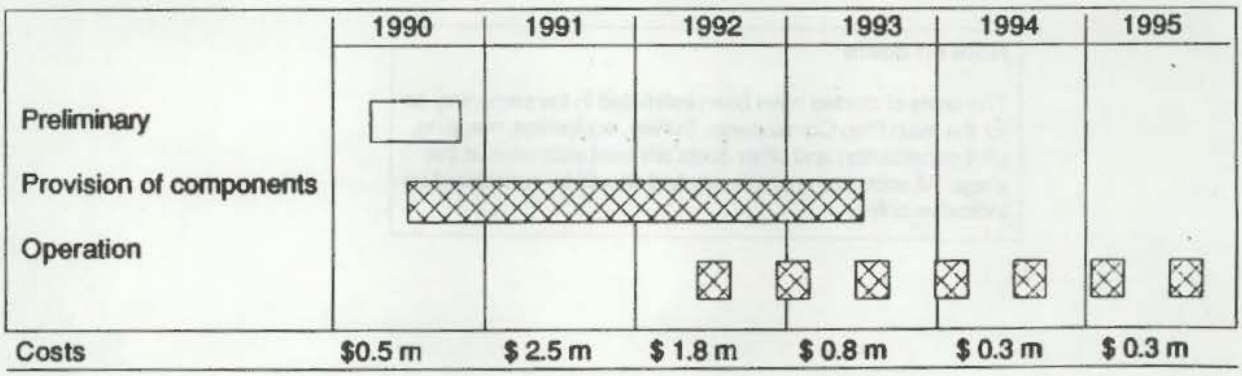


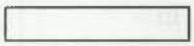
Following the 1988 flood, several studies were made of the relief efforts of the local and central Governments, and of the armed services in order to identify possibilities for improvements. In many respects the relief efforts were found to have been largely effective considering the vast area and large number of people affected. Proposals from a study of flood preparedness and disaster management by international experts has been incorporated in a UNDP Project Document which is under review by the government. The Action Plan will draw on this document and other studies to develop an appropriate program which would involve:

- establishment of a formal and structured emergency planning unit in the central government to develop contingency plans and coordinate inter-agency efforts;
- construction of additional grain storage facilities to fill in gaps in the extensive system which presently exists;
- expansion of refuge areas such as widening the high places on roads and extending the areas surrounding bridge abutments;
- preparation of contingency plans for evacuation and relief in the upazilas;
- provision for more effective communications between the central government and the upazilas;
- provision of vehicles, boats etc to supplement existing fleets.

The establishment of an effective organisation and the provision of the various components could be achieved in three years at an estimated cost at $5 m. The annual costs of operating and maintaining the program would be about $3 m per year starting in 1992.



These activities are complementary to, and support the main Action Plan components. Essentially they supply the general data base, criteria and technology needed for planning, designing, implementing and managing the flood control works and related development.



SUPPORTING STUDIES

Five studies (items 12. 13, 14, 15 & 16) will be undertaken at the start of the Action Plan. Their purpose is to address crucial issues which are common to most of the regions. These studies would be designed to provide the criteria needed for the social , economic, environmental, O&M and management aspects that will be covered in the Regional Studies and in Project Preparation. The studies are interrelated so it will be important to ensure that they are coordinated. Provided that there is no delay in setting up the studies, it may be preferable to combine them into a single package.

PILOT PROJECTS

Five pilot projects (items 17, 20, 21, 22 & 23) to test out new concepts and improved technology will be implemented in the Action Plan period. The pilot projects involve a review of current practices, surveys and examination of alternative solutions before designing and constructing full scale trials at appropriate locations. This would be followed by systematic operation, monitoring and evaluation, with particular emphasis on management . Although the priority will be for the results to be incorporated into tha main program as soon as they are available, the pilot trials could develop into long term research.

SPECIAL ACTIVITIES

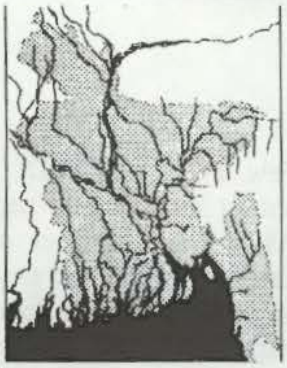
Items 18, 19, 24 and 25 are generally longer term support activities which will provide an information base for the main program. While concentrating on the flood vulnerable areas they cover all regions with priority given to providing topographical, hydrological, socio-economic and mangement data and analyses for the first Action Plan projects. Item 26 is a special program for institutional development.

Note on costs

The costs of studies have been estimated in tha same way as for the main Plan Components. Survey, equipment, mapping, pilot construction and other costs are best estimates at this stage. All costs are approximate and should be considered as indicative only.

FCD/I AGRICULTURAL STUDY

12



Despite considerable experience gained in the planning, implemention and operation of FCD and FCDI projects over the past 25 years, there have been few in depth evaluations of project performance of such projects. A review of FCD and FCDI projects is needed in order to learn from previous experience and to provide an input to the planning of the proposed system of embankments and compartments under the Action Plan.

The aims of the Review would be :

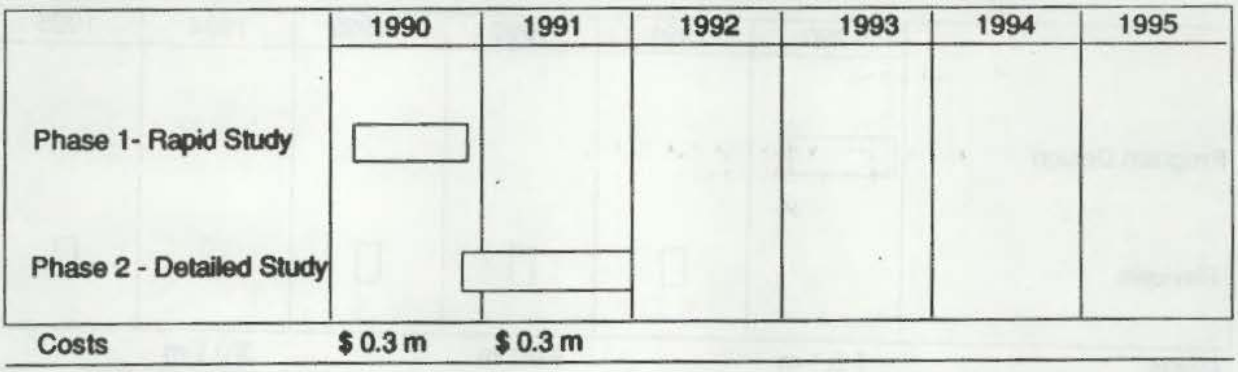
- to assess the impact of FCD and FCDI on agriculture
- to assess the agricultural, economic, social and environmental impacts of FCD and FCDI projects and the extent to which technical and other project objectives have been achieved
- to identify constraints to effective project management and to recommend ways in which project design, operation and maintenance can be improved to increase agricultural and other benefits from the projects
- to develop a methodology to be used in subsequent feasibility and evaluation studies under the Action Plan.

The Review would be in two phases:-

Phase 1 : 'Rapid Rural Appraisal' of 20 completed projects (including major FCDI projects and medium and small-scale FCD projects) by small teams of experienced professionals. These reviews would provide an overall assessment of the performance, problems and potential of each project.

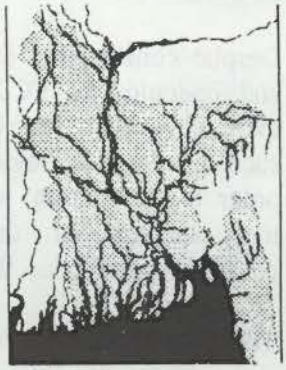
Phase 2 : Detailed evaluations of eight of the projects covered in Phase 1 (a) to assess the detailed agricultural, economic, social and environmental impacts of the projects and, (b) to provide detailed baseline information for the action research projects on operation and maintenance being undertaken under the BWDB Systems Rehabilitation and other projects (see No 13). Each project evaluation would take 12 months and would involve socio-economic and other surveys. Projects for which recent evaluation exist (e.g., Chandpur Irrigation Project) would not be covered.

National seminars would be held to discuss the methodologies used and the results of the studies. Manuals and training materials would be prepared on the methodologies used for use in later evaluations. Phases 1 and 2 are estimated to cost $0.2m and $0.4m respectively.



OPERATION & MAINTENANCE STUDY

13



Few FCD and FCDI projects are operated effectively and, in almost all, there is need to improve operation and maintenance. As a result, project objectives are not realised and, in many cases, conflicts develop between different groups inside project areas (e.g., high land and low land farmers; farmers and fishermen), and between those inside and those outside, which result in damage to project embankments and structures. Maintenance often cannot be carried out effectively due to shortage of funds and in no FCD projects are water development levies effectively collected.

The O&M problem is a major concern of Government and donor organisations, and a number of projects (e.g., BWDB Systems Rehabilitation Project; the Early Implementation Projects; and the Second Small-Scale FCDI project) are experimenting with different institutional approaches to O&M, including the involvement of upazila administration and non-governmental organisations.

The O&M of the compartments proposed in the Action Plan will require a higher level of management than that achieved so far in Bangladesh. In view of this, O&M will be an important component of the Compartmentalization Pilot Project (20). In addition, it is proposed that:

- an annual review of the experience gained in the experimental work on the O&M of other projects should be undertaken to ensure that concepts and approaches developed in these other projects are introduced into projects implemented under the Action Plan;
- O&M issues are covered in detail in the FCD/I Agricultural Study.

The annual O&M review would be financed by the government under the BWDB System Rehabilitation Project. It would be undertaken by specialist covering the fields of water resource engineering, soio-economics, agriculture and environment/fisheries.

	1990	1991	1992	1993	1994	1995
Program Design	▭					
Reviews		▯	▯	▯	▯	▯
Costs	$ 0.1 m		$ 0.1 m		$ 0.1 m	

SOCIO ECONOMICS STUDY 1
ACTIVE FLOODPLAIN

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Many hundreds of thousands of people inhabit the active floodplains of the major rivers (the Brahmaputra/Jamuna, the Ganges, the Padma and the Meghna). Some of these people live near the banks of the main rivers, others on chars (newly emerged land) in the river channels. The active floodplains are hazardous places and the people living there have adapted their settlement patterns and agriculture to the risks involved. The proposed major embankment projects on the main rivers could have significant impacts on those living outside the protected area (e.g., through increased risk of flooding due to higher river stages) and on those who presently live on existing embankments (who will have to be moved when the embankments are upgraded).

In view of these issues, there is a need early in the Action Plan period to undertake a study of the communities living and working in the active floodplains to:

- assess present agricultural practices, settlement patterns and disaster responses;
- estimate the numbers of affected households living on chars and within a short distance of the river banks;
- estimate the number of households living on existing embankments;
- prepare guidelines to be used in the feasibility studies in order to ensure that full account is taken of the active floodplain populations in planning projects.

Socio-economic surveys would be carried out at six selected locations (three on the Jamuna and one each on the Ganges and on the Meghna). These would be complemented by air photo-satellite imagery interpretation and use of secondary sources (e.g., the census) to estimate the population of these areas.

The estimated cost of the surveys and studies is $ 0.4 million.

	1990	1991	1992	1993	1994	1995
Surveys						
Studies						
Costs	$ 0.1 m	$ 0.3 m				

SOCIO ECONOMICS STUDY 2
LAND ACQUISITION

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The construction of a system of embankments and compartments would require the acquisition of substantial areas of land. Some households would lose their homesteads and may become landless; others could lose valuable agricultural land.

This study of land acquistion procedures and the impact of acquisition on rural households would be undertaken in order to recommend how existing procedures could be streamlined and negative impacts on households involved minimised.

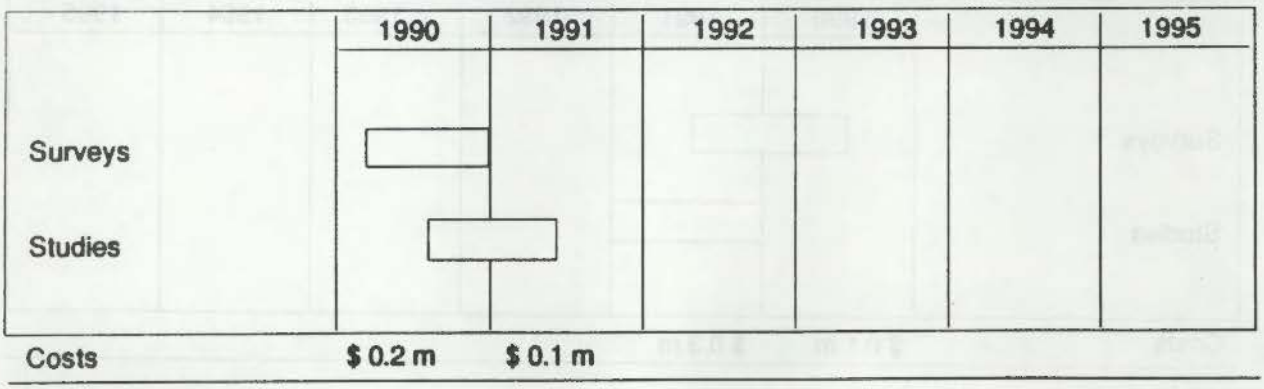
The study would involve :

- A survey of households whose land was previously acquired for embankment construction in order to assess the impact of acquisition on the economics of the household, the ways in which money paid for acquired land was used, and the perceptions of the people affected by acquisition procedures.

- A review of existing land acquisition procedures and provision of counterpart funding, including compensation levels and methods of payment, to assess how these may be streamlined and accelerated to benefit rural households.

- A review of existing rural development projects (e.g., cooperatives under BRDB, Operation Thikana, non-governmental organisations) in order to identify ways in which such projects can be used to support households whose land has been acquired (e.g., through skill development programmes, provision of homestead sites and credit, and resettlement of displaced persons in the project area if possible) until their economic viability can be assured in a new activity or location.

- To prepare recommendations for improving and streamlining land acquistion procedures and rehabilitation programs to overcome the negative impact on households to be used in implementing projects under the Action Plan.



ENVIRONMENTAL STUDY

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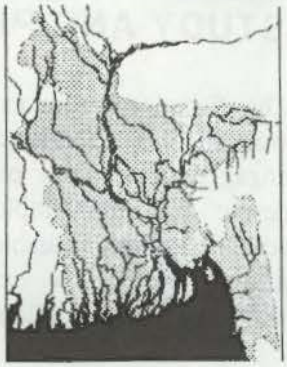

Concerns have been expressed that construction of embankments and modification of natural flooding regimes, together with intensification of agriculture and expansion of infrastructure within flood protected areas, could have adverse impacts on soil productivity, fisheries, groundwater recharge, health and wildlife. In order to meet these concerns, environmental impact assessments (EIA) need to be made as an integral part of water control projects so that, to the extent possible, adverse environmental effects are avoided in the design, execution and operation of projects. Additionally, provision needs to be made for longer-term environmental impacts to be monitored so as to identify any adverse trends and propose practical remedies.

During the first phase of the Action Plan, the following activities will be undertaken to develop an EIA programme:

- identify environmental issues in flood control development in Bangladesh through literature review, field visits to completed flood control projects and consultation with relevant research and development institutions
- prepare guidelines for EIA of flood control and drainage projects to be used in the regional, pilot and feasibility studies included in the Action Plan
- identify institutions and consulting firms competent to conduct EIA studies and assess their capacity to undertake the required studies
- assess needs for training Bangladeshi nationals in EIA methodology
- organise seminars/training workshops to elicit and propagate available knowledge and experience regarding environmental impacts of development activities in flood control projects.

These activities will be undertaken during the first six months of the Action Plan. Estimated costs are $ 200,000. The costs of EIA studies and monitoring will form part of regional, pilot and feasibility studies included in the Action Plan are included in the costs of those projects.

	1990	1991	1992	1993	1994	1995
Base Study						
Environmental Impact Analyses		*as and when required to quality other studies/projects*				
Costs	$ 0.2 m					

RIVERAIN AND FLOODPLAIN FISHERIES STUDY AND PILOT PROJECT

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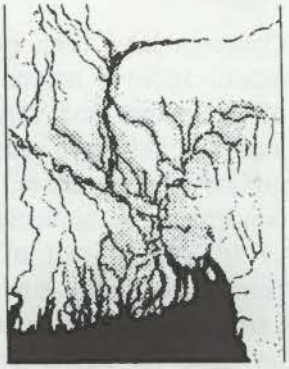


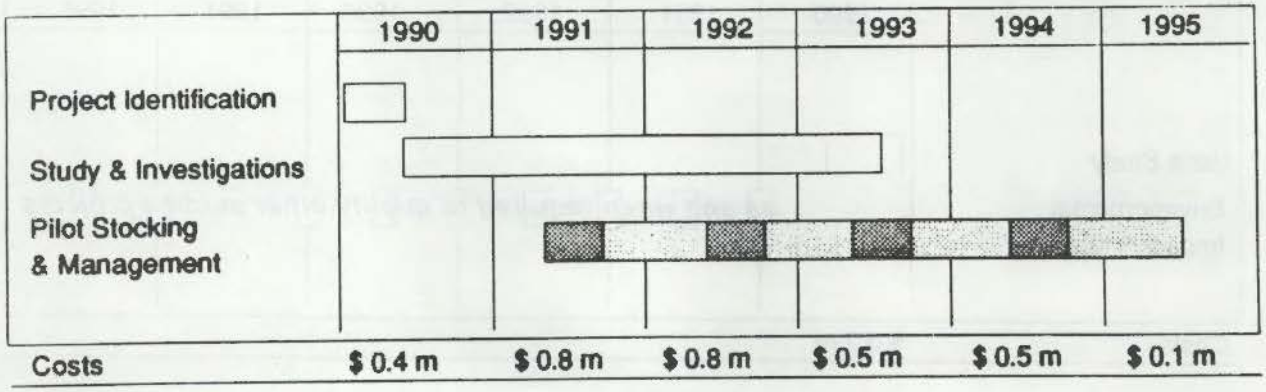
The fisheries resources of Bangladesh are among the richest in the world. It is estimated that 70 percent of the rural population are engaged in seasonal part-time fishing, while nearly 2 million people derive full-time employment from the capture fishery alone. In addition to the valuable contribution of fish to the rural populace as a food source, the export earnings from fish and shrimps reached 140 million US dollars in 1987-88.

Despite the obvious value of the fishery to the national economy, essential information on migratory and feeding behaviour, reproductive biology, and critical habitat requirements of even the most economically important fish has been poorly researched. Due to weaknesses in the data base, accurate estimation of the impact of embankments on the deltaic fishery cannot be reliably estimated. Accordingly, it is proposed to include the following studies and pilot project in the Action Plan:

- Study of fish and shrimp production in selected floodplain water resource systems to be affected by embankments.
- Determination of the social and economic benefits for the fishery and fishing sector in the floodplain areas.
- Evaluation of migratory movements, population, location of spawning grounds, and economic importance of Hilsa and major carps.
- A pilot project to develop fish stocking and impact mitigation measures to ensure continued high levels of fish production from the floodplain areas.

The studies and pilot fish stocking project will provide information necessary for rational economic management and protection of fish populations in the deltaic flood plains of Bangladesh. From the studies, planners would better be able to develop rational management plans for maximising yields from natural river and floodplain fisheries and evaluate environmental changes brought about by flood protection embankments. The studies and pilot project would be in operation for 5 years. Indicative costs would be as follows:

- Project study and team formulation $ 50,000
- Investigative studies $ 1,000,000
- Pilot stocking and management project $ 2,000,000



TOPOGRAPHIC MAPPING & RELATED ACTIVITIES

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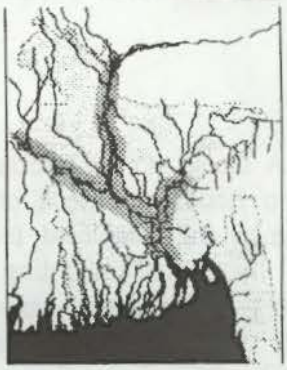


One of the prerequisites of good planning and development, especially in relation to water resources, is a good data base, particularly mapping. The main mapping in use at present dates back to the early 60's and before. Significant development has taken place since then and physical changes have occurred (river alignments, etc).

The following proposals are recommended:

- **aerial photography** to produce working contact prints at a scale of 1:10 000 of the riverain areas of all the major rivers to facilitate identification of existing embankments and undertaking mapping. (some aerial photography is already planned for the Brahmaputra Study).

Project specific mapping at a scale of 1:2000 would be produced.

Estimated Cost = US $ 50 to 70 per ha. for 1:2000 mapping, total cost will depend upon the coverage required for the projects proposed.

Estimated Cost = US $ 0.14 m per year for photomaps of main river system.

- **photomaps of LANDSAT and SPOT** are recommended at scales of 1:250 000 and 1:50 000 respectively of the whole country.

Estimated Cost = US $ 0.6m (whole country except Chittagong)

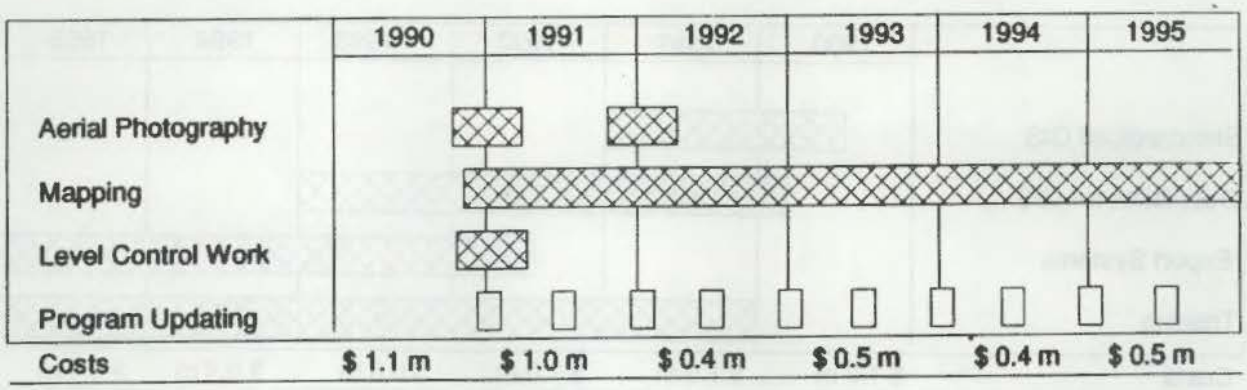
- **global positioning system and co-ordinated level network.** Using satellite control, a programme should be undertaken to establish and/or check principal benchmarks in the country to be used for the mapping exercises and to check the datums of all water level gauges used in modelling studies/analyses of the major river network. Cost to be determined.
- **satellite imagery,** SPOT or LANDSAT, for the following uses:
  - crop coverage and possible damage assessments
  - morphological studies, coastline and river channel changes, and saline intrusion assessments.

Annual imagery sets would be required to facilitate inter-annual change studies. Future satellite developments will enable useful wet season images to be obtained.

Estimated Cost = US $ 300 000 per annum.

Also desirable:

- **controlled aerial photography and mapping** of the country at a scale of 1:50 000 for subsequent mapping by photogrammetry. Suggested national mapping scale of 1:25 000, contours at 1m or less. Estimated Cost = US $ 10m ($ 1.6 approx per ha.)



GEOGRAPHIC INFORMATION SYSTEM

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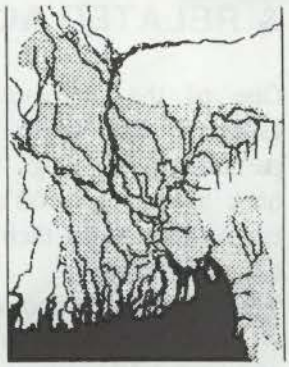


A Geographical Information System would allow information relevant to floods and flood prevention to be standardised in a computerised map and integrated for analysis at different spatial scales :

- point (recording stations, structures)
- line (flood embankments, power lines), and
- areal (flooded land, field plots).

The GIS allows the manipulation of each datum in its entire spatial and temporal context. In this way information on projects can be integrated to assist project design, management and operation.

A GIS, would integrate areal data from the following sources :

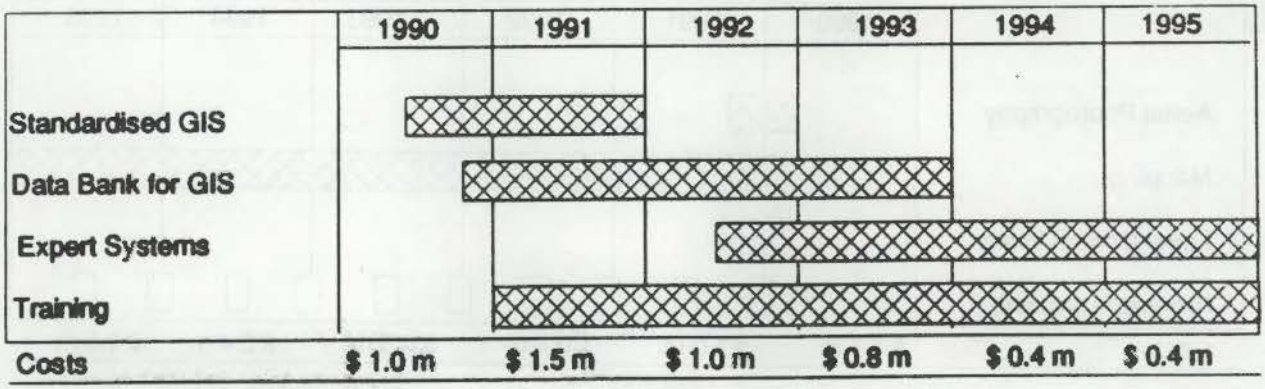
- satellite imagery and radar imagery from SPARRSO,
- hydrological and other data used in the MPO and the national and regional water planning activities,
- population data for mouzas from the Bureau of Statistics,
- crop and other agricultural data for extension blocks from the Department of Agricultural Extension (DAE),
- farming system and socio-economic data for specific sites from BARC and BIDS.

These data should be arranged around the basic geographical units for flood analysis.

Technical assistance would be needed to develop the GIS and to train local staff.

Estimated costs:

- Training in GIS ($ 0.2m).
- Establishment of a standardised, integrated GIS system ($ 0.6m).
- Development of a central data bank ($ 0.7m).



COMPARTMENTALIZATION PILOT PROJECT

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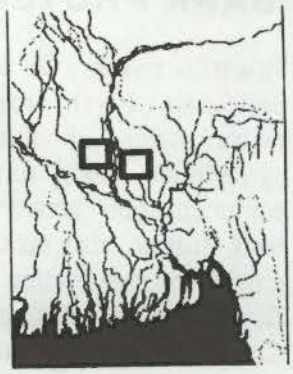


The benefits generated by the proposed embankments will come from increased production in the protected area. This requires an integrated program for Protected Area Development and Management (PADM), to be taken up in parallel with embankment construction. It has been proposed that the protected area be subdivided into "compartments" in which water control (controlled flooding and controlled drainage) can be effectively managed.

Compartmentalization concepts, both structural and non-structural, need to be developed and demonstrated in the field under practical operating conditions. For this purpose a number of pilot projects will be selected to be reasonably representative of the conditions in the protected areas. At this stage two pilot projects will be selected, one on each side of the Brahmaputra and each of about 10,000 ha.

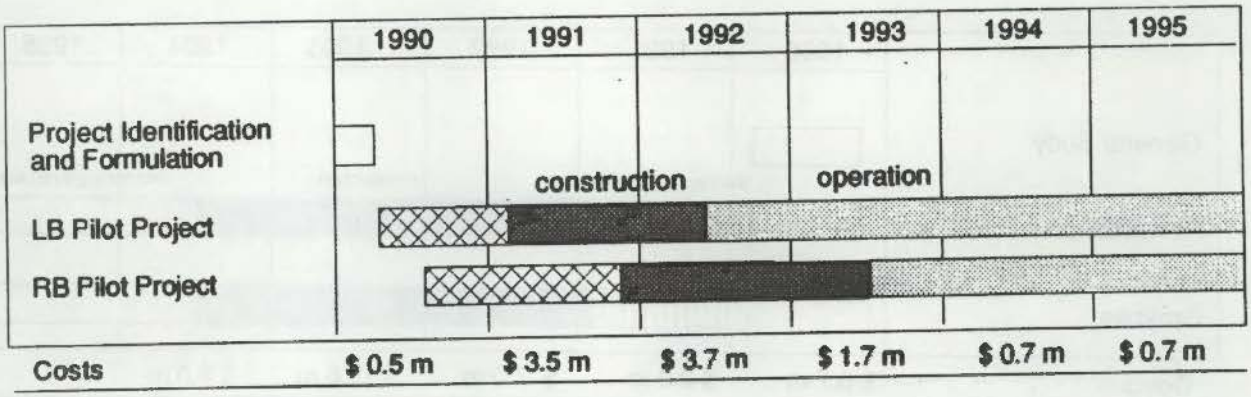
The structural elements of compartmentalization and PADM will include: main river embankments, exiting road and railway embankments, inlet and outlet control structures, and improved waterways for controlled flooding, drainage, navigation etc.

The non-structural elements will include:

- management, operation and maintenance of water control systems
- beneficiary participation and opportunities for disadvantaged groups
- improvement of agriculture, livestock, fisheries etc.
- preservation of the environment

The Pilot Projects will be designed to address such structural and non-structural issues. The vital first step will be to select suitable locations and to assess and possible set-up the appropriate organisations to participate in the pilot project. To produce results that can provide guidance for full scale implementation the pilot projects should be in operation for at least five years. The indicative costs are;

- project identification and formulation $ 7,000,000
- construction $10,000,000
- operation - annual cost $ 700,000



BANK PROTECTION PILOT PROJECT

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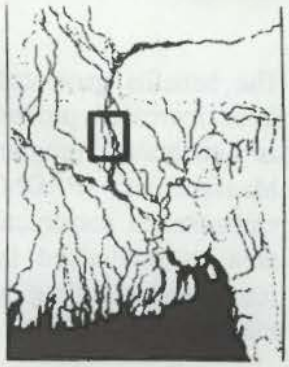


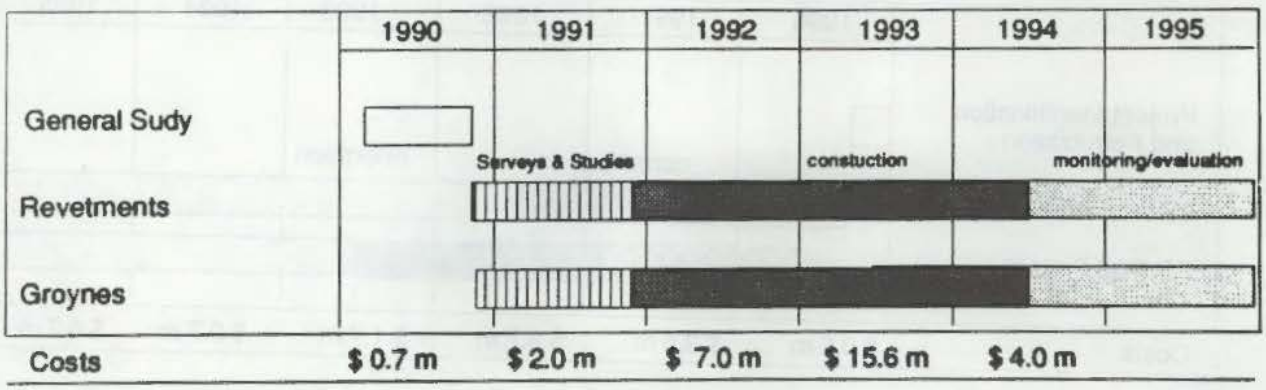
Powerful rivers with unstable banks set a difficult problem for bank protection. River erosion causes serious damage. In undercutting embankments, it threatens the protected area, whether it be agricultural land, rural settlements or urban centers and their communication networks. In areas not protected by embankments, bank erosion also means loss of valuable land. Protection from bank erosion by constuction of revetments or by diverting the undercutting flows by the building of groynes is expensive. The protection of Chandpur and Sirajganj towns has demonstrated how difficult and expensive the task can be. Despite its problems and cost, effective bank protection will be required for key towns, areas and strategic installations. It is therefore necessary to establish the most economic, appropriate and effective methods of bank protection. A pilot project is therefore to be set up to design and carry out full scale trials.

In the feasibility/design stage, existing and new techniques will be examined, together with appropriate construction materials and methods, taking into account river hydraulics, bed and bank material. Geotechnical and topographical surveys, morphological studies, laboratory research on materials and possibly some modelling will be carried out. The performance of existing town protection works will be evaluated and due account will be taken of recent and on-going studies (e.g, Jamuna Bridge Study, Brahmaputra River Training Study).

The next stage will involve the construction of full scale trial works. One pilot scheme will be to test different types of revetment and the other to test different types of groyne. These trials will be located at priority sites and, because of the undoubtedly high cost, where they will have a long term benefit. The designs, construction aspects and performance of the protection works will be evaluated carefully to assess the real costs and effectiveness of alternative techniques.

The approximate costs including an office at Sirajganj are:

- feasibility, design, monitoring and evaluation $ 2.9m
- construction $ 26.4m



RIVER TRAINING & AFPM PILOT PROJECT

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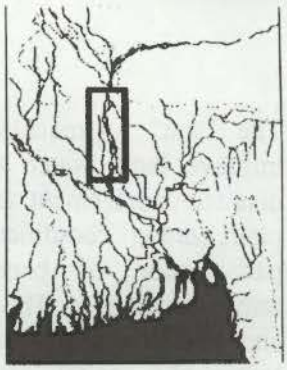

Future development of the floodplains of Bangladesh demands that, eventually, the river courses should be stabilised rather than be left free to change their geometry. This will require an extensive program of river training works. The depth of rivers and the flow velocities on the one hand and the scarcity of building material on the other, make it essential to test various methods of river training through pilot projects.

The need for river training at this stage lies primarily in the prevention of bank (and embankment) erosion. The desire to constrain the river to stable and efficient channels coupled with the need to increase the land resource, will to an increasing extent determine river training efforts. Attention should therefore not be focussed solely on the bank stretches presently under attack. Shifting river channels in the active flood plains of Bangladesh's major rivers constantly threaten riverside towns and embankments. Bank protection works, the traditional solution are expensive to construct and maintain. A more cost effective approach is to divert currents away from threatened sections aiming to increase the hydraulic efficiency of the main channels and to reclaim land for agriculture.

Under the concept of Active Flood Plain Management (AFPM), pilot projects for river training will start in the nothern reaches of the Brahmaputra. This is where the river is at its widest and shallowest and offers the best conditions for AFPM. Potential sites for trials will be selected in the active river channel between the Old Brahmaputra and the Dhaleswari.

The activities to be perfomed will include :

- acquisition and analysis of satellite imageries and airphotos
- river surveys and studies
- trials of channel diversions and closures
- trials of various construction materials
- trials of various reclamation methods
- identification of social and institutional issues

The indicative cost for the river training pilot project, including the costs of foreign experts, would be about $ 6m.

	1990	1991	1992	1993	1994	1995
Initial activities, surveys and studies						
Pilot projects, monitoring and analyses						
Costs	$ 0.6 m	$ 1.0 m	$ 1.2 m	$ 1.2 m	$ 1.0 m	$ 1.0 m

FLOOD PROOFING PILOT PROJECT

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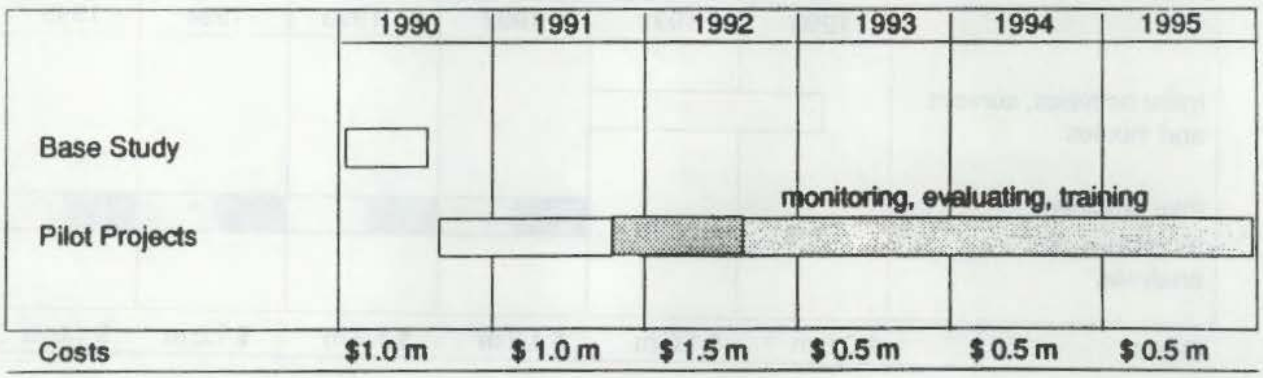
The "soft" approaches to flood protection include measures to improve land, water and environmental management; to improve disaster management and preparedness, flood forecasting and flood plain zoning; coordination of infrastructure planning, and increased participation of beneficiaries in infrastructure planning and implementation. These approaches are a mixture of structural and non-structural measures that rely on high public participation, low public capital inputs, and private investment. They focus on coordinated government policy to affect change and create incentives for beneficial private activities. They require high management and information inputs rather than large public expenditures on physical works.

Under the Action Plan, studies, data collection and analysis, and field demonstration and testing activities will be carried out to identify programmes and policy initiatives and reforms in the following areas:

- changing or regulating land use in flood vulnerable areas
- improving the flood damage resistance of infrastructure including industrial, commercial, residential, and government buildings.
- coordinating government policy in such areas as road, communications, and embankments, etc, to insure that flooding is not exacerbated or that land use and private investment is not put at increased risk.
- developing water management and water control policy that fully takes into account the effects of flood control measures on fisheries, groundwater, agriculture etc.
- developing new, high productivity cropping strategies and choices that involve new varieties, adjusted crop calendars, and increase the use of inputs.
- developing the institutional and human resource capability to disseminate information on the opportunities for and benefits of flood proofing.
- organize seminars, workshops, and training activities and programs to disseminate information and promote beneficial activities, particulary in the private sector.

The total cost is estimated to be about US $7 million.



RIVER SURVEY PROGRAM

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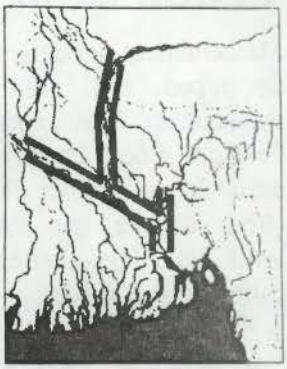


The Action Plan envisages that the Brahmaputra and the Ganges may eventually be embanked on both sides, possibly followed by the Padma and Meghna rivers. Confining rivers between embankments will change their hydrological and hydraulic characteristics, which may induce adaptations in river geometry; increased scouring of the river banks and bed could follow. The planning and design of the proposed works require systematic monitoring of the present situation and subsequent changes so as to develop a basic understanding of the processes at work.

While the routine countrywide programmes continue, a special program for surveys and data collection, focussed on the Brahmaputra, the Ganges, the Padma, the Meghna and the Lower Meghna and should be set up as a key activity of the Action Plan, with particular emphasis on the upgrading of the river gauging, flow measurement and data collection systems generally.

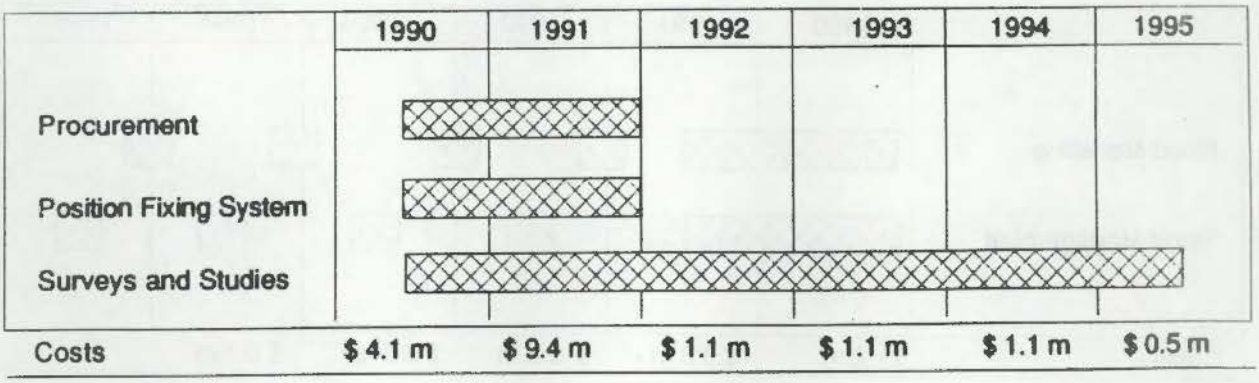
The establishment of proper position fixing equipment along the rivers will be an important first stage of the program, together with the acquisition of new survey vessels equipped with modern equipment and instruments. Satellite imagery obtained at regular intervals, say three times a year, would be an effective method of monitoring horizontal changes in river morphology, particularly in the braided river sections. A similar study has already been completed as part of the Jamuna Multi-purpose Bridge Study.

The program of surveys and data collection will cover both wet and dry seasons, using the network of telemetric stations for water level recording to be set up under Flood Forecasting and Early Warning (10). Analyses of river hydraulics and morphology will be undertaken as the program progresses.

Surveys and studies will continue for the duration of the Action Plan, after which they will be integrated with the routine programs.

The River Survey Program, including experts and satellite imagery, will cost approximately:

- procurement of launches & equipment $ 7,000,000
- setting up position fixing systems $ 5,000,000
- annual costs of surveys $ 1,100,000



FLOOD MODELLING / MANAGEMENT

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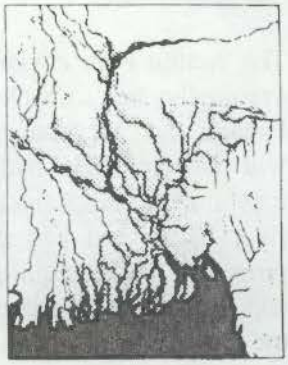


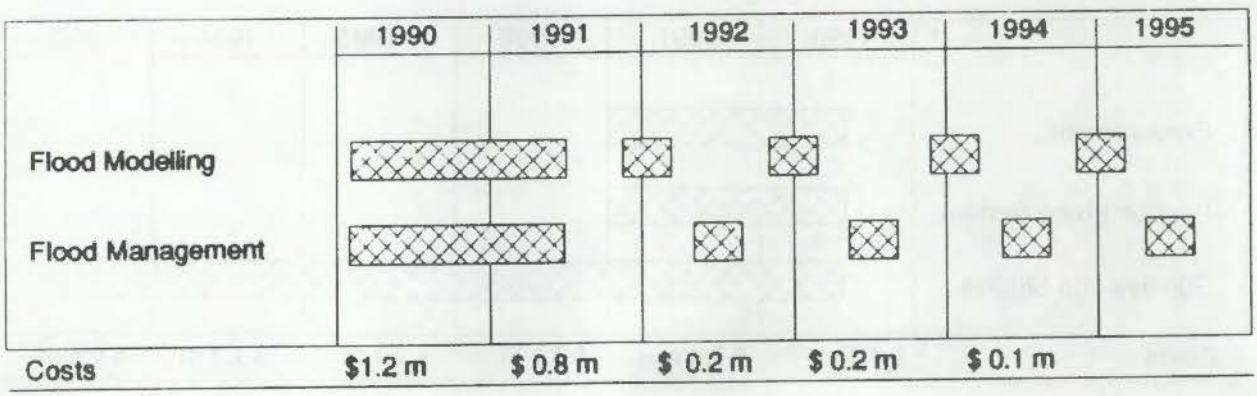
Mathematical models to simulate surface water flows have been developed and used for planning and design purposes in Bangladesh. The experience with these models could be used to develop flood management models. These models would be designed to predict flood conditions using incoming river flows (from outside the country), rainfall, internal runoff and water level data. Hypothetical situations would be used to develop and calibrate the model.

To assist the management of the various flood measures a computerised simulation model would serve as a link mechanism between incoming hydrological data, existing status reports from the field and the prediction of future situations based on various climatological and/or operational scenarios. The existing hydrological and hydrodynamic simulation models as presently used in the Master Plan Organisation (MPO) could act as a basis for the flood modelling proposed.

A flood management model would be constructed to simulate various scenarios - how much land is flooded at different river stages for combinations of river flows and internal rainfall, with and without embankments and compartments. The construction of the model would be on the basis of existing models developed within the MPO. The model would examine controlled flooding and main drainage design and management under the compartmentalisation concept. Its initial application would be as a training, planning and design tool but, as the model develops with linkages to the MPO models and the GIS, it would be used for flood management activities. The latter would include emergency operation of major hydraulic structures, mobilising emergency food supplies, assisting in transport movement decisions relating to emergency supplies, identification of areas likely to be subjected to rapid water level changes etc..

A specialist unit would be set up in the BWDB to develop and run the model in direct association with the MPO and BWDB, and with links to SPARSSO, Department of Meteorology, and Ministry of Relief and Rehabilitation. The modelling and flood management procedures would be periodically updated and improved to incorporate new developments and improved communications systems etc. Initially, however, technical assistance would be provided to establish the unit.

The indicative cost for technical assistance modelling and management, including equipment is US $ 2.5m.



INSTITUTIONAL DEVELOPMENT PROGRAM

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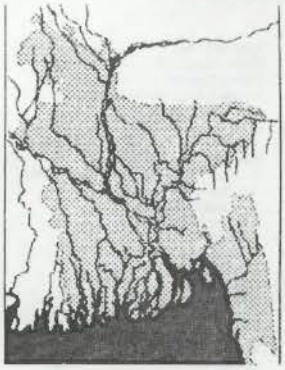

The construction of projects included in the Action Plan is scheduled to start in 1992, by which time appropriate institutional arrangements and procedures should be in place. To this end, an Institutional Development Programme will be started in mid-1990. It will comprise: (a) a six month study of institutions and procedures followed by (b) a four year Institutional Development Project (IDP).

The study will:

- examine the problems facing BWDB in the implementation of water control programs, including delays in appointing consultants and awarding contracts, shortage of local funds for construction and maintenance, and procedural delays in land acquisition and project approval;

- review the capacity and present workload of existing institutions (including BWDB) at national and local levels and assess their potential contribution to the implementation, operation and maintenance of projects under the Action Plan, including compartments;

- propose ways to strengthen BWDB and other institutions to implement the Action Plan and/or propose a new institutional set-up. Consideration would be given to ways of ensuring the participation of beneficiaries and local councils and of involving the private sector (e.g., through 'turnkey' projects).

The study would be carried out by a task force composed of foreign and local experts, independent of government and its agencies.

The IDP will be carried out in stages to meet plan requirements and deadlines. Extensive staff development and training programmes are envisaged together with upgrading of offices, facilities and transport. Pilot projects involving the testing of alternative procedures and institutional arrangements would also be undertaken. The study is estimated at $600,000 and the annual cost of the four year program would be $ 500,000.

	1990	1991	1992	1993	1994	1995
STUDY						
INSTITUTIONAL DEVELOPMENT PROJECT						
Costs	$ 0.6 m	$ 0.5 m	$ 0.5 m	$ 0.5 m	$ 0.5 m	

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