The impact of the proposed project development is to reduce peak water levels by over 1m throughout almost the entire reach of the Ghagot. This impact is dominantly due to the sealing of the TRE upstream of Kaunia and thereby preventing Teesta water contributing to those in the Ghagot.

Construction of the regulator at the head of the Alai has no significant impact on water levels in the Ghagot since, at the point where the Alai Nadi spills from the Ghagot, water levels are determined by backwater effects from the Brahmaputra. Immediately downstream of the new regulator site on the Alai water levels are reduced by about 2m although further downstream, near the confluence with the Karatoya, water levels are not changed since at this location the local backwater effect from the Karatoya dominates. The Alai regulator would effectively remove problems of spillage on its right bank and allow the rainfall-runoff from the surrounding area to drain more freely down the Alai.

The peak discharges in the Ghagot, Alai Kumari and the drainage channels which enter the north of the Gaibandha area are significantly reduced by the sealing of the TRE. This reduction in flow is reflected throughout the Ghagot river system. Monsoon flows in the Alai Nadi are cut-off by the new regulator and this reduces the flows which enter the Middle Bangali basin by approximately $300m^3/s$.

5.6 Morphological Impact of Proposed Developments

5.6.1 Impact of the BRE

Impact of spills through BRE breaches

A recent impact on the morphology of the rivers in the Middle Bangali basin has been the development of breaches in the BRE during the 1980's. These breaches have had a major impact on the magnitude and distribution of flows in the rivers of the region; this is described in Section 5.2. The spills through the BRE have also introduced large quantities of sediment into the rivers of the region.

The larger discharges in the Bangali appear to be causing a localised backwater effects, upstream of the major breach locations, on the Bangali river. The reduced flow velocities and increased flow depths are reducing sediment transport rates at Mohimaganj. It is likely, therefore, that the spills from the Brahmaputra are causing sediment deposition in this reach. A similar effect appears to be occurring in the Ichamati causing sediment deposition in the reach upstream of where the breach channel from the Kazipur breach meets the Ichamati.

Downstream of Simulbari, in both the Bangali and the Ichamati, the flows and sediment transport rates are significantly increased. The increased quantities of sediment being transported within the system are likely to be deposited in the Lower Bangali at points where water levels from the Hurasagar exert an influence.

Regime calculations were carried out using the discharges generated by MIKE11. In those reaches which are affected by spills through the BRE breaches, the results assuming no spills predict widths and depths which are smaller than those observed. This suggests that the morphology of these reaches of the river is being affected by spills from the Brahmaputra. If the existing conditions are maintained in the region and spills continue through breaches in the BRE then it is likely that the affected lengths of the Bangali and the Ichamati will be subject to change. The channel widths and depths will increase and the plan form of the river will become more sinuous.

It would appear that the Middle Bangali river system is still adjusting to this change in the flow and sediment regime which has resulted from the breaches in the BRE. The present system should therefore not be regarded as being in equilibrium; continuing morphological development should be expected if the present conditions are maintained.

Impact of sealing the BRE

If the breaches in the BRE are closed it is likely that the rivers of the Middle Bangali basin will return to conditions similar to those that existing prior to breaching.

It is unclear whether or not the present morphology of the Bangali river system is "in regime" with the increased flows and sediment which passes through the breaches in the BRE. Given this situation it is not possible to state precisely what the impact of sealing the BRE on river morphology will be.

If it were assumed that the rivers of the Middle Bangali basin are "in regime" with the present conditions the likely impacts of sealing BRE breaches are,

- enhanced sediment transport in reaches immediately upstream of where the breach channels join the main river system.
- reduced sediment transport in the downstream reaches of the Bangali and Ichamati.
- reduced sediment deposition in the reaches of the Lower Bangali where there is a backwater effect from the Hurasagar.
- a decrease in channel width and depth in those reaches which are affected by spills through the BRE breaches.
- in the reaches which are affected by spills through the BRE the river will exhibit a tendency to follow a straighter course.

In addition to these changes in the morphology of the Bangali river system, the sealing of the BRE breaches will reduce sediment deposition in the areas immediately behind the breaches and also in the areas adjacent to the breach channels.

Sealing of the breaches in the BRE adjacent to the Middle Bangali basin will not have an impact of the morphology of the Brahmaputra river.

5.6.2 Bangali Floodway

The morphological implication of the Bangali Floodway is dependent on the residual flow which is allowed to pass down the Bangali and, to some extent, the type of structures which are used to control the flow splits. The residual flow in the Bangali was selected such that the dominant discharge remains close to that which would occur under present conditions; without upstream development in the Upper Karatoya. The morphological change due to the Bangali Floodway will therefore be small in comparison with that due to sealing the BRE breaches. Control structures at the head of the Bangali, such as fixed weir structures, may restrict the movement of sediment in to the Bangali from the Karatoya. This will reduce the sediment load entering the Bangali and may lead to some localised morphological problems.

Along the Floodway itself, the morphology will be largely dependent on the channel sizing and design. Adopting a two-stage channel design will help to minimise the morphological changes. However, The levels in the lower part of the Floodway will be heavily dominated by backwater effects from the Brahmaputra and deposition is likely to occur in this reach.

5.6.3 The Lower Atrai

The Atrai rises in the north-west of the region and initially flows south passing through India. A short distance downstream of Mohadevpur it turns eastward and outfalls to the Brahmaputra through the Hurasagar. In the lower reaches flow in the Atrai is affected by high water levels in the Brahmaputra. A number of rivers such as the Little Jamuna and the Nagor run southward parallel to the Atrai and then enter the Atrai where it takes a more easterly course. All these rivers carry sediment through the Atrai system. The Fikirni spills from the Atrai at Jotebazar and carries a significant quantity of flow and sediment. The Little Jamuna and the Nagor contribute sediment to the Atrai.

The sediment transport rates in the Lower Atrai system are high, this means that the timescale for morphological change in the system is likely to be rapid, probably of the order of 20 to 50 years. This means that any intervention which alters the sediment transport rates is likely to generate a rapid morphological response.

Much of the sediment which is transported into and through the Lower Atrai system will be deposited in the downstream reaches of the river where the backwater influence from the Jamuna exerts an influence. Seasonal variations are likely to occur with the sediments deposited during high stages of the Brahmaputra being eroded once again as the external river level falls, the water slope steepens and local velocities increase.

The Green River concept is designed to try and retain the present hydraulic regime in the Lower Atrai basin by leaving the floodplains adjacent to the river system as flood storage and flow areas. The morphological impacts of this approach will lead to only minor changes in the morphology of the basin.

5.6.4 Teesta basin

Impact of sealing the Teesta Right Embankment

Impact on Teesta river : The long-term effectiveness of sealing the TRE will depend upon the future morphological change of the Teesta river. If the right bank of the river moves to the south-west, towards the TRE then breaches are likely to occur with increasing frequency. This can be avoided for some considerable period of time by allowing a large set-back distance between the embankment and the river. Unfortunately this would be at the cost of not providing flood protection to a large area of land adjacent to the Teesta. This is also not a viable option in the reach where the Ghagot comes close to the right bank of the Teesta.

For the TRE to be effective in reducing flooding down the Ghagot it is imperative that the TRE separates the Teesta from the Ghagot. It is therefore necessary to prevent any further moving westwards by the right bank of the Teesta in this area. Unfortunately this critical location coincides with one of the unstable reaches of the Teesta river.

The policy to protect this and other reaches of the TRE could be based upon that proposed by FAP-1 for protection of the BRE. In this approach it is not proposed to provide non-erodible protection for the full length of the BRE. Instead it is proposed to establish a number of hard points along the river. If the distance between these hard points is less than the natural wavelength of the anabranches then the incursions of the anabranches can be controlled. Though erosion may occur between the hard points, deep incursions will not occur. The same philosophy could be adopted for the Teesta based on the observed wavelength and utilising the natural fixed points along the length of the river.

Impact on the Ghagot river : If spillage from the Teesta into the Ghagot is prevented by the completion and rehabilitation of the TRE then the results of the MIKE11 simulations suggest that the dominant discharge will be reduced to approximately 50 m^3/s. The regime conditions for these revised conditions would be a width of 22m, depth 2.7m and a slope of 0.00013.

These results suggest that, in the long-term, the channel would reduce significantly in both width and depth. The change in equilibrium slope suggests that the sinuosity of the river would reduce to approximately 1.4. Thus the river course would become much less tortuous than at present. The time for these morphological re-adjustments is likely to be less than 20 years.

CHAPTER 6

ANALYSIS OF DEVELOPMENT OPTIONS AND SCENARIOS

6.1 General Approach

6.1.1 Scope of Economic Analysis

Economic analysis was conducted for the Lower Atrai "Green River" scenario, the proposed Upper Karatoya/"Bangali Floodway" development, and a number of independent proposals (Teesta Left Bank, Little Jamuna Right Bank, Mohananda, and Hurasagar). The analysis of the Green River scenario in the Lower Atrai is a development from the analysis conducted at Interim Report stage, when the impacts of the Interceptor Drain and Diversion Drain were analysed and found to be not economically feasible. Full FCD in the Lower Atrai was also analysed at Interim Report stage.

6.1.2 Conceptual Approach and Link with Multi-Criteria Analysis

The study places considerable emphasis on the importance of the multi-criteria analysis as a guide to policy-makers in the selection of projects. The results of the economic analysis are entered into the multi-criteria analysis (MCA) and should be considered in conjunction with the other indicators making up the MCA.

It had been intended to use an extended cost-benefit analysis approach in the economic analysis, in order to value impacts which might conventionally be excluded from analysis. This extended CBA approach has been used to some extent, particularly in regard to economic valuation of capture fisheries to take account of current and future depletion of stocks, but data limitations mean that a number of possible impacts have not been valued. Sensitivity analyses have been carried out to assess impacts on soil fertility (as well as analysis of potential for navigation and a hazard analysis for the Gaibandha priority project area), but where valuation has not been possible, quantified impacts have been entered into the Environmental Impact Assessment (EIA) and important indicators from there have been included in the multi-criteria analysis. The MCA is therefore an important focus for policy-makers since it integrates the impacts which have been given monetary values and those which have not.

6.1.3 Components of Economic Analysis

The main components entering into the economic analysis are:

A. Project costs

- construction and O & M costs
- economic cost of land acquisition.

B. Project benefits/disbenefits

- crop intensification benefits
- benefits of reduced damage to crops, property and infrastructure
- (dis) benefits for fisheries
- other ecological/environmental impacts.

The main ecological impact, at least in the short-term, is likely to be on floodplain fisheries, and this impact is analysed in some detail. The data on other ecological and environmental impacts are generally more approximate and attempts at valuation were not thought advisable at this stage. It should also be noted that at the regional planning stage detailed mitigation measures have not been proposed, since it is felt that these are more appropriately developed at the feasibility stage. Specific mitigation measures are therefore generally not included in the economic analysis. However, the Green River scenario in the Lower Atrai is itself in a sense a mitigation approach, since it aims to compensate for the negative impacts of the full FCD strategy hitherto attempted there. In another sense the Green River scenario is more than mitigation, being an alternative strategy to full FCD with a greater emphasis on sustainable development from a social and ecological viewpoint.

The following sections describe data sources and methodology used in developing the economic analysis.

6.2 Estimation of Agricultural Benefits

6.2.1 General

Direct agricultural benefits from flood control fall into two main categories:

- benefits due to agricultural intensification and shifts to crops with higher returns
- benefits due to reduced crop damage as a result of floods.

If significant increases in output of high yielding crops can be attained, such increases make the greatest contribution to project viability. However, experience from previous FCD projects (as documented, for example, in the FAP 12 study) shows that the increases that appear to be theoretically possible are in reality often unachievable, for a variety of reasons (e.g. disbenefits caused to outsiders which result in regular public cuts). Reductions in crop damage may then take on greater importance although they are rarely in themselves enough to justify a project.

These remarks emphasise the need for careful assessment of particular proposed schemes so that a realistic forecast of project benefits can be made.

6.2.2 Estimation of Incremental Crop Production Benefits

Cropping Patterns and Flood Phase Transitions

The estimation of cropping pattern changes as a result of flood control requires three essential sets of data : present cropping patterns, present flood depth-area relationships, and future flood depth-area relationships.

The approach used in this study, utilising the three data sets, can be termed a modified MPO approach, since it follows to a large extent the approach developed by MPO (now WARPO) for the National Water Plan Phase I. MPO developed a classification of land according to depth of flooding (based on data originally collected by the SRDI). The MPO classification is:

F0	0 - 0.3 m
F1	0.3 - 0.9 m
F2	0.9 - 1.8 m
F3	> 1.8 m deep flooded
F4	> 1.8 m very deep flooded, cropping not possible

This classification was applied on a Catchment Area and Planning Area basis to all land. Typical cropping patterns for a particular flood phase ("F") category were developed. The impact of a water control project was then analysed by assuming a shift in the flood phase distribution within the project area, e.g. some land previously classified as F2 would be changed to F1 and would as a result take on the cropping pattern associated with the new land classification. In this way overall changes in cropping patterns would be worked out.

A standard transition was assumed to take place depending on the nature of the project. For example, for FCD schemes with gravity drainage, the assumed transition was as follows:

a. Irrigated Land.

    100% F1 land to F0
    75% F2 land to F0
    25% F2 land to F1
    20% F3 land to F1
    45% F3 land to F2
    35% F3 land remains F3

b. Non-Irrigated Land.

    100% to F0.

The above MPO methodology is basically appropriate for national and regional-level planning, but in this study the approach has been modified in a way that should allow a more realistic assessment of individual project areas to be made.

The modified approach involves the following:

The method of deriving present-condition cropping patterns by flood phase uses BBS 1989 cropped area statistics (on a thana basis, converted to project area basis), and MPO thana-level flood phase data, and a set of rules by which individual crop areas are allocated to different flood phases. These rules are described in the Agriculture Annex, Volume 12 of the Draft Final Report (section 5.2.2). The main point to note here is that the method of allocating individual crop areas to flood phases according to specific rules appeared to give consistent and plausible results, even though the data were from different sources.

Having established the baseline conditions for analysis, the next step was to determine the changes in flood phase distribution and any other relevant parameters (e.g. irrigation rate) which would influence with-project cropping patterns. In general, the only change between present and future-without conditions was the assumed increase in irrigation (although the assumed sealing of the BRE also affected some areas), and the only difference between future-without and future-with conditions was the changes in flood phase distribution. Once the change in flood phase distribution was determined, the likely shift in cropping patterns was worked out using rules essentially similar to those used to determine present-condition cropping patterns. These rules and the overall procedure are again described in the Agriculture Annex, section 5.2.2 and the Economics Annex (Volume 13), Section 4.3.2 of the Draft Final Report.

The main difficulty with this analysis is how to determine the extent of changes in flood phase distribution, other than by using the standard MPO approach, which does not allow for variations in the extent of possible change between projects, and which, if applied to all projects, would certainly overestimate the extent of change possible in some areas.

The method followed in this study has involved a combination of the forecast changes produced by FAP 2's model analysis and drainage analysis, modified by judgement based on knowledge of the area, the FAP 12 study, etc. The model and drainage analysis produced flood phase distributions by project area for present, future-without and future-with conditions. The present-condition flood phasing was compared with the MPO flood phasing for a particular project. There appeared to be a consistent tendency for the model and drainage output to suggest a significantly higher proportion of F0 land in a project area than the MPO data, although in some areas the sum of F0 + F1 land showed a quite good correspondence. Although conditions in some areas have changed since the MPO data were compiled, it seems more likely that the model does tend to overestimate the extent of F0 land, and this overestimate can be assumed also to apply to future conditions.

In addition, the model tended to show considerable with-project reductions in F2-F4 land in deeply-flooded areas (especially the Lower Atrai) which experience has shown are not likely to be attainable to such a great extent.

It is therefore necessary to make some adjustments to the flood phase distribution before it was used for the analysis. The adjustments were made to present-condition flood phases after comparing the model output and MPO flood phase data, and using knowledge of the project area to decide which set of data was more appropriate. Adjustments to the with-project flood phase distribution, which was generated by the model, were made largely on the basis of judgement about feasible outcomes for particular types of projects, taking account of past experience with such projects.

The adjustments made for a sample of projects are shown in Table 6.1.

Table 6.1 Adjustment of Flood Phase Data: Sample Projects

	% of NCA			
	F0	F1	F2	F3
TEESTA LEFT BANK				
MPO Present	35	62	3	0
Model Present/Future-Without	76	6	7	11
Assumed Present/Future-Without	49	46	4	2
Assumed Future With-Project	56	41	2	1
CHALAN BEEL POLDER C CFD AREA				
MPO Present	29	24	29	18
Model Present/Future-Without	58	14	16	12
Assumed Present/Future-Without	58	14	16	12
Assumed Future With-Project	66	11	14	9
CHALAN BEEL POLDER D CFD AREA				
MPO Present	46	20	24	10
Model Present/Future-Without	33	18	24	25
Assumed Present/Future-Without	44	19	23	14
Assumed Future With-Project	58	22	12	8

This approach as described above could be usefully developed in future. One of the strengths of the MPO approach is that it provides a logical framework for land classification which is practical for agricultural development planning. However the assumption of a standard transition is limiting, and in that sense the hydro-dynamic model provides great potential for making more accurate and project-specific assessments of likely shifts, as well as allowing more detailed analysis of the timing and duration of flooding for floods of different magnitudes.

The cropping patterns used in analysis comprise 16 composite crops, following MPO practice. The main shifts in cropped areas as a result of flood control relate to paddy crops, but there are also some adjustments in areas of rabi crops. The principal shifts are:

A. Between present and future-without
Increased HYV boro and declining B. aus (and sometimes rabi crops)

B. Between future-without and future-with
Increased t. aman and declining b. aman (and sometimes rabi)
Increased t. aman and declining b. aus
Increased HYV t. aman and declining local t. aman
Increased deep water aman ("Green River" areas).

The main source of incremental agricultural benefits is undoubtedly increased HYV t. aman production. However, a number of points need to be made with regard to the potential for increased HYV t. aman production as a result of flood control schemes.

(i) In many parts of the NW region HYV t. aman is already more important than local t. aman in terms of cultivated area, and this trend will continue even without flood control. Some farmers continue to grow local t. aman even on land where they could grow HYV t. aman, possibly because of lower input costs, or taste preferences etc. There is little doubt that most of these farmers will ultimately switch to HYV cultivation.

(ii) One constraint on further expansion of the HYV t. aman area at present is the indirect impact of lack of irrigation. On some non-irrigated land farmers grow b. aus (perhaps preceded by rabi crops) and then find it difficult to follow b. aus by HYV t. aman, due to time constraints opting for local t. aman or fallow.

(iii) Farmers in parts of the Lower Atrai are emphatic in claiming that the HYV t. aman variety most commonly used in that area (BR21) is tolerant of quite high depths of flooding for a few days. It is therefore possible that the general view that local t. aman can withstand floods where HYV t. aman cannot is becoming, or will become, less important in future, thereby reducing one of the economic justifications for flood control.

In summary, not all the increase in HYV t. aman in future can be attributed to flood control. What can be said is that, where some land is converted to F0 from another flood phase, the potential for growing HYV t. aman has been increased. This is one of the principles adopted in this study in deriving future cropping patterns, where a proportion (usually 75-80%, depending on the starting condition) of the incremental F0 land is assumed to be cropped with HYV t. aman.

Other points to note in regard to cropping pattern analysis are:

(a) HYV boro areas are taken to be the same in future-without and future-with conditions. Flood waters generally rise relatively late in the region and in most years will not affect HYV boro, certainly not preventing it from being planted. Any occasional effect of floods on boro is accounted for in the crop damage analysis.

(b) Cropping intensities barely increase and may even decrease with project. Incremental HYV t. aman cultivation, for example, generally replaces another paddy crop (local t. aman, b. aus or b. aman) and, if the cropping pattern HYV boro - HYV t. aman replaces rabi - b. aus - local t. aman, cropping intensities decline.

(c) In the Lower Atrai, some benefits can be gained from regulating the rise of water to allow deepwater aman to become established. Some farmers try to transplant deepwater aman after harvesting boro, but rising floods may wash away the plant before it has developed. Modest benefits have been assumed to accrue in "flow" areas of the Lower Atrai as a result of partial protection provided there.

Crop Input Use

Crop input-output data were compiled from the following secondary sources:

- MPO Technical Report No. 14: Agricultural Production Systems
- Agro-Economics Research Costs and Returns Reports for selected years, 1982-83 to 1988-89
- IFDC Farm-Level Fertiliser Use Surveys for 1989-90 and 1990-91
- World Bank: Selected Issues in Rural Employment (1983).

The agricultural survey conducted by the study in 1991 gave further information on input use and yields.

These data sources were combined to get a composite data set for input use and yields. These data are shown in Table 6.2.

Table 6.2 Physical Input Quantities and Production per hectare - NW Region Present Condition

Crop	Labour (man days)	Draft Animal (pair days)	Seed (kg)	Fertiliser Urea (kg)	Fertiliser TSP (kg)	Fertiliser MP (kg)	Fertiliser Manure (kg)	Pesticide (kg)	Production Main Crop (mt/ha)	By-Product (mt/ha)
HYV Boro	215	50	30	186	123	41	0	0.5	4.5	4.5
Local Boro	160	40	30	62	41	14	0	0	2.5	2.5
HYV Aus	205	50	30	130	90	30	0	0.5	3.75	3.75
Local B.Aus	160	45	80	50	0	0	1300	0	1.6	1.6
HYV T.Aman	190	50	30	130	90	30	0	0.5	3.75	3.75
Local T.Aman	140	44	30	45	30	10	1300	0	2.25	2.25
DW Aman	115	45	30	50	0	0	660	0	1.6	2.4
Wheat	120	40	140	75	25	0	0	0.25	1.7	1.7
Jute	230	48	7	60	20	15	0	0	1.7	3.4
Sugarcane I	260	65	5000	175	70	105	1400	0.75	42	
Sugarcane II	230	65	5000	50	20	30	1400	0	20	
Potato	190	45	1000	75	50	75	1500	0.5	10	
Pulse	50	30	30	30	0	0	0	0	0.8	1
Oilseeds	75	36	10	75	75	30	700	0.5	0.7	1
Onion	150	40	6.2	55	37	55	0	0	8	
Vegetable (Brinjal)	270	50	0.3	60	40	60	0	0	15	
Tobacco	260	60	0.1	0	25	25	2600	0.5	1	
Banana										

Source:

(1) MPO Technical Report No. 14.

(2) World Bank: Bangladesh: Selected Issues in Rural Employment (1983).

(3) Agro-Economics Research, MoA: Costs and Returns for years 1982-83 to 1988-89.

(4) IFDC Farm-Level Fertiliser Use Surveys for 1989/90 Rabi/Boro and Aman Seasons.

(5) Consultants' field survey data.

Crop Yields

Comparing different data sources, there tends to be greater variability in yield estimates compared to estimates of input requirements. This is important since assumptions on yields have a significant impact on potential project viability. MPO "future" yields, for example, tend to be significantly higher than those given by other sources.

There also appears to be some intra-regional variability in yields, with parts of the Lower Atrai having particularly high HYV boro yields. In this study, however, no such variability has been considered, on the assumption that other areas would tend to close the gap over time.

It has been assumed that yields will increase in future, particularly of HYVs. Available data tend to show rather flat yields, even of HYV s, in recent years, with overall yield increases being achieved by substitution of HYVs for local varieties. Nonetheless, it is reasonable to assume that, during the life of FAP projects, yield increases will occur, and these will affect project viability, even though the higher yields will also apply to future-without conditions. The assumed yield increases are 1% per annum over 15 years for HYVs (until the year 2007, which has been taken as the reference year for analysis), and 0.3 % per annum for other crops.

Crop Residues and Livestock Benefits

The FAP 12 studies showed that some flood control projects resulted in significant loss of grazing land as cropped areas increased. Any loss of grazing land would further weaken the already under-nourished livestock used for land preparation and thereby could adversely affect production. Conversely, increased crop production results in increased crop residues which can be used as fodder (despite the lower nutrient value of HYV straw compared with an equivalent weight of local paddy straw).

As a simplifying assumption, it has been assumed that the gains and losses to livestock balance out and that the overall impact of flood control projects on livestock is neutral. In the economic analysis this is accounted for by removing the value of crop residues from the value of both future-with and future-without crop production.

Minor Irrigation

The dramatic increase in minor irrigation throughout much of the region has been the main source of growth in agricultural output in the last decade. Most of this increase has been due to the spread of shallow tubewells (STWs) which from a water management viewpoint are well suited to Bangladesh's agrarian structure. Most of the additional irrigation capacity is used for HYV boro cultivation, and to a much smaller extent for supplementary irrigation of HYV t. aman post-monsoon.

The growth of minor irrigation in the region has been independent of flood control and will basically continue to be so. Nonetheless availability or non-availability of irrigation is a major determinant of without-project cropping patterns and therefore has an indirect influence on the types of cropping pattern changes that might occur with flood control.

The approach used here has been, for each area, to project forward the likely coverage of irrigation by the year 2007, and to use the projected irrigation rate as an estimate of the HYV boro area in future-without and future-with conditions.

Financial Prices of Crops and Inputs

Financial prices for crops were derived from the farmgate price data collected at twenty survey locations in the region by the Directorate of Agricultural Marketing. There was a high degree of uniformity in prices between locations so a simple average of prices at the twenty locations was used as a basis for calculating financial prices. Price data were collected for the last five years (1986-87 to 1991-92) for the months for which they were available (generally the three months immediately post-harvest). The average prices for the last three years were then converted to 1991-92 prices using the GDP deflator, and the average of those three years was taken as the relevant financial price.

Input price data were collected from different sources. Labour wage rates and draught power rents were collected during field surveys. The wage rate data were also checked against BBS data. In comparison with other regions, the wages and draught power rents appear to be rather low in the NW region.

Fertiliser prices were collected from 1991-92 regional data provided by IFDC. These data showed a considerable reduction in the extent of subsidy on TSP and MP during 1991-92, which brought the financial prices of these inputs more in line with world prices.

The conversion of financial prices to economic prices generally followed the recommendations in the FAP Guidelines for Project Assessment.

The study did however differ from the Guideline in regard to a few issues, as discussed in the Section 1.3, Economics Annex, Draft Final Report.

The resulting financial & economic prices for inputs are given in Table 6.3, and for crops in Table 6.4.

Crop Budgets

Crop budgets were derived in economic prices from the physical input-output data and the economic price data. A number of adjustments were made to the crop budgets before they could be used in analysis:

- exclusion of crop residues (except jute) to account for livestock impacts
- inclusion of irrigation costs (mostly for HYV boro production)
- inclusion of the cost of credit, equivalent to 80% of cash production costs for six months, at a rate of interest of 12% reflecting the opportunity cost of capital
- inclusion of an additional 10% of total production costs to reflect miscellaneous costs.

The adjusted crop budgets are shown in Table 6.5.

Table 6.3 Financial and Economic Prices for Inputs,NW Region,mid 1991.

Input	Financial Price (Tk)	Conversion Factor	Economic Price (Tk)
Labour(m-d)	31.67	0.75	23.75
Draft power (pair-days)	25.00	0.87	21.75
Urea(kg)	5.12	1.17	5.99
TSP(kg)	6.60	1.34	8.84
MP(kg)	5.55	1.45	8.05
Manure(kg)	5.00	0.87	4.35
Pesticide (Kg)	504.00	0.87	438.48
LLP(ha)	2732.00		2068.00
STW(ha)	6611.00		4736.00
DSSTW(ha)	7324.00		5182.00
DTW(ha)	10883.00		6653.00
SEEDS: (Kg.)			
HYV Boro	9.92	0.88	8.73
Local Boro	9.92	0.88	8.73
HYV Aus	8.76	0.88	7.71
Local B.Aus	8.76	0.88	7.71
HYV T.Aman	9.60	0.88	8.45
Local T.Aman	9.48	0.88	8.34
B.Aman	9.48	0.88	8.34
L.I.Aman (Paijam)	9.48	0.88	8.34
Wheat	10.11	1.29	13.04
Jute	25.71	1.06	27.25
Sugarcane		0.95	
Potato		0.87	
Pulse	24.50	0.87	21.32
Mustard/Rape	19.89	0.88	17.50
Onion		0.87	
Vegetable (Brinjal)		0.87	
Tobacco		0.87	

Source: NWRS Estimates

Conversion factors from GPA except for revised fertiliser factor

Table 6.4 **Financial and Economic Prices for Crops, NW Region, 1991-92**

Crop	Financial Price (Tk/kg)	Conversion Factor	Economic Price (Tk/kg)
HYV Boro	6.61	0.88	5.82
Local Boro	6.61	0.88	5.82
HYV Aus	5.84	0.88	5.14
Local B.Aus	5.84	0.88	5.14
HYV T.Aman	6.40	0.88	5.63
Local T.Aman	6.32	0.88	5.56
B.Aman	6.32	0.88	5.56
L.I.Aman (Paijam)	6.32	0.88	5.56
Wheat	6.74	1.29	8.69
Jute	8.57	1.06	9.08
Sugarcane		0.95	
Potato		0.87	
Pulse	16.33	0.87	14.21
Mustard/Rape	13.26	0.88	11.67
Onion		0.87	
Vegetable/(Brinjal)		0.87	
Tobacco		0.87	
Rice Straw - HYV	0.70	0.87	0.61
Rice Straw - Local	0.93	0.87	0.81
Jute Sticks	2.73	0.87	2.38

Source: NWRS Estimates
Converstion factors from GPA

Table 6.5 Adjusted Crop Budgets (Economic Prices) (Tk./ha, 1991-92 prices)

Crops	Gross Return (excl.crop residues)	Cost of Inputs	Irrigation Cost	Cost of Credit (12%)	Miscell. Costs (10%)	Total Production Cost	Net Return
HYV Boro	30119.00	9532.00	4262.00	662.11	1445.61	15901.72	14217.28
HYV T.Aman	24282.00	8149.00	474.00	413.90	903.69	9940.59	14341.41
DW Aman	9526.00	4362.00	0.00	209.38	457.14	5028.51	4497.49
L.T.Aman	13138.00	5349.00	0.00	256.75	560.58	6166.33	6971.67
B.Aus	8635.00	5868.00	0.00	281.66	614.97	6764.63	1870.37
HYV Aus	24282.00	8149.00	1705.00	472.99	1032.70	11359.69	12922.31
Jute	24704.00	7395.00	0.00	354.96	775.00	8524.96	16179.04
Pulse	11936.00	2665.00	0.00	127.92	279.29	3072.21	8863.79
Oilseed	8577.00	4465.00	0.00	214.32	467.93	5147.25	3429.75
Wheat	15512.00	6364.00	0.00	305.47	666.95	7336.42	8175.58
Potato	41790.00	14853.00	0.00	712.94	1556.59	17122.54	24667.46
Veg/Spices	66108.00	8828.00	0.00	423.74	925.17	10176.92	55931.08
Tobacco	22639.00	8448.00	0.00	405.50	885.35	9738.85	12900.15
Sugarcane	42380.00	15506.00	0.00	744.29	1625.03	17875.32	24504.68

N.B. Crop residues not excluded from jute since not used for fodder.

Source: NWRS Estimates

Timing of Crop Production Benefits

The basic assumptions with regard to timing of the flow of benefits are that no benefits accrue until a project is completed, and that there is a five-year build-up to full development. The year 2007 has been taken as the reference year for the analysis, assuming on average that full development could be reached by that year (some projects will reach full development earlier): the choice of reference year mostly affects projections of the irrigated area and of future yields.

The analysis is conducted using 1991-92 constant prices.

6.2.3 Reduced Crop Damage

The second agricultural benefit from flood control is reduction in crop damage caused by floods: the value of crop damage averted is then added to the benefit side of the analysis. In some parts of the region the major flood "problem" appears to be crop damage, rather than inability to intensify production because of water constraints. This is the case for example in the Thakurgaon and Dinajpur areas where monsoon cultivation of t. aman predominates but where flash floods, particularly in recent years, have caused localised damage. It is probably also the case in the Lower Atrai, where farmers are especially concerned about losing existing crops as a result of public cuts, and in the Upper Karatoya.

Therefore, although the highest returns come in theory from changes in cropping patterns, in practice reduced crop damage is also of great concern to farmers living within project areas.

The methodology used to assess crop damage involved deriving the expected annual crop damage by developing a crop flood damage - frequency curve. The data to enable the crop damage - frequency curve to be derived only exist at Old District level. The first output of the analysis was therefore a frequency curve for each of the five Old Districts, from which the expected annual crop damage was calculated for each Old District. The results are shown in Table 6.6. It should be emphasised that there are very wide confidence limits attached to these calculations, but the resulting per hectare damage figures appear to be reasonable. The detailed calculation of damage by Old District is shown in Table 4.15, Economic Annex, Volume 13 of the Draft Final Report.

The next step in the analysis involved distributing the Old District-level figure for expected annual crop damage according to the severity of damage within each Old District. The only disaggregated data that allowed such a distribution to be made were the thana-level damage figures for 1987 and 1991 (collected by the DAE). These years were both years of high flooding. The crop damage data for these years were used to give a weight to each thana by which the Old District data could be distributed. The weight used was as follows: (1987 t. aman fully damaged area + 0.5 1987 b. aman fully damaged area + 1991 t. aman fully damaged area + 0.5 1991 b. aman fully damaged area)/2. Basically this means the average of damage in the two years, taking into account the higher value of t. aman compared to b. aman.

The above method provides only an approximation, but it appears to be the best that can be made with the available data, and it clearly identified the thanas where it is known that crop damage is significant and persistent.

Once thana-level damage data were derived, these were applied to project areas pro-rata to the proportion of a particular thana falling within the project area.

Table 6.6 Estimated Average Annual Crop Damage Avoided by Flood Protection By Old District (Tk. mm, 1991-92 prices)

A. BOGRA DISTRICT

	1:5	1:10	1:20	1:50	1:100
Total	80.4045	91.8995	97.405	101.6884	102.7592
Tk. per NCA	233.046	266.442	282.293	294.756	297.902

B. DINAJPUR DISTRICT

	1:5	1:10	1:20	1:50	1:100
Total	31.581	36.058	38.236	39.9058	40.3293
Tk. per NCA	52.151	59.532	63.162	65.945	66.671

C. PABNA DISTRICT

	1:5	1:10	1:20	1:50	1:100
Total	76.8955	85.1235	89.0802	92.1536	92.9159
Tk. per NCA	203.159	224.939	235.345	243.452	245.509

D. RAJSHAHI DISTRICT

	1:5	1:10	1:20	1:50	1:100
Total	101.3617	113.3407	119.1124	123.6015	124.7147
Tk. per NCA	114.95	128.623	135.157	140.239	141.449

E. RANGPUR DISTRICT

	1:5	1:10	1:20	1:50	1:100
Total	131.4665	146.531	153.7305	159.3207	160.7122
Tk. per NCA	160.325	178.717	187.55	194.326	196.02

Source: NWRS estimates based on data from Yearbook of Agricultural Statistics, BBS, various years

One point of interest from Table 6.6 is the relatively small difference between damage avoided from protection upto a 1:20 year return period, and damage avoided from lesser degrees of protection (1:10, 1:5 year). These results have to be treated cautiously because of the low levels of confidence attached to the damage - frequency curves, but they do have a logic to them: clearly the damage caused by a 1:20 year flood is considerably greater than that caused by 1:5 year floods, but the infrequency of the major events means that major damages in one year do not translate into major changes in the value of expected annual damage. The results also suggest that crop damage in years of moderate flooding may also be quite widespread if less dramatic than in high flood years.

6.3 Estimation of Fisheries and Environmental Impacts

6.3.1 General

As discussed earlier, the main ecological/environmental impact of flood control, at least in the short - medium term, is likely to be impacts on the floodplain fisheries. The data exist to value these changes and include them in the main economic analysis. With other impacts data are scarce and/or difficult to value.

The approach adopted here is therefore to include fisheries impacts in the basic economic analysis and to conduct some sensitivity analyses to give guidance on other impacts such as navigation and soil fertility.

6.3.2 Estimation of Fisheries Impacts

Production

Reliable secondary data on the fisheries sector is rather limited, therefore much of the information used here has been collected by FAP 2.

A basic distinction has been drawn between capture and culture fisheries: capture fisheries includes beel, river, floodplain and borrowpit fisheries, while culture fisheries comprises ponds in different states of development. Each habitat-type has different catch rates and different areas: further, productivity rates can be expected to change between future-without and future-with conditions. In this respect the treatment of yield rates between future-without and future-with differs from the analysis of crop changes, but for good reasons: any difference in yield rates for crops would depend on farmers feeling confident that increased investment was justified, something which can be hoped for but cannot be predicted with confidence. In contrast, fisheries yields would change, in the case of capture fisheries, as a direct biological response (mostly negative), and in the case of culture fisheries, as a direct result of reduced overtopping of ponds.

The different catch rates are shown in Table 6.7.

Table 6.7 Fish Catch Rates (Kg/ha)

	Present Condition	Future Without	Future With (Full FCD)	Future With (Partial Protection)
Beels	400	400	250	400
Rivers	40	40	20	40
Floodplains	70	70	50	70
Ponds:				
Cultured/Cultura	850	850	1000	850
Derelict	180	180	50	50
Borrow Pits	180	180	250	250

Source: NWRS estimates

The area of floodplain was derived from the output of the hydro-dynamic model and from drainage analysis. The area of F1 - F4 land flooded to more than 0.3 ms for a period of at least 3 months was taken as the potential floodplain area for capture fisheries. This tended to give higher estimates of floodplain fisheries than in previous analyses but it is felt to be a correct representation.

The areas of perennial beels, rivers and canals were determined from SPARRSO satellite imagery, although the imagery was developed in the early 1980s. Areas of ponds were collected from Thana Fisheries Officers as well as SPARRSO data.

Prices and Production Costs

Financial prices were determined on the basis of field surveys. They represent the price actually received by the fisherman/pond owner, rather than retail prices.

Costs of labour and materials were also obtained from field surveys supplemented by secondary sources.

The issue of economic valuation of fisheries output, as well as wider socio-economic impacts resulting from continued decline in capture fisheries, has been particularly addressed during the study, including collaborative work with FAP 16 (the Environment Study) and FAP 17 (the Fisheries Study). It is now generally accepted that capture fisheries have been seriously declining and that part of this decline can be attributed to FCD projects which hitherto paid little or no attention to the issue. Since capture fisheries are an important source of nutrition and income for a large proportion of the rural population, continued decline has serious implications for poor households.

There are a number of ways in which these issues can be addressed, but the likelihood of rising real prices due to increasing scarcity can be addressed directly in the economic analysis through the pricing system chosen. An analysis carried out by the study for selected species did show an increase in real prices for most of the species, as shown in Fig. 6.1 and Table 6.8.: if the increase is not generally as dramatic as might be expected, that can be partly attributed to the ineffectiveness (in their own terms) of previous FCD projects (the ulcerative fish disease might have also contributed by causing a reduction in demand in the late 1980s). Therefore, if FCD projects were working to full effectiveness, a further decline in capture fisheries could be anticipated.

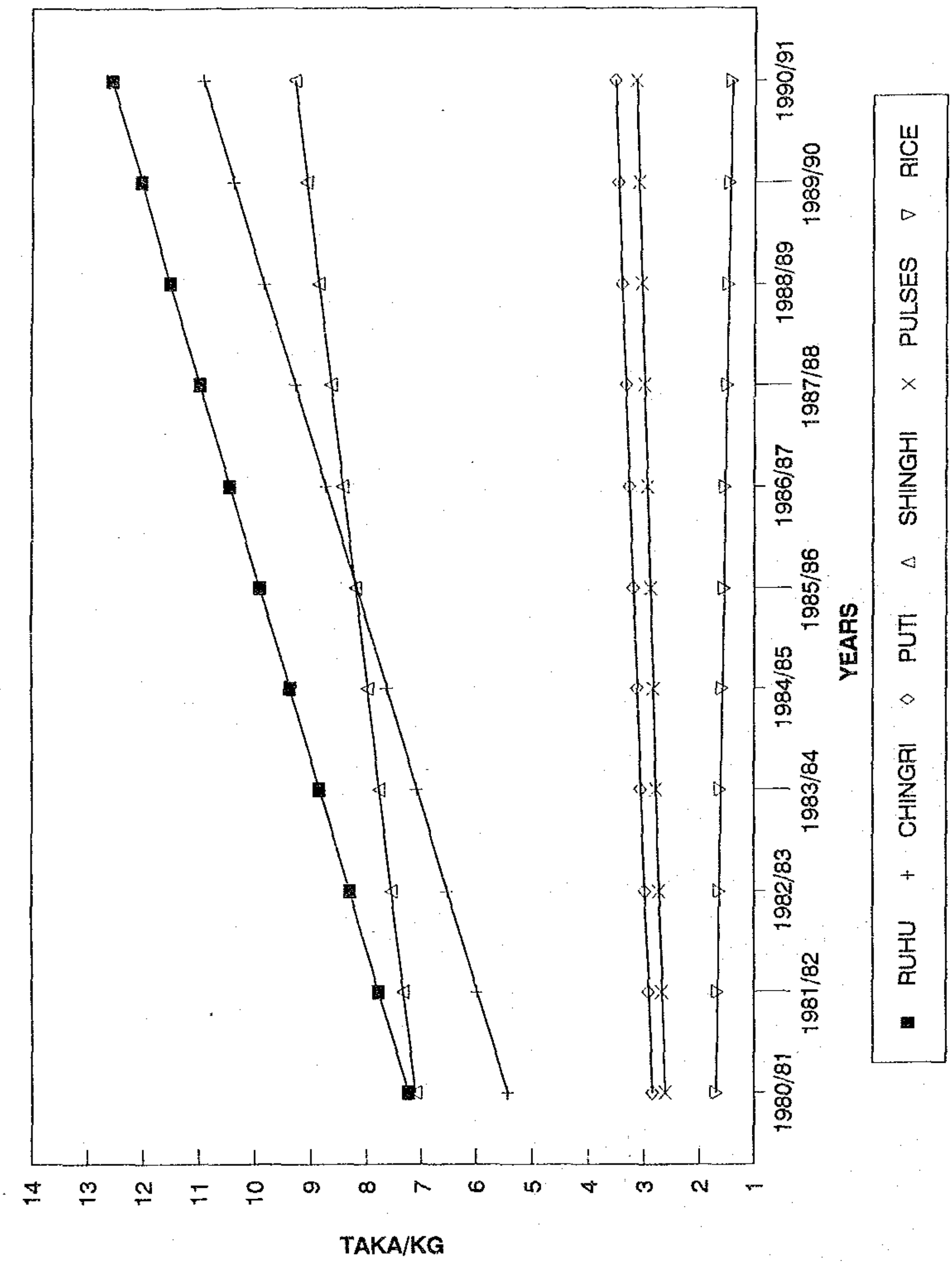
There are no readily available perfect substitutes for capture fisheries. Although culture fisheries can increase output of certain species, the costs involved in completely making up lost output would be enormous. In addition, capture fisheries are part of the natural resource stock of the country, and any intervention which results in depletion of the stock should not be reflected only in terms of loss of the stream of income, but also in terms of loss of the capital stock itself.

Taking the above factors into account, it was decided that fish output in the economic analysis would be valued on the basis of 25% increase in real market prices. This higher market price was then deflated by the SCF of 0.88 to derive the economic price. This premium was applied equally to capture and culture fisheries. It is felt that this adjustment is clearly justified by current trends, and it is interesting to note that, for example, the World Bank applies a scarcity premium in the pricing of projects relating to tropical hardwoods.

Sensitivity analyses have been conducted excluding this premium, and these analyses show that project viability is not significantly affected. It is felt, however, that applying a premium recognises the real possibility of a serious decline in fish stocks if current trends continue.

Figure 6.1

Trend of Real Prices of Rice, Fish and Pulses in Rajshahi



Source : Estimated from BBS (GOB).

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Table 6.8 Nominal and Real Retail Prices of Fish Rice and Pulses in Rajshahi (Tk.)

Year	NOMINAL PRICES						72-73 GDP Deflator	REAL PRICES					
	Ruhu	Chingri	Puti	Shingi	Pulses	Rice		Ruhu	Puti	Chingri	Shingi	Pulses	Rice
1980/81	25.12	16.92	9.25	22.3	9.75	5.05	3.26	7.72	2.84	5.20	6.85	2.99	1.55
1981/82	26.09	22.79	10.71	24.33	11.73	6.2	3.67	7.11	2.92	6.21	6.63	3.20	1.69
1982/83	30.82	23.43	10.84	27.16	9.9	6.9	3.85	8.00	2.81	6.08	7.05	2.57	1.79
1983/84	40.72	26.44	11.45	37.31	10.28	7.23	4.49	9.08	2.55	5.89	8.32	2.29	1.61
1984/85	42.14	30.22	14.2	37.14	10.66	8.24	5.15	8.18	2.76	5.86	7.21	2.07	1.60
1985/86	65.33	45.67	26.01	51.02	14.78	7.4	5.45	11.99	4.77	8.38	9.36	2.71	1.36
1986/87	66.23	77.4	20	59.8	19.61	9.75	5.98	11.07	3.34	12.94	9.99	3.28	1.63
1987/88	68.33	76.64	21.16	64.3	21.2	10.79	6.64	10.29	3.19	11.54	9.68	3.19	1.62
1988/89	76.46	67.42	22.3	62.29	21.8	10.77	7.15	10.69	3.12	9.43	8.71	3.05	1.51
1989/90	92.38	71.9	27.25	60.66	24.05	10.35	7.70	11.99	3.54	9.33	7.87	3.12	1.34
1990/91	104.12	73.8	26.72	69.5	26.9	11.34	8.08	12.89	3.31	9.14	8.60	3.33	1.40

Source:BBS,Monthly Statistical Bulletin Various Issues

6.3.3. Environmental Impacts

Other environmental impacts have generally not been valued in monetary terms. While it has been intended to value as many impacts as possible in the cost-benefit analysis, the nature of the data available made it difficult to do so. In addition, it was felt that potentially important components such as navigation and health should be the subject of more in-depth studies in the next stage, which would be able to look at issues on a sub-regional basis, rather than any piecemeal analysis being done at this stage which might well understate the importance of these components.

Similar reasoning applied to the evaluation of the wetlands, particularly Chalan Beel. The information collected at this stage now needs to be integrated with other work, e.g. by FAP 16 and FAP 17, and carried to a more detailed level of analysis. The work conducted in this study provides an important baseline for future work. Nonetheless, the economic analysis of the Lower Atrai as a system allowing extensive flows through it is itself some indication of the practical value of the wetlands system in that area.

A further small survey was conducted in the Lower Atrai to attempt to determine the economic value of natural products from the Chalan Beel wetlands system. The study focussed on landless households and estimated a household's average annual net income purely from use of natural resources to be over Tk2,000 (in terms of money earned or saved). It is felt that this is only a small portion of the benefits which could be attributed to the wetland system.

A sensitivity analysis of reductions in natural soil fertility due to embanking was conducted in one area (Polder C). This had no impact on the rate of return, but may be important in the longer-term: again, data on long-term processes were not available to extend the scope of the economic analysis.

6.3.4 External and Downstream Impacts

Many previous plans for flood control projects have neglected external and downstream impacts: this neglect has in some cases contributed to subsequent failure of a project, as those adversely affected outside the scheme are forced to cut the embankment to reduce damaging water levels: much of the Lower Atrai suffers from this essential neglect of integrated planning.

A major justification for the FAP regional approach is precisely the need for integrated analysis of flood control measures. The planning work of FAP 2 has been explicitly aware of the need for avoiding adverse external impacts where possible. One example of this has been the adoption of a planning principle by which any development should, if possible, not add to discharges downstream. Another example has been the planning for the Lower Atrai on a basin-wide level, aided by a hydrodynamic model which can be used to analyse the impact on water levels throughout the basin of any proposed structural development.

In terms of implications for the economic analysis, the planning approach adopted has either specifically excluded some downstream effects or internalised them, i.e. they are part of the analysis because of the way the planning area has been defined. For example, the analysis of the Lower Atrai basin includes impacts in Bogra Polder 4, an area for which no development is planned but where water level changes as a result of upstream developments do have an impact. In analysis of the Upper Karatoya/Bangali Floodway, the impact in terms of reduced damage downstream has been included.

In terms of external impacts, the likelihood of continued public cuts in areas such as Chalan Beel Polder D has been taken into account by scaling down the expected damage reductions that will occur with development. The analysis in Polder D reflects the utility of the hydro-dynamic model in also capturing the impact of developments external to the project being considered, as well as the external impact of projects being proposed (in this case, the imminent completion of the Barnai project will raise water levels to the west of Polder D).

In summary, to a large degree external and downstream impacts have been included in the analysis, and the minimisation of negative effects has been made an explicit goal of planning.

6.4 Estimation of Non-Agricultural Benefits

6.4.1 Damage to Infrastructure and Property

The significant damage to infrastructure, private and public property due to major floods was amply demonstrated in 1987 and 1988. Avoidance of such damage is therefore potentially an important benefit of flood control.

Quantification of such damage is difficult, but an attempt has been made to derive figures which should be of the correct order of magnitude. Detailed data on non-crop damage exist principally for 1987 and 1988. In addition, the 1989 Prefeasibility Study for Flood Control in Bangladesh (carried out by GoB with funding from France) gives data for 1985 and 1986. There are, therefore, four years' data to use in making estimates of expected annual damage avoided. This is not adequate, and a different approach had to be used, as described below.

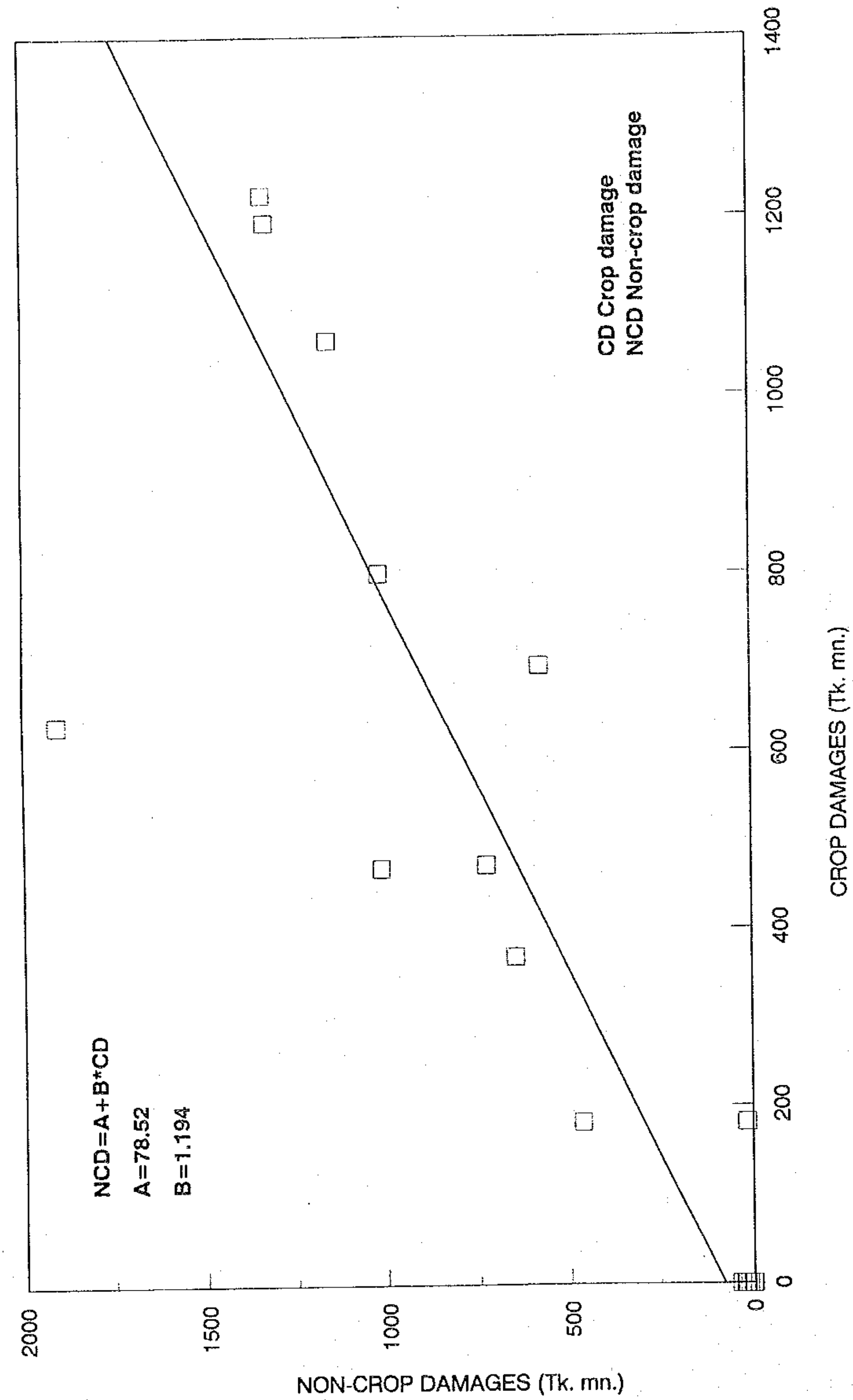
Initially, a detailed analysis of damage figures for 1987 and 1988 was undertaken. Damage assessment reports were collected showing the value of damage to roads, embankments and bridges under BWDB (1987 and 1988), LGEB (1987 and 1988) and R & H (1988 only). Additional data were collected for the following sectors: energy, industry, sugar, health, education, telecommunications, infrastructure, housing and livestock. Data on the last three sectors were available in the GoB/French Consortium Flood Study referred to above. The other data were collected from the Planning Commission and respective State bodies. The sectoral breakdown by Old District is shown in Table 6.9.

The data collected by this study were combined with the data from the GoB/French Consortium Study to give a fairly comprehensive coverage of non-crop damage by Old District for 1985-88. As noted above, four years' data are insufficient to derive a flood damage - frequency curve, so the following method was used.

First, a statistical relationship were derived between crop damage and non-crop damage using the pooled cross-section and time-series data (i.e. five Districts over four years, twenty pairs of observations). It is reasonable to suppose that there is a relationship between crop damage and non-crop damage, particularly in years with high floods. Fig. 6.2. shows the derived linear relationship.

Next, this relationship was used to derive non-crop damage data for the years 1971-84 based on the crop damage data for those years. This gave a data series for non-crop damage for the period 1971-88, from which non-crop damage - frequency curves and expected annual damage were estimated.

Figure 6.2
Crop and Non-Crop Damages
Annual Values for 1985-88



Source : NWRS

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Table 6.9 Non-Crop Flood Damage by Old District, 1985-88 (Tk. Million)

1988

District	Education	Health	Industry	Telecom	Sugmills	Railway	Energy	Other	Dwelling	LGEB,R&H	Total
Bogra	42.89	67.87	58.00	8.14	3.30	42.12	6.59	34.20	89.30	660.75	1013.17
Dinajpur	71.45	28.67	119.33	11.84	30.53	12.79	7.49	49.59	61.60	252.99	646.28
Pabna	132.71	55.76	342.67	17.62	0.00	225.57	5.39	94.69	268.01	761.54	1903.96
Rajshahi	77.25	148.69	282.70	12.60	11.25	0.77	2.35	25.53	58.25	391.35	1010.74
Rangpur	96.10	122.32	282.89	15.86	59.71	307.03	20.04	72.15	74.45	274.37	1324.90
NWRS TOTAL	420.41	423.30	1085.60	66.06	104.78	588.28	41.86	276.16	551.61	2341.00	5899.05

1987

District	Education	Health	Industry	Telecom	Sugmills	Railway	Energy	Other	Dwelling
Bogra	223.90	23.90	20.80	62.70	10.50	139.50	36.73	58.00	576.03
Dinajpur	112.50	5.90	10.50	51.80	22.30	80.75	61.18	119.33	464.26
Pabna	72.90	0.00	58.80	17.00	10.20	118.45	104.55	342.67	724.57
Rajshahi	216.70	99.00	59.30	138.20	2.50	213.30	140.86	282.70	1152.57
Rangpur	416.00	91.40	11.10	171.30	15.10	154.50	190.24	282.89	1332.53
NWRS TOTAL	1042.00	220.20	160.50	441.00	60.60	706.50	533.56	1085.60	4249.96

1986

District	Education	Health	Industry	Telecom	Sugmills	Railway	Energy
Bogra	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dinajpur	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pabna	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rajshahi	0.19	0.21	5.22	15.75	0.15	0.00	21.52
Rangpur	0.91	0.00	0.32	0.00	0.75	0.00	1.98
NWRS TOTAL	1.10	0.21	5.54	15.75	0.90	0.00	23.50

1985

District	Education	Health	Industry	Telecom	Sugmills	Railway	Energy
Bogra	0.75	0.00	0.00	0.00	0.00	0.00	0.75
Dinajpur	20.49	0.00	0.00	0.00	0.00	0.00	20.49
Pabna	32.61	0.00	0.00	0.00	0.00	0.00	32.61
Rajshahi	12.48	0.11	0.15	0.54	0.00	0.00	13.28
Rangpur	15.28	0.02	0.00	0.00	1.05	0.00	16.35
NWRS TOTAL	81.61	0.13	0.15	0.54	1.05	0.00	83.48

Source: NWRS estimates, based on data from GoB Departments, and GoB/French Consortium Study

Table 6.10. gives the resulting figures.

The next step was, as for crop damage, to disaggregate the Old District-level data by thana and project area. Since no data for non-crop damage existed at thana level, it was decided to apply the same weights as were used in the crop damage disaggregation. This simplification is reasonable given that a relationship between crop damage and non-crop damage has been shown to exist.

Comparison of the damage data for crop damage and non-crop damage shows that non-crop damage values are greater, by 10-20% in Bogra, Rajshahi and Rangpur old Districts, and by more than 100% in Dinajpur and Pabna Districts. This pattern appears logical: the greater proportionate damage in Dinajpur reflects the low level of crop damage there in normal years, while the high degree of damage in Pabna reflects specific damage to the Bogra highway and the BRE itself by flood water entering through breaches in the BRE.

Table 6.10 Estimated Average Annual Non-Crop Damage Avoided by Flood Protection by Old District (Tk. Mn, 1991-92 Price)

Districts	Return Period				
	1:5	1:10	1:20	1:50	1:100
Bogra	92.0205	104.907	111.1143	115.918	117.128
Dinajpur	61.71	70.18	74.173	77.319	78.166
Pabna	160.446	179.322	188.276	195.294	196.988
Rajshahi	120.7338	134.7698	141.4974	146.7246	148.0314
Rangpur	138.061	154.033	161.656	167.585	169.037

Source: Consultants' Estimate (see volume 13, Draft Final Report)

6.4.2 Other Non-Crop Benefits

Other possible benefits from flood control could include, for example, reduction in human suffering and discomfort, and increased mobility along embankments. As noted above, an attempt was made to collect data relating to health costs and supply of relief materials as an indicator of human suffering, but the data was too incomplete to allow inclusion in the analysis. The benefits of major embankments in providing settlement for landless and displaced families are recognised, but it is difficult to imagine that embankments would be built actually to serve that purpose. Indeed, embankments on both sides of a river can cause a confining effect which might itself force those living outside the embankments to move: therefore embankments can cause displacement as well as provide a solution for it.

In regard to increased mobility, this benefit is considered to be rather small, and usually less significant than the disbenefits caused by disrupting navigation routes. In areas of generally medium-high land, embankments often run parallel to pre-existing rural roads which already provide adequate access. In low-lying areas with fewer roads the integrity of the embankments can rarely be totally maintained, thereby reducing their potential role as a means of communications. It seems reasonable to conclude therefore that these potential benefits are in practice generally not very large, and can be excluded from the economic analysis.

6.5 Cost Estimates

6.5.1 Financial Cost Estimates

Financial cost estimates for the various options were worked out in general accordance with the FAP design and cost estimation guidelines". Pre-feasibility level designs were made for the options under consideration, and appropriate unit rates applied to them. Details of Financial costs are given in Volume 3, Regional Plan Engineering, of the Draft Final Report.

Costs were calculated for the following items;

- Direct construction cost,
- Administration cost,
- Physical contingencies,
- Engineering cost, and
- Land acquisition cost

The direct construction cost and land acquisition cost were estimated based on general type designs, while the remaining costs were estimated in proportion to construction cost. The ratios to the total direct cost were determined by each of the cost items as follows;

- Administration cost	:	3 % of the direct construction cost
- Physical contingency cost	:	25 % of the direct construction cost
- Engineering cost	:	15 % of the direct construction cost plus physical contingencies

In the regional planning, O & M cost is assumed to be proportional to the direct construction cost. The following rates are adopted for earthwork and structural work, respectively;

- Earthwork : 5 %
- Structural work : 3 %

Costs were estimated in foreign currency portion and local currency portion, respectively. All prices are adjusted for September 1992 (US$ 1.0 = Tk. 38.9 = Yen 123).

Unit rates of construction works were estimated from a variety sources including schedules of rates from official publication of BWDB, RHD, etc. as well as information from newly completed projects in Bangladesh. Unit rates of construction work were estimated through the analysis of unit rates of labour, materials and equipment required for execution of such work elements as embankment, excavation and other structural works. The basic rate for earthworks by labour-intensive methods was Tk. 69 per cu.m, which is significantly higher than standard BWDB rates. Estimated values of work elements were checked with the unit rates prevailing over the ongoing projects and other FAP studies completed.

Capital costs per hectare (NCA) range up to about Tk 12 000 per ha (apart from the expensive option of the major drains) for most of the options considered. This relatively low cost is because many of the projects are effectively rehabilitation projects. In the "green river" option costs per hectare reduce to as low as Tk 1700, which is because the proposed works are effectively stabilisation of the present situation.

O&M costs per hectare range from Tk 50 to about Tk 300 per annum for the full CFD options (again, except for the major drains, which have much higher costs). Absolute O & M costs are much more for those options with expensive river training works but many of the regional plan scenarios impact a large area (eg the Teesta Right Bank sealing) so that costs per hectare are still fairly low.

6.5.2 Estimation of Project Economic Costs

Capital Costs

Financial cost estimates for each proposed project were estimated as above for two alternative construction methods, mechanical and manual. In the regional planning economic analysis only the manual cost estimates were used (sensitivity analysis was carried out between the two methods for the Gaibandha project, and results are discussed in the Gaibandha report, Volume 5).

Economic capital costs were derived by breaking down the main forms of construction project into their basic cost items (labour, cement, bricks etc.), dividing each cost item according to local and foreign costs, and then applying the relevant conversion factor to the local element of costs. The outcome is a composite conversion factor which is then applied to the financial cost estimates. The composite conversion factors range between 0.66 for earthworks and 0.89 for structures.

The timing of economic capital costs, and proportions of expenditure in each year, are taken to be the same as for the financial costs: for most projects the construction period is 4 years, but for large projects it is 6-8 years.

O & M Costs

the annual economic cost of O&M has been derived as a proportion of the economic capital cost, using the following proportions:

- earthworks 5% of capital cost
- structures 3% of capital cost.

Costs of Land Acquisition

The economic cost of land acquisition is the value of production foregone from the land acquired. This was derived in the analysis by assuming that the "without project" cropping pattern for the project area would also have been grown on the acquired land. The net return from this land in economic prices was then calculated, and deducted from the benefits in each year.

6.6 Economic Analysis

6.6.1 Scope of Analysis

For every proposed project and scenario, three measures of economic viability have been calculated:

- net present value (NPV)
- IRR
- NPVR(1).

The NPVR is the appropriate economic measure to use when ranking projects, on the assumption that public investment funds are the major limiting constraint on investment. The NPVR(1) is defined as the net present value of all net benefits minus project costs (all in economic prices), divided by the public capital and O & M costs in financial prices.

Although the NPVR should be used for ranking on economic grounds, it is again emphasised that an overall assessment of a project's viability must include other factors which in reality can determine the success or failure of a project. For that purpose, the multi-criteria analysis, which incorporates the economic analysis and other factors, is the appropriate analysis to guide decision making.

In order to allow direct comparisons of projects, the analysis is made as if they could all be carried out at the same time, i.e. the same assumptions about yield increases, same sets of prices etc. are applied to all projects. In reality it is not possible to implement all projects during the same period, as is reflected in the plan phasing. Any future re-appraisal will therefore be dealing with a different set of conditions with respect to prices, yields etc., and may therefore produce different results, but clearly the current analysis can only be based on trends which are apparent now.

6.6.2 Results

Scenarios

(a) Lower Atrai

Results of the economic analysis and other analyses are shown in Table 6.11. The analysis for the Lower Atrai considered three basic scenarios, full FCD, full FCD with major drains, and "Green River". The first two analyses were conducted at the Interim Report stage.

Full FCD was analysed in the Interim Report as a series of projects (polder rehabilitation). Most of these showed theoretical high returns. However, it appears to be not possible to attain full FCD conditions in the Lower Atrai, and therefore the full FCD analysis was not considered as a feasible scenario. The IRR of the full FCD scenario is 24% but, as noted here, this return is not felt to be attainable in practice.

Full FCD with the major drains was analysed as a scenario for the Lower Atrai. The Diversion Drain, draining out into the Ganges, and the Interceptor Drain, draining to the Jamuna, were analysed in terms of their impact on the Lower Atrai. The Diversion Drain had an IRR of 2% and the Interceptor Drain a negative IRR. The very high costs of these developments made them clearly infeasible and they have not been analysed further.

The analysis for the Lower Atrai during the final stage of planning has therefore focused on the "Green River" scenario. This essentially comprises a combination of FCD set much further back from the river, and flow areas close to the river. These proposals have been analysed for every sub-unit of the basin, and then in overall terms. The general approach appears to be economically viable as well as having benefits in terms of reducing social conflicts induced by major differences in water levels inside and outside the polders. The IRR of the Lower Atrai basin as a whole is 21%. Benefits comprise some increases in HYV t. aman in the FCD areas, and some increases in deepwater aman and fisheries in some of the flow areas. There are also benefits in terms of damage reductions. Conversely, disbenefits are relatively small.

(b) Upper Karatoya

The Upper Karatoya scenario is primarily intended to address development in the lower part of the Upper Karatoya basin, where crop and non-crop damage can be quite significant. Different options were considered for the area but the option to be analysed involves full FCD works on both banks of the Upper Karatoya, and construction of a shortened interceptor channel, the "Bangali Floodway", to discharge flows out to the Jamuna, leaving a residual flow to go down the Bangali River. The Bangali Floodway was analysed on its own merits but also following the planning principle that increased discharges should not be passed downstream.

Table 6.11(a) Economic Analysis of Scenarios

	Lower Atrai Full FCD	Lower Atrai Major drain	Lower Atrai Gr. River	Up. Karatoya (Bangali F.way)	Gaibandha (incl. Teesta RB)	Teesta LB (B'water Embkt)	L. Jamuna R. Bank	Mohananda 20 Year
Net Cultivable Area(ha)	382756	382756	355692	(180000)	(197780)	51021	9500	15073
Total Cost (Tk '000)	4161000	16023000	1498010	2182147	1670080	452397	33584	159418
O&M Cost (Tk '000)	133000	480000	47138	57802	42619	13033	898	4088
IRR(%)	24%	2%	21%	5%	10%	9%	16%	5 %
NPVR(1)	+1.02	-0.5	+0.42	-0.27	-0.02	-0.06	+0.16	- 0.27

Table 6.11(b) Economic Analysis of Lower Atrai Projects

	Polder 2 Gr. River	Polder 3 Gr. River	SIRDP Gr. River	Hurasagar S Gr. River	Polder A Gr. River	Polder B Gr. River	Polder C Gr. River	Polder D Gr.Riv	Hurasagar N CFD	Hurasagar S CFD
Net Cultivable Area(ha)	52089	55578	64275	6225	27716	29411	42498	52650	25250	6225
Total Cost (Tk '000)	223589	98270	153704	63145	159171	162901	163184	239466	226281	86804
O&M Cost (Tk '000)	6156	2770	9115	1958	4622	4565	4431	7115	6456	2265
IRR(%)	24%	21%	35%	7%	14%	19%	15%	17%	- ve	21%
NPVR(1)	+0.8	+0.55	+1.61	-0.23	+ 0.1	+ 0.45	+ 0.15	+ 0.29	-0.58	+0.74

Benefits from the proposal include changes in cropping patterns on the Upper Karatoya left bank (increases in HYV t. aman) and reductions in damage on both the left and the right bank. Further damage reductions were expected downstream of the Bangali Floodway in the Middle Bangali planning unit. Although the main development to benefit this area would be the effective sealing of the BRE, crop and non-crop damage would still occur as a result of flooding greater than a 1:5 year return period. Therefore damage reduction benefits were included for the difference between a 1:20 and a 1:5 return period. Fisheries disbenefits are significant, with a 30% decline in the total value of fisheries output, but purely in value terms these disbenefits are far outweighed by the benefits.

The project is extremely costly, however, and on cost grounds it is clearly unviable. It is probable that Upper Karatoya developments without the Bangali Floodway would approach viability, but they would also worsen conditions downstream, and such developments have therefore not been considered in this analysis.

(c) Gaibandha

The Gaibandha scenario involves back protection works on the Teesta Right Bank, extension of embankments on the Ghagot river and division of the area into drainage sub-units of compartments to reduce drainage congestion in the basin. A regulator is also proposed on the Alai River at Manas its confluence with the Ghagot in order to divert Ghagot River flows out to the Jamuna.

Benefits from these measures include some changes in cropping patterns, considerable reductions in damage to crops and property and avoidance of significant erosion losses which would result if the Teesta River was not controlled. Some of these benefits accive outside the rpoject area and have also been indluded. The proposals have an IRR of 10%. Detailed description and analysis of the proposals is contained in the Gaibandha Feasibility Report.

(d) Teesta Left Bank

Earlier analyses for the Teesta Left Bank included river training works. Inclusion of such works resulted in a negative rate of return and therefore they could not be economically justified. Although erosion does occur on the left bank, the Teesta is not generally moving landwards on the left side, so that omission of river training works appears logical at this stage.

The remaining project, comprising a backwater embankment on the Sati River, a tributary of the Teesta, has an IRR of 9%. This reflects the fact that most of the land area is medium-high or high land, so that major cropping pattern shifts cannot be assumed. In addition, most damages occur as a result of overland flow from the north, and would only be partially alleviated by development on the Sati River. Fisheries disbenefits are highly significant, showing a projected decline of 62% in the value of total fisheries output.

(e) Little Jamuna Right Bank

This relatively small scheme is proposed to mitigate the specific problems of crop and non-crop damage north of Naogaon caused by spillages from the Little Jamuna. Costs are small and benefits have been assessed only in terms of damage reductions. Other benefits or disbenefits have not been considered. The project as analysed has an IRR of 16%.

(f) Mohananda

The Mohananda area is affected by spills from the Mohananda and backwater from the Ganges. The proposed project essentially involves rehabilitating and heightening an existing embankment. Mohananda has specific characteristics resulting from proximity to the Indian border: cultivation of t. aman is extremely low even where conditions allow it. Cultivation of HYV boro is also low due to groundwater constraints. Trade, including cross-border trade, is important, so that the area is relatively important for navigation. Opportunities for relatively high wage employment also exist, so that a significant labour constraint stands in the way of agricultural intensification. Under these circumstances, even where a major shift in flood phases can be brought about through flood control, it is not at all clear that there would be a major response in terms of increased farm output.

The result of analysis taking the above limiting factors into account is an IRR of only 5%.

Lower Atrai Projects

A detailed analysis of the sub-units within the Lower Atrai basin has also been made, although for future development purposes it is important that the basin continue to be considered in its entirety. A brief summary of the main points of the sub-unit analysis is nonetheless given here. Table 6.11(b). presents results of the analysis.

(i) The highest returns occur in the SIRDP area. These returns are a combination of many positive factors: increased crop production (particularly HYV t. aman), considerable reductions in crop and non-crop damage which at present are significant, and increases in fisheries output since SIRDP includes a large flow area. It should be noted, however, that many of these gains are contingent on sealing of the BRE and the re-opening of the Taras embankment.

(ii) Relatively high returns (above 20%) are found for Bogra Polders 2 and 3, Chalan Beel Polder B, and Hurasagar South. In all these areas increases in HYV t. aman are set against relatively low project costs. Fisheries disbenefits are quite significant in three of these areas, however, emphasising the general conflict between FCD and capture fisheries (the setting-back of FCD structures has reduced the extent of this conflict, however, and net fisheries benefits are found in some polders).

(iii) Areas with lower returns are Chalan Beel Polders A, C and D, and Hurasagar North (and Hurasagar South flow option). The reason for lower returns in Polders A and C is the smaller areas which are planned for full protection, and therefore the smaller changes in crop output that are forecast. In Polder D a further factor is the problem of high external water levels resulting from the completed Barnai project, which are likely to cause continued cutting of embankments and continued damage. At the same time, major fisheries disbenefits are predicted for Polder D.

(iv) Hurasagar can to some extent be considered separately, since it is not subject to the confinement effect experienced elsewhere in the basin. Hurasagar North appears to have low returns because sealing of the BRE would bring about the major improvement, and other measures would not result in significant cropping changes. In Hurasagar South, two options were considered. It is obvious that the option showing the higher returns is the FCD option since it has been established that if FCD can be made effective, it can in principle create the conditions for major increases in HYV t. aman production. Therefore, although the outcome between the two options is predictable, it is still not clear that FCD in Hurasagar South can be made to be more viable than it is at present.

This brief review of the individual polders in a sense underlines the reasons why such a piecemeal approach is undesirable. It is not valid to compare two interdependent areas and select between them solely on the basis of their relative rates of return: for example, the rate of return in Polder B is higher because of the measures in Polder C which make returns there lower; again, any failure of the system in Polder D will make returns in Polder C lower than predicted; and so on. It is essential to regard the Lower Atrai as an interdependent system and to look at the proposals for the basin as a single plan.

6.6.3. Sensitivity Analysis

A large number of sensitivity tests were carried out on the options/scenarios in the plan. These tests were of four types:

- to calculate "switching values" for different elements of the cost-benefit analysis (switching values are the % change in the value of a variable to bring the IRR to 12%);
- to test the particular role of rice prices in the viability of a project;
- to test the impact of two key assumptions made in the analysis, i.e. the assumption that crop yields would increase in future, and the assumption of a scarcity premium on the price of fish;
- to test the impact of other specific factors (only one such analysis is reported here, the effect of loss of natural soil fertility due to embanking).

The results of these tests are discussed and results of specific analyses are shown in Table 6.12.

(i) Change in net value of agricultural output with project.

All projects have been found to be quite sensitive to the level of agricultural benefits forecast in with-project conditions. Relatively small percentage increases in the area under HYV t. aman can have a large impact on project viability (an increase of only 100 ha. would be enough to increase the net value of output by Tk 1 mn). Increases in yields would also tend to increase benefits significantly. Conversely, relatively small decreases in net value can also significantly reduce project viability.

The sensitivity analyses to test this impact found that, particularly in the Lower Atrai where rates of return are not far above 12% in some cases, reductions of 1-5% in the net value of agricultural output with-project would reduce the IRR to 12%. For the Lower Atrai scenario as a whole, a reduction of about 2.5% brings the IRR to 12%.

The project with the lowest rate of return is the Upper Karatoya/Bangali Floodway development. In this case an increase in net value of output of 25% would be needed to make the project economically viable.

TABLE 6.12 SENSITIVITY ANALYSES FOR SCENARIOS AND PROJECTS

		BASE CASE	NO PREMIUM FOR FISH	NO CHANGE IN YIELDS	INCREASE RICE PRICE BY 20%	DECREASE RICE PRICE BY 10%	DECREASE RICE PRICE BY 20%
A. SCENARIOS							
LOWER ATRAI GREEN RIVER	IRR	21	21	18	23	20	16
	NPV	581	630	346	779	493	215
	NPVR	0.42	0.46	0.25	0.57	0.36	0.16
BANGALI FLOODWAY	IRR	5	5	4	6	4	3
	NPV	-388	-381	-450	-333	-426	-478
	NPVR	-0.27	-0.27	-0.32	-0.23	-0.3	-0.33
GAIBANDHA IMP. PROJECT	IRR	10	10	9	11	10	9
	NPV	-112	-113	-185	-66	-163	-217
	NPVR	-0.02	-0.02	-0.04	-0.01	-0.03	-0.05
TEESTA LEFT BANK	IRR	9	10	6	11	7	5
	NPV	-37	-26	-79	-12	-62	-90
	NPVR	-0.06	-0.04	-0.13	-0.02	-0.1	-0.15
MOHANANDA 20 YR	IRR	5	5	2	8	2	-ve
	NPV	-38	-39	-49	-27	-49	-61
	NPVR	-0.27	-0.27	-0.34	-0.19	-0.34	-0.43
B. LOWER ATRAI PROJECT AREAS							
BOGRA POLDER 2	IRR	24	24	21	26	22	19
	NPV	161	168	103	201	125	83
	NPVR	0.8	0.83	0.54	1	0.62	0.41
BOGRA POLDER 3	IRR	21	21	21	22	21	20
	NPV	49	45	48	52	46	43
	NPVR	0.55	0.5	0.54	0.58	0.52	0.49
CHALAN BEEL POLDER A	IRR	14	13	12	17	13	11
	NPV	15	10	1	42	5	-6
	NPVR	0.1	0.07	0.01	0.29	0.04	-0.04
CHALAN BEEL POLDER B	IRR	19	20	14	22	15	10
	NPV	66	76	14	105	29	-13
	NPVR	0.45	0.52	0.1	0.72	0.2	-0.09
CHALAN BEEL POLDER C	IRR	15	15	12	17	12	10
	NPV	23	27	2	42	2	-19
	NPVR	0.15	0.18	0.02	0.28	0.01	-0.13
CHALAN BEEL POLDER D	IRR	17	19	11	21	13	7
	NPV	63	101	-10	120	14	-44
	NPVR	0.29	0.46	-0.04	0.55	0.06	-0.2
SIRDP	IRR	35	35	34	36	35	34
	NPV	223	217	204	235	214	201
	NPVR	1.61	1.56	1.47	1.69	1.54	1.45
HURASAGAR NORTH	IRR	-ve	-ve	-ve	-ve	-ve	-ve
	NPV	-120	-120	-122	-118	-121	-122
	NPVR	-0.58	-0.58	-0.59	-0.58	-0.59	-0.6
HURASAGAR S. CFD	IRR	21	22	17	24	19	16
	NPV	57	62	30	76	40	19
	NPVR	0.74	0.8	0.39	0.98	0.51	0.25
HURASAGAR S. GREEN RIVER	IRR	7	7	4	8	5	4
	NPV	-15	-15	-20	-12	-18	-21
	NPVR	-0.23	-0.24	-0.31	-0.18	-0.28	-0.33

Notes:

1. Base case includes premium on fish price of 25% deflated by SCF=.87

2. No fish price premium: market price deflated by SCF=.87

3. No increase in yields: future yields assumed the same as present yields

4. Changes in rice price, e.g. 20% increase in market price, deflated by converstion factor = .88

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(ii) Change in capital + O & M costs.

Conversely, projects are not very sensitive to large changes in construction and O & M costs (these two variables were considered together since they are positively related). It would require an increase in costs of 90% to reduce the IRR on the Lower Atrai scenario to 12%. Conversely, a reduction of 65% would be required to make the Bangali Floodway viable.

No other sets of switching values are reported here, since other factors - delays in implementation time, delays in the stream of benefits etc.- appear to have little influence.

(iii) Import parity pricing for rice.

The recommended economic valuation of paddy production now uses the mean of the import and export parity prices, to reflect the situation of near self-sufficiency which has developed. It is possible that in the future import parity pricing may again be appropriate, which would result in a higher economic value for paddy. This sensitivity analysis considered the impact of import parity pricing. The FAP Guidelines for Project Assessment derive a conversion factor of 1.02, but a more appropriate figure appears to be 1.19. Sensitivity was conducted with both conversion factors. The Teesta Left Bank project was tested: the base case IRR of 9% increased to 15% with the 1.19 conversion factor, and to 12% for the 1.02 conversion factor. The Bangali Floodway was also tested: the base case of 5% was increased to 8% with the higher conversion factor, and 6% for the lower factor.

The changes in rate of return are moderated since the different conversion factors would boost without-project net benefits as well as with-project benefits.

(iv) Change in farm-gate price of price

Table 6.12 shows the impact of changes in the farm-gate price of paddy (using the conversion factor of 0.88 to derive the economic price). Major (20%) shifts in price do have a significant impact on the rate of return of all except the largest investments. Nonetheless, the Lower Atrai Green River scenario remains viable even with a 20% decrease in prices.

(v) No increase in future yields

In the main analysis, it has been assumed that future yields would be higher than at present (see section 6.2.2). If this assumption is dropped, the sensitivity analysis indicates a relatively significant decline in rates of return, of a similar magnitude to the impact of a 10% decline in farm-gate prices of rice.

(vi) No scarcity premium for fish prices

In the main analysis, it has been assumed that future fish prices will increase in real terms (see Section 6.3.2). If this assumption is dropped, the sensitivity analysis generally indicates no significant change in rates of return. The largest change occurs in Chalan Beel Polder D where, in the absence of mitigation measures, substantial declines in fisheries output are predicted.

(vii) Changing soil fertility.

The ecology report has highlighted the likelihood of loss of natural soil fertility if FCD embankments prevent any spillage of river flows onto the fields. The extent of such loss is not clear, but one sensitivity analysis was carried out to assess the impact of a 50% increase in use of nitrogenous fertiliser without any change in benefits. The analysis was carried out for Chalan Beel Polder C, and showed no change in the basic rate of return. This is not surprising since N fertiliser costs still form a relatively small part of total costs. However, such an increase may have important longer-term impacts.

CHAPTER 7

IMPACT ASSESSMENT

7.1. Approach to Planning

The impact assessment has followed the most recent version available of Guidelines for Project Assessment and Environmental Impact Assessment (FPCO/FAP 16). In May 1992 a new Environmental Policy was adopted by the GOB. This introduced new objectives into the scope of work under FAP. The policy directions given in relation to FCD/I projects are clear and are listed below.

- remove the adverse environmental effects of previous water resources management and flood control projects.
- adopt and extend environmentally and ecologically sound land use practices and conserve soil fertility.
- maintain ecological balance, conserve wildlife and biodiversity and conserve and develop the national wetlands and the migratory bird sanctuaries.
- protect, conserve and develop fish habitats.
- re-evaluate FCD/I projects known to cause adverse effects on fisheries.

However, there is little guidance as to the criteria by which these objectives are to be met.

7.2 Impact Assessment

The impact assessment summarises the overall effects of the Lower Atrai strategy and the regional projects. The economic analysis and regional planning time scale consider the short to medium term future under certain given conditions. The impact analysis complements these by assessing long term processes, a range of development trends, other risks and hazards and cumulative effects.

Table 7.1 summarises the physical, biological, human and development impact numerically. This presentation show the net incremental difference between the "future without" and "future with" situations to distinguish their differential effects. These impacts will occur against a backdrop of on-going trends in society and the natural world. Understanding these trends is important to judge if even small project-induced changes might cause critical thresholds to be exceeded.

The main purpose of the matrix used here is to highlight contrasts between the various tactical options. The matrix shows these differences adequately for most components. However, it does not represent the assessment of the final status after either interactions or potential mitigations have been accounted for. At this planning stage it is more important to arrive at a sustainable strategic approach. Details of mitigations will be the subject of future research and feasibility studies.

Table 7.1 Summary Analysis of Impacts within Target Areas - Lower Atrai Strategy and Regional Sub-Projects

IMPACT ISSUE/Important Environmental Component	Mohananda	L. Atrai		Hurusagar	Bengali Drain		Gaibandha		Teesta R.B.	Teesta L.B.	
	1	1	2	1	1	2	1	2	1	1	2
PHYSICAL RESOURCES											
Flood Frequency/Duration	+4	+1	+1	+3	+4	+2	+1	+4	+4	+1	0
Drainage Conditions	-2	-1	-1	-2	+3	-3	+1	+4	+2	-2	-2
Morphological Change	0	0	0	0	0	0	-1	0	+2	+2	+2
Seasonal groundwater availability	-1	0	0	-2	-4	-2	-1	-1	-1	0	0
Water Quality	-2	0	0	-2	-3	-2	-3	-4	-1	-2	-2
Soil Quality	-2	0	0	-2	-2	-2	-2	-2	-2	-1	-1
Disposal of Construction Spoil	-1	0	0	-1	-5	0	0	0	-1	-1	-1
BIOLOGICAL RESOURCES											
Diversity Terrestrial Species/Habitats	-1	-1	-1	-1	+4	+3	-1	-1	-1	-1	-1
Diversity Aquatic Species/Habitats	-1	-1	-1	-1	-1	-1	-1	-1	-2	-2	-1
Habitats for Threatened Species	-1	0	-1	-1	-1	-1	-1	-1	-2	-2	-1
Pest and Disease Levels	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
Wetland Functions and Productivity	-2	-1	-1	-3	-4	-4	-1	-1	-4	-4	-3
SUSTAINABLE RESOURCE USE											
Crops and Livestock	0	0	0	-1	-1	-1	-1	-1	-1	0	0
Fuel and Energy	0	0	0	0	0	0	-1	-1	0	0	0
Capture Fisheries	-1	-1	-2	-2	-2	+5	-2	-2	-2	-2	-1
Cultural Fisheries	+4	+1	+2	+2	+4	+4	+3	+3	+4	+2	0
ECONOMIC EFFECT											
Construction Employment	+2	+3	+4	+3	+5	+5	+2	+3	+4	+3	+4
Farm Income & Employment	+3	0	0	+2	+3	+3	+4	+4	+3	+2	+2
Fishery Income & Employment	-2	0	-1	-2	-2	-1	-3	-3	-3	-3	-2
Navigation Income & Employment	-3	0	-1	-2	-4	-4	-1	-1	-3	-3	-2
Income & Employment for Landless	+5	0	-1	+2	-2	-1	+2	+4	+5	+4	+4
Equity	-4	-1	-2	-4	+4	-4	-1	-1	-1	-1	-1
INFRASTRUCTURE											
Road Networks	+3	+1	+2	+3	+3	+3	+1	+2	+3	+3	+4
Navigation Networks	-4	-1	-2	-3	-3	-3	-1	-2	-3	-2	-2
SOCIAL EFFECT											

IMPACT ISSUE/Important Environmental Component	Mohananda	L. Atrai		Hurusagar	Bengali Drain		Gaibandha		Teesta R.B.	Teesta L.B.	
	1	1	2	1	1	2	1	2	1	1	2
Community and Family Cohesion	-4	0	-2	-4	-4	-4	+3	-3	-3	-3	-2
Minority Groups	-4	0	0	0	0	0	0	0	0	+2	+2
Attitudes to Flood Risk	+4	0	+1	+3	+3	+1	+5	+5	+4	+1	+1
Access to Flood Survival Strategies	-2	0	+1	0	+1	+1	+3	+3	+3	+2	+1
Land Acquisition/Displacement	-4	2	-3	-3	-4	-4	-2	-3	-3	-3	-3
HEALTH AND NUTRITION											
Nutritional Disorders	-1	0	-1	0	-1	-1	-1	-1	-1	-1	-1
Water Related Diseases	-3	0	-1	-4	+3	-3	-2	-5	-5	-4	-5
Sewage and Sanitation	-3	0	-1	-3	-3	-3	-2	-4	-3	-3	-3
INSTITUTIONAL											
Public Participation	-3	+4	0	-3	-3	-3	+4	?	-3	-3	-4
Institutional Complexity	-3	-1	-2	-3	-3	-3	0	-4	-3	-3	-3
HAZARD DAMAGE											
Design Criteria Floods	+3	+4	+4	+3	+4	+4	+4	+4	+4	+4	+4
Exceptional Floods and Disasters	-1	0	0	-1	-1	-1	0	0	-1	-1	-1
Drought (field crops)	-2	0	0	-1	-4	-3	-1	-1	-2	-1	-1
Liquefaction	-2	-1	-3	0	0	0	0	0	-4	-3	-3

+1 = Slightly Beneficial, +2 = Somewhat Beneficial, +3 = Beneficial, +4 = Very Beneficial, +5 = Highly Beneficial, 0 = No Response or Effect Detectable
-1 = Slightly Negative, -2 = Somewhat Negative, -3 = Negative, -4 = Very Negative, -5 = Highly Negative,

Mohananda 1 = 1:20 Year CFD Embankments
Lower Atrai 1 = Green River and Partial Protection; L. Atrai 2 = Green River with Max. Feasible CFD
Hurusagar 1 = 1:20 Years CFD Embankment (N.B. Option included in L. Atrai Green River)
Bengali Drain 1 = Drain with Full Excavation; Bengali Drain 2 = Drain without Excavation
Gaibandha 1 = 1:20 Year CFD without Drainage Compartments; Gaibandha 2 = 1:20 Year CFD with Drainage Compartments
Teesta R. Bank 1 = 1:50 Year CFD, River Training and Regulators (N.B. option = "do nothing")
Teesta L. Bank 1 = 1:20 Year CFD, River Training and Regulators; Teesta L. Bank 2 = 1:20 Year CFD, River Training and Backwater Embankment

N.B: (Matrix measures absolute difference between the "future with" and "future without" impacts only for the target area. Serious external issues affecting policy decisions are shaded) worse than an unimpeded system.

7.3 Physical and Biological Impacts

7.3.1 Geomorphology

The most critical physical impacts will be natural processes that affect risk and hazards. Morphological change on the inside of protected areas is not believed significant in selecting between options. However, morphological change in the major rivers (particularly if associated with seismic events) will be highly significant. The dynamic nature of the river morphology, and the range of seismic events that will occur within the period being planned for, poses serious risks of system failure. A system failure will cause considerable damage and create an risk of loss of human life greater than that if there were no embankments. This risk will be greatest in areas of deeply flooded land.

The removal of the existing Manos regulator, and the Bangali Floodway would open these channels to the Brahmaputra. The risks of capture of the Brahmaputra down the Alai or the Bangali would have major implications for the basic fixed conditions assumed for planning these and other downstream sub-regions (i.e. the BRE remains sealed and in its current course).

There is a high probability that the Brahmaputra could break through to the Bangali river within the short term future (< 5 years). It is not clear that the FAP 1 priority programme can avert this particular risk given the short time period involved. In this event a reappraisal would be required of the conditions of the Middle and Lower Bangali and the Hurusagar project, in particular. This would suggest that investments in these areas should await the physical outcome of the FAP 1 works and Confirmation that the break-through of Brahmaputra can be prevented.

7.3.2 Access to and quality of Water

Problems already exist from the too-rapid draw down of dry season groundwater tables in some areas. These affect village hand pumps and some manual irrigation methods. CFD can limit recharge to higher land or increase the rate of drainage. However, tubewell irrigation abstraction is the main cause of the draw down affecting these higher lands. The main areas affected are currently in the Barind Tract and the Mohananda and Lower Atrai basins.

Replacement of village pump technology are strategies that would be a legitimate mitigation for flood protection schemes to carry out. The resulting change in village water supply technology would also solve other health problems due to pollution of the hand pump water supplies. The Green River and water management concepts would provide the main hydraulic method of ensuring that recharge to higher ground and flushing of water bodies were maintained.

All the projects show a negative impact due to the changed drainage conditions behind embankments. Impeded drainage behind embankments will increase the likelihood that areas of stagnant water will result. In the case of the Teesta right embankment the reduction of flushing to the floodplains will have the same effect. A considerable mitigation and improvement can be made by the methods of water management, sanitation and public health programmes. If this is to be effective it will have to become an integrated programme in the future planning and operation of schemes.

The concept of compartmentalised drainage for the Gaibandha Improvement Project will need close monitoring since the logic is to cut off minor natural drainage lines. While modelling shows overall improvements to the flood conditions in most compartments, the detailed problems within compartments must be reviewed carefully in the detailed design stage. The final proposals will need to ensure that conditions for the spread of malaria and cholera or poor sanitation do not occur. A similar joint approach would also be required for the Teesta Left and Right Bank project impact zones and for the areas impacted by the Bangali Floodway.

The surveys of this study do not suggest that pollution of groundwater and water bodies from agro-chemicals and fertilisers is a current problem. There is some evidence of low background levels of pesticide in water bodies and DDT accumulation in the food chain do exist. However, the continued use of DDT causes cumulative impacts, and if more intensive use of agro-chemicals were to increase, it emphasises the need for proper monitoring capacities and the need to encourage integrated pest management systems.

7.3.3 Soil Quality

Localised problems for soil quality developing as a result of CFD and irrigation could occur to varying degrees in all project areas. While the net affects have been recorded as potentially negative the number subsumes a complex range of issues. The impacts in the matrix range between a "no net impact" in the Lower Atrai, where the most likely strategy would leave the soil system essentially unchanged from the present, to a "somewhat negative" change in areas where more intensive terrestrial agriculture would result from new embankments, drainage or intensified irrigation. The Teesta left bank would be less affected, since little improvement in flooding conditions from overland flow is likely.

No intervention appears to risk provoking major problems that would compromise future development possibilities. However, irreversible changes to the role of wetland functions would result if the traditional approach to flood protection were adopted. Within a new approach, based on integrated land and water management, this could be either significantly mitigated or, avoided. The actual outcome will depend on whether the future operational strategy actively plans to maintain the advantages of floodplain process. More basic research into wetland and agro-ecological processes is required to help detail the specific requirements for individual project areas and how they might enhance the sustainability of the production systems.

7.3.4 Biological Resources

Successful CFD developments would lead to a notable shift in favour of terrestrial habitats and species. How this is managed would determine its ultimate value. If transformed to rice mono-cropping agricultural lands, this would encourage well-adapted rice field and storage pests, and the net result could be increased crop and storage damage from pest epidemics. If managed to enhance the diversity of habitats and economic products a different pattern could emerge. The most significant adverse effects would be the loss of the remaining wetland functions and processes upon which many important survival strategies, livelihoods and the quality of life still depend.

The Bangali Floodway and the Teesta right embankment would be the most influential at a regional level. Smaller projects would be as influential, but at a localised level. The effective sealing of the BRE would also affect a significant area of floodplain wetlands in the Lower Bengali-Karatoya floodplains which has already been impacted ever since its first construction. This impact is not part of this study but comes under FAP 1.

Recent history has witnessed sweeping alterations to the structure and distribution of the natural communities of macro flora and flora that were once characteristic of the aquatic and terrestrial landscape of the NWR. Centuries of human intervention and management have already seen the environment go through many alterations. The contemporary episode involves an unprecedented change in the rate of resource use and habitat alteration transformed into the farming, floodplain and homestead systems that prevail today. The once diverse flora and flora formed an intricate web of natural resources used throughout the life styles and life support systems of local communities. These survival strategies have been fundamentally affected and will continue to be so.

The continued elimination of habitats that were once common, but that are now highly specialised and at risk, should be a major source of concern. The projects contained within the regional plan will each contribute cumulatively to the continued loss of the few important habitats that remain to support the species diversity.A few vital sites showing the original aquatic floral and faunal diversity do remain. The surveys of this study confirmed remnant floral and faunal wetland sites in the Lower Atrai both in the deeply flooded regions and in at least one permanent beel in Chalan Beel D. A number of threatened species were identified in the wetlands behind the BRE, as well as along the main riverine and charland zone of the Padma and Brahmaputra. Secondary sources indicate the potential importance of the differing aquatic habitats of the far north-west and the Teesta river and floodplains.

To assess the needs and options for this would require a special properly resourced study to specifically survey, assess, zone and plan for these areas. The limited areas identified by this study do have special significance for the nation's approach to developing protected area networks, wetland management areas and establishing a comprehensive genetic conservation programme. These habitats should receive special attention if their future genetic and economic potential is not lost altogether. These are often sites where the issue is the absolute and final disappearance of a biological resource with unquantifiable economic costs to future generations. Valuation based on their present conversion to achieve benefits for rice production are thus irrelevant to the decision-making on whether these areas should, or should not, be developed and how.

Of particular importance will be those species or groups and their habitats which are responsible for maintaining major ecological processes. Fish are important for recycling floodland residues benefiting both aquatic, terrestrial and human communities. Others may well be responsible for maintaining the pollination of economically important trees.

The issue of conservation of genetic and wetland resources involves many strategic issues that are of local, national and international concern. They will need to be addressed in the decisions on the future path of water development and management in the NWR. Whether it is acceptable to loose the final remnants, and to ask future generations to rely solely on that which replaces it, is not a question that this study can answer. Bangladesh is now a signatory to the Ramsar Convention and has an environmental policy to deal with these issues. Various considerations and options are provided for discussion and further research in the environmental management plan.

To resolve some of these problems will require developing proper research and monitoring system. It will also require the FAP and the national ministries involved to urgently clarify whether these issues are important or not, and to lay down clear guidelines for future planning, project design, wetland responsibilities and accountability.

7.4 Economic Impacts

The main economic effects are envisaged to derive from changes to the income and employment status of communities of farmers, fishermen, boatmen and landless. All these features are directly valued in the economic analysis and summarised in the multi-criteria analysis (Chapter 8).

The main short-term employment effect will be for construction where Labour Contracting Societies and the landless can be expected to reap significant benefits. The largest contracts will be on the works for the Bangali Floodway, the Teesta right embankment and the rationalising of the Lower Atrai system. Other projects would be of more local significance.

The main beneficiaries from an effective CFD scheme without public cutting would be the farming communities with land, and the seasonal migrants labourers who work for them. Under the fixed conditions of the analysis this would appear to derive to the providing full protection schemes. The history of the existing Chalan Beel polders gives every indication that most of these benefits could not, in fact, be achieved. This approach is, therefore, unlikely to be sustainable or socially acceptable, as evidenced from the rounds of public participation.

The issue of equity has been shown by the FAP 12 evaluations to be both complex, but also, in most cases, negative. This is mainly attributed to the lack of mitigation undertaken for dis-advantaged groups and the losses which take place in the impacted areas outside of the schemes. Other effects include the take-over or monopolising of land, water and infrastructure by the more influential and the larger landowners. The most serious inequalities would likely result from the full CFD options for Mohananda, Hurasagar and the Bangali Floodway projects.

The status of economic infrastructure would be improved in areas where new embankments were and where work on existing road embankments improved their road worthiness. The Teesta left bank would have the greatest advantages for new access. In all cases, the traditional approach to drainage regulators would adversely affect small and medium-scale navigation networks, both on the inside and outside of projects. This has knock-on effects into reduced employment, disrupted marketing and higher cost transportation. Providing mitigation is not as simple as just costing in for the replacement of standard regulators with locks. Many critical network, marketing and servicing issues arise in proper navigation planning. This will require detailed study if CFD projects are to intervene and still try to mitigate. Study will be required of the range of users and their objectives; dredging requirements and impacts; transhipment facilities; marketing routes and networks; and navigation impacts on structures (such as the wave erosion effects on river banks and embankments). There are also a number of key industrial planning issues which may benefit from a proper integrated regional water management/navigation study, such as the development of the mining, fertiliser, and power sectors.

7.5 Social Impacts

Field surveys and public participation revealed two main ways communities define their acceptance of any flood control option. These are:

1. The extent it protects or creates hazards to life and property.

2. The extent to which it enhances or curtails their means of livelihood in cutting or disrupting routes of movement or reducing the amounts of floodplain water needed to sustain both agriculture, fisheries and cheap boat transport.

Even when the majority receive protection, it cannot stop a minority (often involving only a handful of people) from cutting an embankment to protect their lives, property or livelihoods. Throughout the NWR the most common reason for cuts is that communities have to relieve flooding actually created by the protection system itself. Cutting to protect livelihoods involves diverse groups. The cutting involve people either inside protected areas or on the outside. The motives all reflect reasonable and justifiable human responses. The problem is not due to irrational action or vandalism, nor is this type of problem amenable to policing tactics. It is a human response that highlights the deficiencies of the strategy itself.

It only takes one cut to undermine the whole rationale of the original protection strategy. In the case of the Lower Atrai one cut in Polder D along the Sib river has been shown to cause a chain reaction that ultimately can impact on an estimated 1.3 million people. These cuts create more damage and disruption than would have occurred without the structures. Similar problems or a smaller scale were recorded from the Sonail Scheme near Gaibandha.

These facts lead to a conclusion that the main future strategy can be built on lessons well-learned with the advantage of hindsight. The future strategy must now seek to actively avoid and solve these problems to ensure that the considerable public investments can go to schemes that are compatible with the wider development needs, technically sustainable and that are publicly acceptable. The regional plan contains the basis of this in presenting the case for the Green River within a fully operationalised strategy of integrated, inter-sectorial water management. It is very likely that this same strategy will have direct relevance to all the other planning units; a fact which was confirmed from the feasibility level studies in Gaibandha.

While the main divisible analysis of the matrix assessment assumed no public cuts, this risk is assessed under the community and family cohesion row. This is used as a proxy for the likely inequality of water levels indicated by the results of the hydraulic and drainage model outputs of seasonal water levels inside and outside projects. Thus, while in the row of attitudes to flood risk there is a positive benefit attributed, this direction, or its ranking, would be reduced if public cuts were to be assumed. The main benefits have been attributed to the areas which would be impacted by the sealing of the Teesta right embankment, the BRE, and where CFD embankments were introduced. The rounds of public participation found a general support for the strategy of sealing the embankments on the main rivers of the Teesta and Brahmaputra with considerably more reservations on the role of the CFD schemes within this.

In the cases of the embankment options for Mohananda, Lower Atrai, Hurasagar, the unexcavated Bangali Floodway which makes use of the natural low-flow channel and the Teesta right and left embankment the risks of potential public cuts appear and therefore cannot be discounted. The problems for the Teesta embankments will depend on the degree of confinement if both embankments are built, and the reaction of the people who live on the chars and the riverside of the embankments. The experience of the BRE in the Gaibandha area show public cuts being from the countryside to let impeded drainage out. A similar situation occurs behind the Teesta left embankment. No public cutting would be expected in the case of the fully excavated Bangali Floodway which appears to achieve its particular drainage objectives.

The positive impact recorded for the Gaibandha project assumes the effect of the improved drainage cells of the compartmentalisation option will distribute across the project area flood water that currently severely impacts areas at the natural drainage outlet at the Manos regulator. This would improve the equity of the distribution of flood waters. However, by cutting across small local drainage lines, the new drainage cells would risk differences in water levels building up in areas immediately behind and below these embankments. The scale restrictions of the model and the topographic base do not allow these problems to be assessed adequately and a monitoring programme is proposed to investigate this effect in the future studies.

The issue of minority groups will arise in all projects where traditional fishing communities will be undermined to the extent of having to out-migrate to India or to try to find alternative employment in other sectors. Adverse effects could impact on groups of Shantals in the Mohananda basin. A positive impact would benefit Hindu traders advantaged by the Teesta left bank project.

In general, there would be a somewhat negative impact for both women and children. This would mainly result from the likely deterioration in the food diversity and cohesion of the fishing communities. In the summary table women and children will be mainly positively affected by the increased access to survival strategies associated with the reduced flood risk and the increased employment created from the improved agriculture. In this respect the areas protected by the sealing of the Teesta right embankment would be the most advantaged out of the various projects considered.

7.6 Public Health and Nutrition

The most significant risks are those from water-related diseases. Broad foci of cholera, severe diarrhoeal disease, goitre and vitamin disorders are already identifiable along the west bank of the Brahmaputra. Filariasis and malaria are also present in the north of the region. An epidemic of Kala azar is focused in villages in and around the Chalan Beel polders, although the association with these empoldered areas is not yet understood.

The vectors of malaria and cholera are known to be present. Therefore, as all the northern projects are likely to suffer impeded drainage, the likelihood of more stagnant waterbodies most suitable for vector breeding can be expected. These projects have been flagged for a highly negative health hazard which must be taken account of before any further designs are prepared. The sub-division of drainage cells for compartmentalisation in Gaibandha may result in a worse condition than without compartmentalization. Clear criteria are needed for design and operational features of the schemes. Similarly, all additional methods of environmental management should be designed into the complementary programmes.

Malnutrition, economic deprivation, poor sanitation and under-resourced health services are general problems throughout the region. These create a backdrop of severe vulnerability to any disease and health stresses occurring as a result of flood protection projects. The loss of capture fisheries will remove the most widespread intake of diverse fish species. The potential loss of protein sources is but one aspect of this problem. Of equal relevance is the loss of access to important minerals, vitamins and oils. The mitigation of developing cultured fisheries and restocking with major carps will have commercial benefits for a quite different range of people and will not be a nutritional mitigation at all. The cumulative impacts of this loss on poor people already caught in a state of on-going nutritional decline over at least the last 50 years could be dramatic. For CFD projects to continue to actively contribute to this state of affairs without well-targeted and proper mitigation, funded directly within the project costs, would be unacceptable. This effect argues even more strongly for a move to an integrated water management strategy and a Green river concept for the Lower Atrai.

7.7 Institutional Impacts

Two areas of institutional analysis have been selected to highlight key issues. For all project areas the decision to move towards a more inter-sectorial and integrated approach to land and water management would immediately involve more institutional complexity. In the matrix the assessments relate to the potential community-based issues resulting from potential public cutting. The size of water management units is also considered in this assessment. Thus, the larger the numbers of smaller drainage basins the more likely the overall complexity will increase.

The public participation figures assess the degree to which the current study was able to base its selected design options on rounds of public discussion. The first stages of public participation were carried out for many of the design features for the Gaibandha project, but not the option of compartmentalisation; which only showed its potential benefits after field work had been completed. Further public participation was carried out in the Lower Atrai and confirmed the essential logic of the Green River concept, although the sub-strategies of partial protection and confinement were not dealt with in the detail achieved for the components of the Gaibandha project.

7.8 Other Impacts

The building of the Jamuna bridge will bring a significant range of potentially cumulative impacts. These were the subject of a detailed EIA by independent consultants in 1991. The main positive impacts for the NWR will result from the economic and transport linkages established and the focus it may provide for a future Asian highway to pass through. Delays to achieving these benefits would occur if the bridge were outflanked by the Brahmaputra breaking into the Bangali. The scheme would create a significant demand for construction labour. It will potentially compete for scarce construction materials with the BRE and NWRS projects and add to the demand for fuelwood timber for brick and aggregates. New trading and migration effects would also result.

The main negative impacts would result from morphological responses to fully embanking the Brahmaputra linked to unforeseen changes associated with the Jamuna Bridge.

A further set of impact problems are related to the phasing of the FAP studies and the boundary conditions for this study. Throughout the NWRS planning a fixed condition for planning assumes the BRE will be sealed and all the relevant issues dealt with by FAP 1. The final BRE Master Plan is still awaited, although the priority works proposals are known. Major uncertainties exist for the NWRS depending on the future outcome of the BRE works. Social and economic problems from continuing displacement of population due to river erosion or land acquisition for retiring the BRE will change the scale of human problems in this part of the region. Of far more planning significance will be the physical impacts of continued erosion of the west bank and the imminent break through of the Brahmaputra into the Bengali.

7.9 Risk and Hazard Assessment

The major risks to project investments in the NWR will come from a number of sources. Many of these would be cumulative impacts that are externalities but, nevertheless, are likely to affect the long-term sustainability of the plans. These issues are discussed further variously in Volumes 4, 7, 10 and 12 and in summary include the items given in table 7.2

Table 7.2 Risk and Hazard Assessment

Issue	Potentially Severe Local Damage	Planning Assumptions or Configuration Potentially Deficient	Potentially Irreversible Changes
Physical Risks			
Seismic and tectonic events	X	X	X
Mass wasting in the upper catchment	X	x	x
River capture in the upstream catchment		x	X
Brahmaputra break through to Bengali	X	X	X
Extreme climatic events in the upstream catchment	X		X
Coincident high floods in different rivers	X		X
Global warming, climatic change and rising sea levels			X
Delays or ineffectiveness of Brahmaputra river training programmes	X	X	X
Biological Risks			
Continued collapse in the floodplain fisheries	X		X
Under-valuation of loss of species and habitats	x	x	X
Under-valuation of cumulative impacts due to changes to wetland functions and processes	x	X	
Under-valuation of the background linkages between FCD, public health and nutrition	X	X	X
Economic Risks			
Inappropriate signals indicated by discounting or discount rate used	x	x	
Inappropriate signals sent by lack of inter-sectorial investment appraisal to resolving development problems	x	x	
Inappropriate signals sent by utilising sunk cost infrastructure	x	x	
Human Risks			
Public cuts	X	X	
Cumulative impacts associated with loss of social cohesion	X	x	X
Cumulative impacts due to un-targeted tactics to reduce inequalities	x	x	X
Cumulative impacts due to un-targeted tactics to maintain nutritional entitlements	X	x	
Cumulative impacts due to un-targeted strategy to diversify natural resource base and products	x	x	
Lack of adequate O & M	x	x	

X = Severe   x = Less Severe

7.10 Disaster Preparedness and Response

Coordination of projects in the NWR and other regions will be required, to know in advance how best to fail the system safely and which areas would be used for storage and which would be protected. These requirements should be built into detailed planning of the projects. In addition, programmes for training of staff, preparation of manuals, provision of communications equipment, public participation and warning systems will also need to be set up.

In view of the complexity and range of hazard risks that exist, full contingency planning and resourcing should accompany the feasibility and detailed design of future projects. Under international criteria relating to dam construction (which is effectively what the major embankments are) all such designs would normally have to conform to the most stringent technical and quality control standards and be expected to plan a full disaster preparedness strategy. This aspect may require more detailed consideration in future planning for Gaibandha and other regional sub-projects.

A number of recommendations have been made in this study. These can be summarised as follows:

- Financing and planning of flood proofing measures are required with or without the interventions proposed. This is because the risks of exceeding the design criteria involve many hazards that could occur in the economic lifetime of the projects. As the basic strategy will not be abandoned at the end of the economic life, these risk become certain hazards, if the long term planning period is adopted. For engineering planning the most significant works will be the survey and proofing of all vulnerable public infrastructure, facilities, services and communications to ensure that these continue to function during and after a disaster event.

- The most significant hazards will involve events associated with, or occurring coincidentally with, the monsoon season. Full disaster preparedness will depend, to a large extent, upon the navigation services, resources, facilities and planning considered in future planning. River ambulances and emergency supply boats can play a dual role in monsoonal development activities, as well as disaster response. Prior coordination will required, primarily for local communities, local government, the health services, the NGOs, national coordinating bodies and the international community.

- Prior programmes to ensure the improvement of the basic conditions for clean water, latrines, food storage and improved sanitation, particularly for char and embankment dwellers, would reduce the risks of disease and these people's current susceptibility to post disaster problems.

CHAPTER 8

REGIONAL PLANNING

8.1 Introduction

8.1.1 The Planning Framework

The regional plan is being prepared during the period of the Government's Fourth Five Year plan and after the publication of the National Water Plan Phase II. These two important documents therefore provide the framework for the plan.

The Fourth Five-Year Plan

The Fourth Five Year Plan (1990-95) is the first plan period for the current perspective Plan (1990-2010). The main objectives of the Fourth Plan are:

- acceleration of economic growth;
- poverty alleviation and employment generation through human resource development;
- increased self reliance.

In the broad sector of agriculture, water resources and rural development there are a number of objectives which contribute to the overall Plan objectives. Amongst others, these include self sufficiency in food, diversification of production especially for greater nutrition, containment of areas under cereals (especially rice) within limits of soil and ecological balance to release land for other crops, reduction of rural poverty and promotion of income equality, economic and employment opportunities.

The policies for water control and drainage would aim to:

- bring shallow and medium flooded land under controlled flooding to permit environmentally desirable integrated agriculture and aquaculture development through construction of dykes and polders with regulators and structures;

- in suitable deep flooded areas, construct submersible embankments to permit safe harvest of winter crops;

- improve drainage especially at thana level;

- introduce comprehensive analysis of FCD/FCDI projects with social costs and full accounting of externalities and linkages;

- create appropriate institutional frameworks for the O&M of schemes;

- emphasise rehabilitation of existing projects and, for new projects, focus on short gestation cost-effective projects;

- implement on-going large projects through a modular approach;

- maximise local participation in projects at all stages;

These policies are in general reflected in the priorities of the FAP and in the approach adopted in this study: for example the study has closely examined partial protection options with compartmentalisation, whilst social and institutional issues have been considered in some detail.

The National Water Plan

The Fourth Plan is linked closely to the National Water Plan (NWP), prepared by the Master Plan Organisation (MPO now WARPO), in regard to proposals on water resources. The NWP however has a longer planning perspective.

The National Water Plan contains data on regional development opportunities. In summary, a total of 515000 ha in the NW region had benefitted from FCD development by the end of the Third Five Year Plan (1990), out of a total net cultivated area within the region of 2.45 million ha. It was estimated that a total of 1.27 million ha. could be protected by FCD, and the NWP proposes projects which would protect an additional 506000 ha. over the period 1991-2010.

In discussing development possibilities in the region, the NWP report notes that the main problems are drought in the whole region and flooding in the Atrai basin. Irrigation from internal water resources is almost exhausted except from groundwater.

The total cost of the whole NWP for the Fourth Five-Year Plan is Tk 48 bn. of which about 50% is non-discretionary. Net funds available are Tk 24.6 bn, out of which FAP programmes comprise Tk 17.6 bn.

The following sections outline the proposed regional plan, which combines projects and complementary activities identified by the NWRS, with on-going and proposed projects identified by other organisations. These investments taken together will to an important extent fulfil the objectives of the National Water Plan.

8.2 Ranking of Scenarios and Options

The various planning scenarios and options for individual areas which were considered in the regional planning process are summarised in Table 8.1 and 8.2. This gives summary details for each of the options considered, together with their scores against a number of key indicators, for ranking purposes.

8.2.1 Ranking Criteria

The criteria used for ranking are based on the National Water Plan priorities and analysis of experience of flood control projects to date. They are as follows:

NPVR : The use of this measure (the present value of benefits minus present value of costs at shadow prices, in the numerator, divided by the present value of public sector capital and O&M costs at market prices, in the denominator), is now widely accepted as the correct method of economic ranking of projects, in the case where the availability of public sector funds is the greatest constraint on development.

Changes in Rice and Fish Output: Rice output is generally increased by the proposed interventions, while fish output generally falls. High economic returns are generally a reflection of increased rice output while decreases in fish output are a measure of dis-benefits to poor and disadvantaged groups.

O & M Cost per ha : The difficulties of effective O&M are widely acknowledged to be major constraints on CFD development. Whilst there are a wide range of factors which contribute to these difficulties, it is thought that the O&M cost per hectare gives a reasonable indication of the degree of difficulty which will be experienced on any particular project.

Social Impact : It has become clear through the range of evaluation studies currently being carried out that the social impacts of FCD development are often as important as the likely increases in agricultural productivity from them. The social impacts of the various scenarios under consideration are summarised in the preceding chapter, and detailed in Volume 11 of the Draft Final Report. Values are given against three quantitative indicators, construction employment, incremental agricultural employment, and land acquisition.

Biophysical Impacts : The approach to environmental evaluation has been in accordance with good international practice and the guidelines being developed in FAP16, in encompassing a broad range of environmental impacts. In the ranking criteria, only biophysical impacts are included, as the key socio-economic factors are included in the factors already discussed.

Social Conflicts : A key factor in the performance of past flood protection schemes has been the degree to which they cause social conflicts which can result in poor O&M and, in extreme cases, public cuts and serious damage. This criterion attempts to assess this factor.

Institutional Complexity : This factor attempts to assess the complexity of particularly projects or scenarios and the likelihood of possible failure. It is related to O&M costs per hectare, and social conflicts, as discussed above.

Hazard : This criterion measures the susceptibility of the project to failure caused by natural or man-made factors and the impacts that such failure would have on the protected area, or adjacent and downstream areas.

External Impacts : The external impacts of CFD development are in many ways as important as the internal impacts. One of the major features of the present situation is the very low tolerance of people for perceived disadvantage from CFD infrastructure. This is shown by the amount of embankment cutting that now goes on. It is therefore important to try and assess the degree of impact on areas outside the project boundary. The smaller this impact, the higher the rank of the project.

Table 8.1 Scenario Summary and Ranking Analysis - NW Region

	Lower Atrai Full FCD	Lower Atrai Major drain	Lower Atrai Gr. River	Up. Karatoya (Bangali F.way)	Gaibandha (incl. Teesta RB)	Teesta LB (B'water Embkt)	L. Jamuna R. Bank	Mohananda 20 Year
Net Cultivable Area(ha)	382756	382756	355692	(180000)	(197780)	51021	9500	15073
Total Cost (Tk '000)	4161000	16023000	1498010	2182147	1670080	452397	33584	159418
O&M Cost (Tk '000)	133000	480000	47138	57802	42619	13033	898	4088
IRR(%)	24%	2%	21%	5%	10%	9%	16%	5 %
Ranking Criteria								
NPVR(1)	+1.02	-0.5	+0.42	-0.27	-0.02	-0.06	+0.16	- 0.27
Rice Output (000t)	-	-	1879(+4%)	310(+7%)	335(+8%)	248(+3%)	-	29(+20%)
Total Fish Output(mt)	-	-	19968(-11%)	826(-31%)	675(-3%)	274(-62%)	-	269(-3%)
O&M Cost/ha nca (Tk.)	348	1254	132	(321)	(215)	225	94	271
Const. Empl('000 dyas)	-	-	10035	30360	9760	4280	290	1300
Ag. Empl ('000 days)	-	-	99149(+4%)	19016(+5%)	20037(+6%)	15530(+2%)	-	2191(+8%)
Land Acquisition-ha	-	-	601	3421	425	293	30	166
Biophysical Impacts	-2	-3	-1	-2	0	0	-1	0
Social Conflict	-5	-2	+3	+1	0	+2	0	+1
Inst. Complexity	-2	-3	-1	-3	+1	-1	+2	0
Hazard	-5	-2	0	-1	0	0	+1	0
External Impacts	-3	-3	0	0	+2	0	0	0
OVERALL RANKING	N	N	1	3	1	2	1	3

Source: NWRS estimates

Notes:

1. Impacts range from +5 (very positive) to -5 (very negative)
2. Overall ranking: 1-high priority, 2-medium priority, 3-low priority, N-not recommended
3. Economic indicators for Lower Atrai full FCD and Major Drains based on analysis in Interim Report.
   Some ranking criteria for these scenarios are excluded since they were calculated on different basis from 1992 analyses.

Table 8.2 Project Summary and Ranking Analysis - Lower Atrai

	Polder 2	Polder 3	SIRDP	Hurasagar S	Polder A	Polder B	Polder C	Polder D	Hurasagar N	Hurasagar S
	Gr. River	Gr. River	Gr. River	Gr. River	Gr. River	Gr. River	Gr. River	Gr.Riv	CFD	CFD
Net Cultivable Area(ha)	52089	55578	64275	6225	27716	29411	42498	52650	25250	6225
Total Cost (Tk '000)	223589	98270	153704	63145	159171	162901	163184	239466	226281	86804
O&M Cost (Tk '000)	6156	2770	9115	1958	4622	4565	4431	7115	6456	2265
IRR(%)										
Ranking Criteria	24%	21%	35%	7%	14%	19%	15%	17%	- ve	21%
NPVR(1)	+0.8	+0.55	+1.61	-0.23	+ 0.1	+ 0.45	+ 0.15	+ 0.29	-0.58	+0.74
Rice Output (000t)	283(+6%)	340(+3%)	228(+2%)	29(+5%)	122(+4%)	148(+13%)	193(+5%)	221(+12%)	120(+4%)	35(+30%)
Total Fish Output(mt)	1587(-14%)	1636(+25%)	4137(+5%)	387(+2%)	1037(+18%)	833(-30%)	2020(-6%)	1774(-42%)	341(-3%)	229(-40%)
O&M Cost/ha nca (Tk.)	109	49	68	315	169	155	98	133	256	264
Const. Empl('000 dyas)	1558	637	1340	500	1490	1390	1280	2340	2080	510
Ag. Empl ('000 days)	13453(-7%)	15975(+1%)	12978(+1%)	1657(+3%)	6625(+3%)	8914(+8%)	10645(+4%)	12989(+8%)	7132(+4%)	2242(+40%)
Land Acquisition(ha)	108	35	77	13	55	84	76	130	23	13
Biophysical Impacts	-1	-1	-2	-1	-1	-1	-1	-1	-1	-3
Social Conflicts	+3	+3	+3	0	+1	+1	+3	+3	-1	0
Inst. Complexity	-1	-1	-1	-1	-1	-1	-1	-1	0	0
Hazard	+1	+1	+1	0	0	0	0	0	-1	-3
External Impacts	0	0	0	0	0	0	+2	+2	-1	0
OVERALL RANKING	1	2	2	N	2	2	1	1	N	3

Source: NWRS

Notes:
1. Impacts range from +5 (very positive) to -5 (very negative)
2. Overall ranking: 1-high priority, 2-medium priority, 3-low priority, N-not recommended

8.2.2 Plan Ranking

The plan has not been formulated on the basis of putting each option into a rank order, nor is it desirable to do so. The best use of the ranking analysis is to provide a broad view of priorities. Other factors will also determine the order in which options are selected for implementation. Thus from Table 8.1 it can be seen that, comparing the Lower Atrai scenarios analysed, the Green River would be recommended because it has high economic returns (an NPVR of + 0.42) and generally scores well against other criteria. Notably it should reduce social conflict in the basin which at present causes significant economic and social dislocation. Full FCD in the Lower Atrai appears to give higher economic returns, but is the cause of severe social conflicts, is very susceptible to hazard, and is regarded as infeasible, taking into account all ranking criteria. Of the other scenarios analysed, only the Little Jamuna right bank is feasible in conventional economic terms. This is a small and simple river embankment project with a low O&M cost per hectare and few negative impacts: it can be included in the short-term plan but will not make a major contribution to development in the region.

The larger scenarios investigated all had negative NPVRs, though the Gaibandha and Teesta Left bank projects should be classed as marginal, rather than infeasible. Gaibandha is preferred to the Teesta Left Bank development because it generally scores better against the ranking criteria. In particular it has beneficial impacts on downstream areas through the sealing of the Teesta.

In the case of project ranking on the Lower Atrai Green River most projects are feasible in conventional economic terms. Polders C and D score highly in terms of reducing social conflict and hazard to adjacent areas and should have first priority. Other projects in the middle and upper part of the basin are rather similar and can not be definitively ranked. Two of the Hurasagar options would be rejected on economic grounds : the third (CFD development in Hurasagar south) has reasonable economic returns but high O&M costs per hectare, moderately strong negative impacts on the biophysical environment, and high susceptibility to hazard. It can only therefore be recommended for the long term, since other developments would have higher priority.

8.3 The Regional Plan

The regional plan is based on the scenarios considered under the NWRS, together with proposals for other areas which have been put forward by other agencies. The main elements of the plan are shown in the Figure 8.1.

Development within the region is a dynamic process. As external and internal conditions change, so different modes of development become profitable and change the balance of costs and benefits between existing modes. A good example of this is the advent of STWs which in turn led to the rapid and successful development of boro cropping. Any development plan must reflect this dynamism and must be capable of updating to take account of changing circumstances.

The recommended plan puts forward proposals for short-term, medium-term and possible long-term investments, together with a recommended hydrological framework for flood planning within the region. The essential elements of this framework are sealing of the BRE and the Teesta, the Green River concept in the Lower Atrai, and the discharge of flows in the upper reaches to the Brahmaputra where this seems feasible (the Ghagot and perhaps the Bangali Floodway). The plan will need to be reviewed, modified as necessary and further developed in the future.

Figure 8.1

Regional Development

The map shows the short-term, medium-term and long-term measures proposed for incorporation within the regional development plan. Short-term measures (5 years) are concentrated in the south and east, where the most serious flooding occurs. Medium-term measures (5-15 years) would include further restructuring projects in the Green River, following priority works in polders C and D. Long term measures are potential projects beyond 15 years.

SHORT TERM PROJECTS

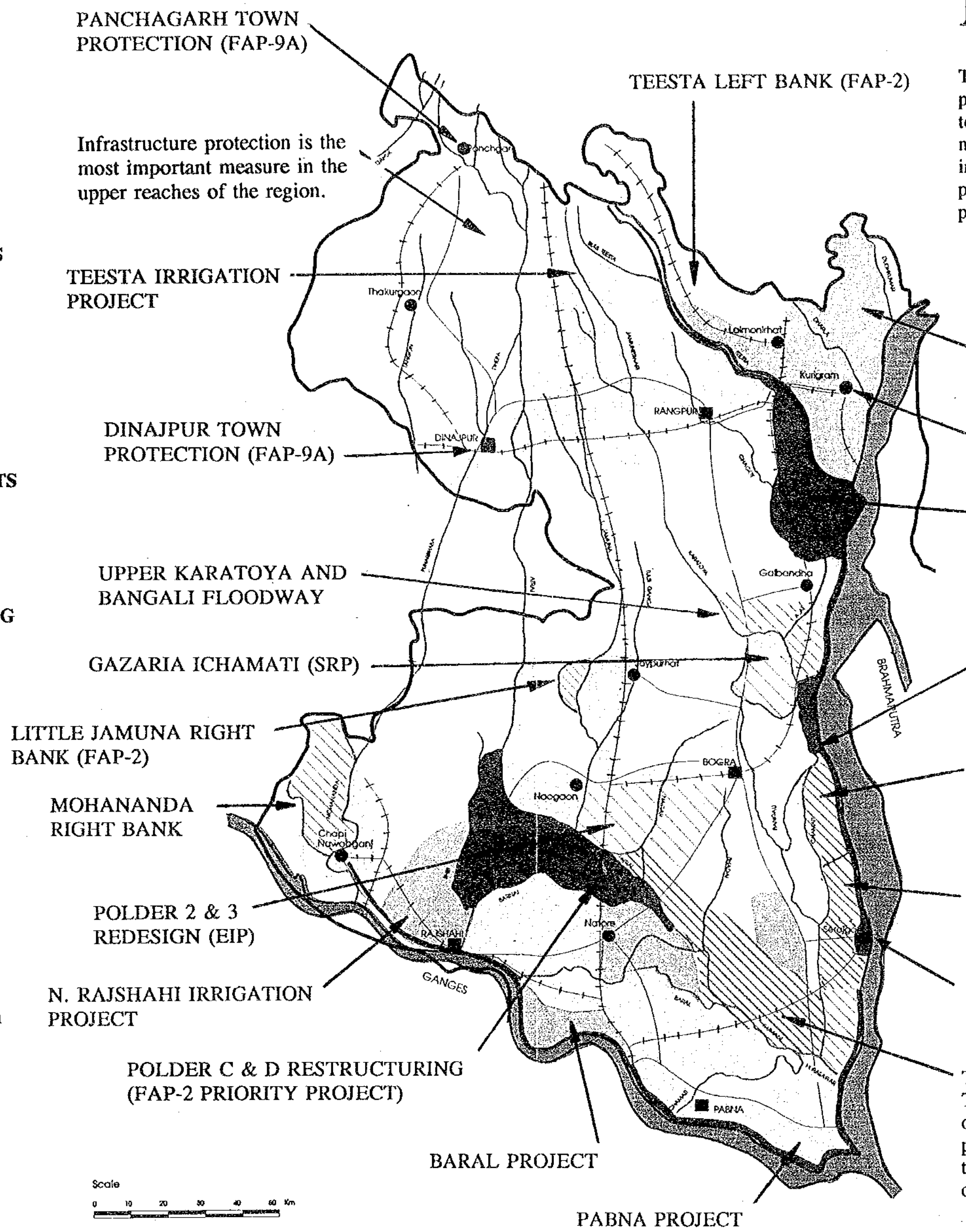
- Priority Works
- FAP Plans
- Other Developments

MEDIUM TERM PROJECTS

LONG TERM PROJECTS

EXISTING AND ON-GOING DEVELOPMENT

N



ASSOCIATED DEVELOPMENT

Important measures associated with the plan would include:

- flood proofing (on the charlands, along BRE, and in the Green River
- fisheries mitigation and enhancement
- navigation infrastructure
- environmental protection & monitoring
- improved O & M

One important factor is the relative urgency of the proposed works. This particularly applies to works which are primarily protective in nature, for instance of major infrastructure, such as the BRE, or urban areas in the upstream reaches. The plan therefore distinguishes between short-term, medium-term and long-term works.

A second important point is to ensure that there is balanced development within the region as a whole. The Brahmaputra Right bank and the Lower Atrai naturally form the focus of most of the flooding problems in the region, but it makes sense, both on the grounds of equity and implementation capacity, to spread development through the region as a whole. In those areas where analysis shows that projects as presently conceived are non-viable, a possible course of action is to implement flood-proofing measures such as raised shelters and strengthened infrastructure, in order to safeguard human lives and property, and animal livestock, at times of severe floods.

The completion or repair of existing facilities is another factor to be taken into account when drawing up a regional plan. As far as possible, it is preferable to ensure the safety and continuity of existing embankments and structures, so as to safeguard the original investment in them, rather than allow them to deteriorate to the point at which complete rebuilding is required. Rehabilitation tends to show higher returns than new construction, in any case, because costs are lower, whilst returns are similar.

In accordance with the focus of this study, the plan identifies a programme of physical work, aimed at increasing control of flood waters, improving productivity, and raising living standards. As shown, the programme should be accompanied by a programme of complementary activities, such as flood forecasting, assistance to dry season cropping and the like.

The schedule for plan implementation is shown in Figure 8.2. The rate of implementation is a reasonable one, which balances the need for further studies with the need to undertake urgent work in a dynamic human and physical environment, and where other organisations are actively working on similar or associated developments. Most projects and options are shown taking place in the short to medium term, reflecting the level of activity in flood development in the North West region at the present time, but possible long-term developments have also been identified.

8.4 Structural Development

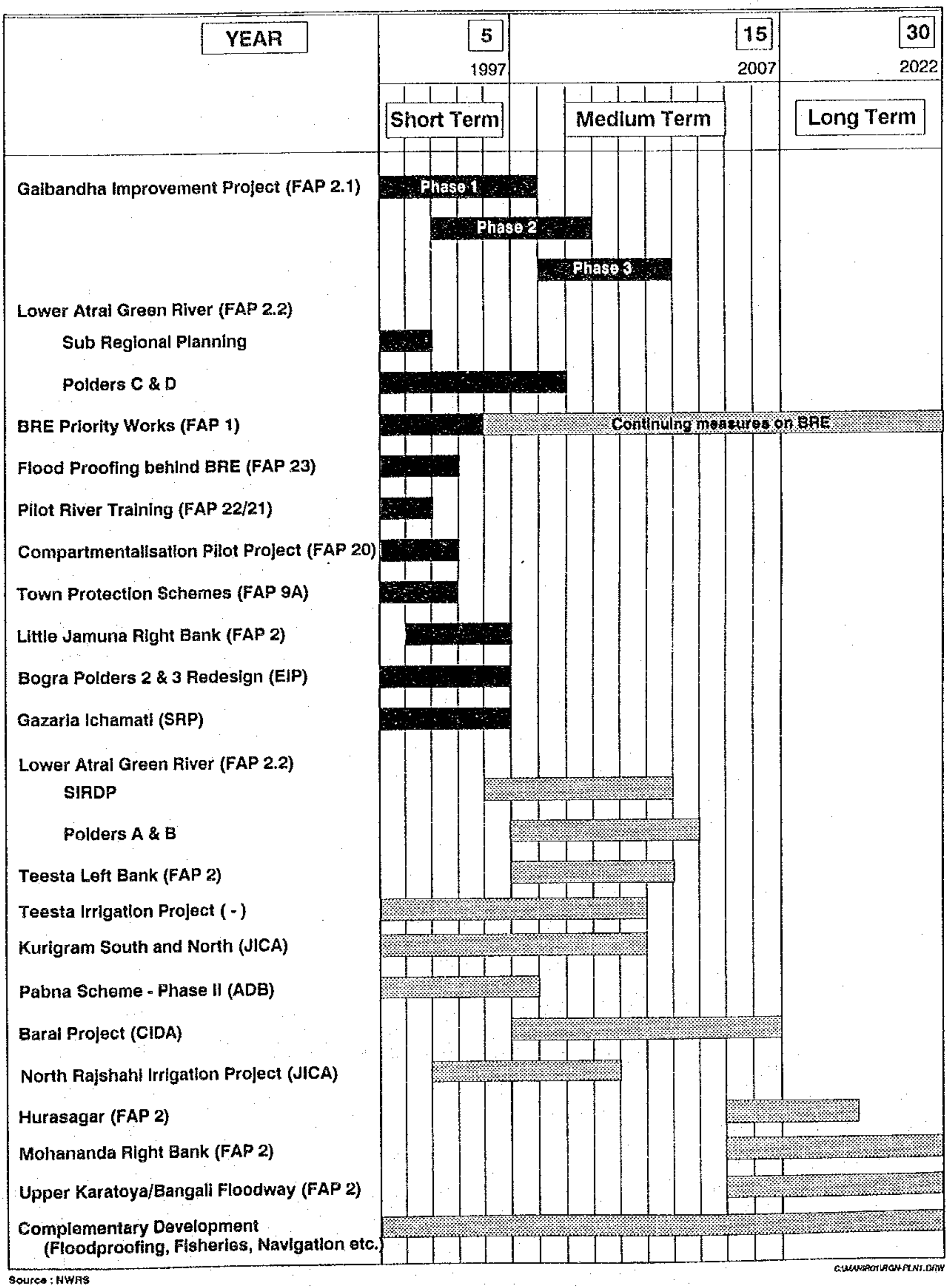
Brahmaputra Right Bank

The most damaging flooding in the region is caused by breaches in the BRE. Every effort should be made to seal the BRE effectively, in line with the recommendations of the master plan to be agreed at the end of the FAP1 studies. Sealing the BRE will be welcomed by practically all the people who live within its influence. Negative environmental impacts are minor by comparison. The effect of sealing the BRE will be to increase Brahmaputra discharges by approximately 2% of the mean monthly maximum flow.

Priority areas for development on the right bank of the Brahmaputra include the Gaibandha area, south of the Teesta confluence, discussed in the Gaibandha Improvement Project Final Report. This project involves rehabilitation of the embankment along the right bank of the Teesta, drainage improvements, and compartmentalisation on an area of about 60,000 ha. This project would become FAP 2.1.

FAP1 priority works are at Sariakandi/Mathurapara and Serajganj (Section 4.2).

Figure 8.2
The Regional Plan



Source : NWRS

FAP20 will be developing the compartmentalisation concept in the reach north of Serajganj, over the same period. This will provide valuable experience on the use of compartments as flood cells for protection from Brahmaputra breaches and will also provide feedback for the proposed development.

It is not possible to schedule other necessary works on the Brahmaputra right bank precisely. Localised work may be needed in the Kurigram stretch and in Pabna; in the latter, protective measures for the existing pumping stations have been identified by the Pabna Feasibility Report as needing immediate study.

Upper Karatoya/Middle Bangali Basin

The lower reaches of the Upper Karatoya are susceptible to flooding. A phased development of CFD facilities is possible for this area, in association with the Bangali floodway, which would connect the Bangali directly to the Brahmaputra. This would form part of a general strategy of passing flood discharges to the Brahmaputra as far upstream as possible. The strategy would also apply to the confluence of the Ghagot and the Brahmaputra, where detailed proposals are presented under the Gaibandha Improvement project for altering the configuration so as to increase discharges to the Brahmaputra and decrease them downstream in the Alai. The latter proposal will reduce the flooding problems in the lower reaches to some extent.

The first phase of such development on the Upper Karatoya would involve extension of controlled flooding and drainage facilities on the left bank, opposite the Nuruller Beel scheme, together with preparatory work for the Bangali floodway. The Bangali floodway must be seen as an integral part of this development, in order to avoid increasing downstream discharges.

In the case of the middle Bangali the essential measure is the sealing of the BRE, as described above. No other major long term projects can be considered since the national benefits will drastically reduce as the sealing becomes effective. However smaller projects such as Gazaria-Ichamati (SRP) will improve water management in the basin, particularly when they can be associated with augmentation of dry season supplies. In the interim period until BRE sealing becomes effective, flood proofing is an important measure to improve the quality of life of people living in the basin.

Lower Atrai Basin

The Lower Atrai basin is an area of deep and persistent flooding. Since this is caused by drainage constraints rather than breaches, the aim should be not necessarily to reduce the depth of flooding but primarily to make it more predictable, so that farmers and others who live there can plan their lives and livelihoods accordingly. Attempts to provide full flood protection by complete exclusion of flood water have proved by experience to be infeasible since public cuts are common-place in areas where people feel disadvantaged by head differences across embankments. This option was investigated further during the first part of NWRS : although the theoretical returns are high, the unpredictability and hazard associated with such measures mean that this option is not recommended in the Lower Atrai. Consideration was also given during the NWRS to the provision of major drains which would completely alter the hydrological regime of the Lower Atrai basin by passing flood discharges from the Atrai eastwards to the Brahmaputra or southwards to the Ganges. These drains were found to be infeasible, and should not be considered further. The proposed plan for the Lower Atrai is based on the "Green River" principle, in which the area close to the river is designed to carry peak flood discharges, whilst areas further away are provided with CFD facilities.

The priority for development in the Lower Atrai depends on a number of factors incorporated in the multi-criteria analysis, as well as a range of practical influences. The priority areas for detailed feasibility study are Polder C, which is a key area influencing the hydraulic regime in the upper reaches of the Lower Atrai, and Polder D, which suffers the greatest uncertainty at present. Nonetheless it is emphasised that there is a need for integrated planning in the Lower Atrai basin, and these feasibility studies should be combined with a detailed sub-regional study (FAP 2.2).

The Teesta Basin

Flooding from breaches in the river Teesta is significant in the north-eastern part of the region. The regional plan is based on progressive sealing of these breaches, both on the left and right banks. The Teesta is the largest of the internal rivers in the region, and it outfalls directly to the Brahmaputra, so that discharges can be increased without significant downstream impacts. Sealing of the embankments will, as for the BRE, benefit many people and have comparatively minor negative environmental impacts.

The first phase of development in this basin is the Gaibandha Improvement Project, of which the major component is the sealing of the Teesta Right Bank both upstream and downstream of Kaunia. Subsidiary developments could include Left Bank sealing and rehabilitation and improvement of the Sati-Nadi scheme, followed by further work on the upstream right bank areas and improvement of the land between the Ghagot and the Karatoya.

Project Completion

The completion of two on-going projects, Barnai and Naogaon, is assumed in the plan. In the case of the latter, further work may be needed to obtain full benefits, since the enclosed area is open to the north. This area would be partially benefitted by the proposed Little Jamuna right bank development. It may also be a suitable scheme to consider for compartmentalisation. The Barnai project is likely to have adverse impacts on levels in the Barnai and the Shib river. Both projects should be monitored as to their performance, social acceptability and environmental impact, and should be included in the proposed Lower Atrai Sub-Regional Study (Section 8.9).

Other Areas

Here priority works are distinguished from those which are on a medium or long-term basis. Town protection works in the upper areas (Dinajpur, Panchagarh and Kurigram) are a priority being undertaken under FAP9A.

Development in the Kurigram area can take place independently of the remainder of the region, since the Dharla and Dudhkumar outfall directly to the Brahmaputra. The same goes for the Mohananda. Major proposals for the Kurigram south area are being formulated under JICA proposals. When these have been implemented, the proposal for Kurigram North would need to be reviewed. In Mohananda only minor proposals have been formulated, under NWRS: there are also proposals for work in this area under SRP and SSFCDI.

Other upstream areas of the region are subject only to flash flooding. Since flood protection measures in these areas will increase downstream discharges, it is recommended that, in general, structural CFD measures are not implemented in the upstream reaches, except to protect urban infrastructure.

Irrigation Projects

This regional plan is concerned with projects to control flooding and improve drainage. However, for completeness a tentative programme is also shown for the major irrigation projects in the region, the Teesta, Pabna, Rajshahi and Baral Basin projects. It would seem sensible to complete the on-going projects, Teesta and Pabna, before proceeding to the new projects, Rajshahi and Baral. The Rajshahi project is, however, scheduled by BWDB to commence shortly.

8.5 Complementary Development

There are a number of important measures to complement the structural projects within the plan. These are discussed below and shown in Figure 8.3.

8.5.1 Flood Proofing

Section 3.5 discusses possible approaches to flood proofing, covering both structural and non-structural measures and distinguishing between the different locations where flood proofing is required. The highest priority is naturally the unprotected areas and charlands, but those living on the major embankments and those affected by BRE breaches are also a high priority. Elsewhere those living in the unprotected area of the Lower Atrai Green River would also have flood proofing needs.

At this stage many aspects of the flood-proofing programme remain to be worked out, particularly institutional arrangements for implementaion. However, approximate assessments of demand, service provision and costs indicate that a sum of about Tk 100 million could be budgeted for an initial flood proofing programme. This would be focused along the BRE and on the charlands, and elements of the programme would be specifically related to the Gaibandha Improvement Project.

8.5.2 Fisheries

A concerted effort is needed to minimise the risk of further damage to fish stocks and the fishing community as a result of flood intervention and to promote measures designed to restore at least some of the past fishery losses. Examples of the types of initiatives required are discussed in detail in the Gaibandha Project Main Report. They include :

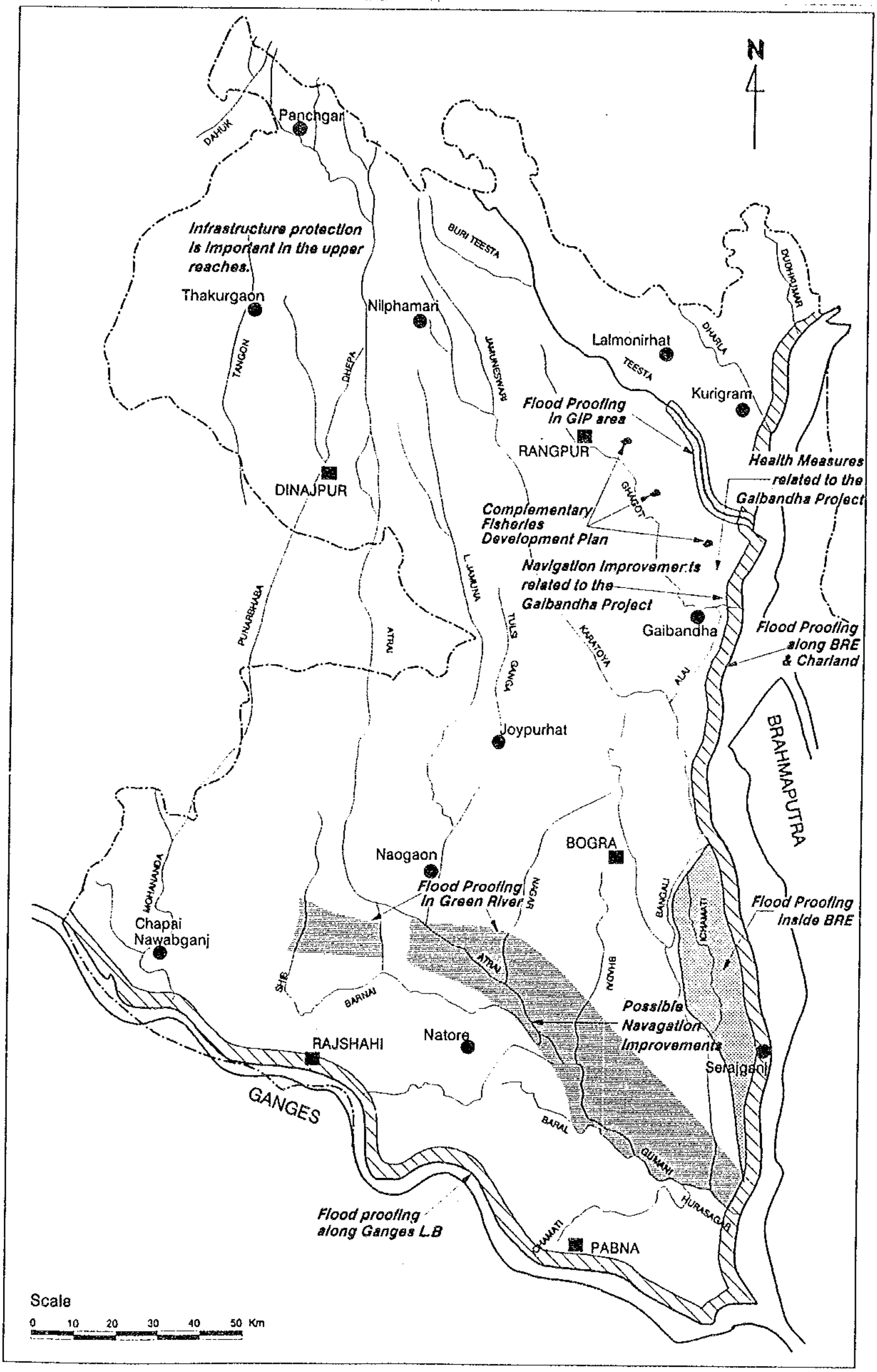
- preservation and improvement of khas water bodies,
- the development of borrow-pit fisheries,
- modification of structures to allow fish passage,
- external enhancement of capture fish resources,
- improved fisheries extension,
- development of rice-fish culture.

A number of these activities could be undertaken by on-going GOB fisheries development programmes, but co-ordination is important to ensure that flood interventions are planned taking the needs of the fisheries sector into account.

8.5.3 Navigation

Navigation is becoming increasingly important and cost-effective with the advent of mechanised country boats. The regional plan assumes that access for navigation will be developed wherever it is feasible. In the lower Atrai the main river itself is of course an important navigation route during the wet season. (During the dry season cross dams are built to hold water for irrigation and continuous navigation is

Figure 8.3
Complementary Development Plan



not possible under present conditions). The plan assumes that the Atrai will remain open for river navigation during the monsoon. In addition, access for country boats to the protected or partially-protected areas will be provided where it is possible. However major development for navigation throughout the Lower Atrai would need to be the subject of a special feasibility study since it will involve the consideration of a variety of factors including boat size, structure design, and draught and dredging requirements.

In other areas also, provision for country navigation will be made where feasible. For the Gaibandha Priority Project, consideration has been given to providing locks on the main regulating structures, plus dredging of three main drainage lines within the project area in order to provide access for country boats, particularly for the transport of jute. In the case of dredging of the drainage lines, there is a trade-off with fish production and retention in some beels, which will need to be thoroughly investigated at the time of detailed design.

8.5.4 Environmental Management Plan

An important element of the regional plan is the Environmental Management Plan (EMP) River approach. A large number of possible measures which could be included in the EMP are discussed in Volume 4, Initial Environmental Evaluation of the Draft Final Report. Among the most important are:

Disease Vectors

To undertake regional mapping and focus studies on disease, disease vectors and public health criteria for regional water management. Specific attention should focus on ways to ensure the epidemics, outbreaks and spread of cholera, malaria, kala azar, filariasis and Japanese encephalitis can be managed.

Wetland Studies:

(a) To fund research and monitoring to allow integration of natural resource and water management planning for maintaining the critical wetland processes and developing programmes of Integrated Pest Management (IPM). This will involve wetland, fisheries and agro-ecological research to involve and draw on the experience of institutions such as BRRI, IRRI, DOE, DOF, ICLARM, WHO, AWB and IUCN. The required approach would seek to integrate different methods to minimise the conditions which can lead to poor public health, soil and water quality. It would concentrate on physical, biological and community-based management techniques to counter-act or remove the causes of poor water quality in situ and to maximise the productive output of the wetland areas.

(b) To ensure that the few remaining sites of high genetic and bio-diversity value are brought under proper management and designated under a protected area network and fully integrated into the future stages of planning of any CFD schemes. Continuous monitoring of conservation sites such as Andasuria Beel in Chalan Beel Polder D would be included;

Ecological Monitoring

To provide training and resourcing for an improved regional water quality and ecological monitoring and research programme under the DOE. This would be to establish a coordinated pollution monitoring system to plan and act on trends in the problems of industrial, agricultural and sanitation pollution. This same facility should also provide services for project planning as a means of generating operating income.

Project Development

It is proposed initially that an environmental management plan should be established in the Lower Atrai, closely co-ordinated with the Lower Atrai Sub-Regional Plan and other on-going work, for example being undertaken by FAP17. The EMP would develop environmental criteria for the Sub-Regional Plan, undertake the wetland research and monitoring referred to above, and begin to undertake ecological monitoring.

An initial sum of Tk 30 million has been included in the plan over three years to establish the EMP. Further investment and recurrent expenditures will obviously be required subsequently.

8.6 Plan Financing and Recurrent Expenditure

Table 8.3 indicates the plan financing requirements.

Financing requirements are shown just for the short-and medium-term, since costs of projects in the long-term could be only speculative at this stage. The table gives detailed financing plans for the proposed FAP2 projects, and summary expenditures for other on-going and proposed projects. Full details of all plan expenditures are shown in Appendix 2.

The proposed FAP2 projects comprise about 10% of the total plan expenditures of Tk 33.7 bn. on structural works. While this may seem to be relatively small, it needs to be put in context.

First, about 30% of all plan expenditures will go towards completion of the Teesta Irrigation Project. Second, a further 22% of all plan expenditures will go to the Pabna Irrigation Project Phase II and North Rajshahi Irrigation Project. Therefore over 50% of all plan expenditures are allocated to major surface water irrigation projects. Third, a further 75% of total plan expenditures are committed to four major projects. The FAP2 proposals comprise about 40% of remaining plan expenditures.

The FAP2 proposals do not include an irrigation component, and the expansion of groundwater irrigation seems likely to continue in any case, predominantly if not entirely in the private sector. In terms of expenditures on flood control and drainage, all the FAP projects including FAP2 proposals are highly significant, comprising about 83% of all plan expenditures on flood control and drainage. The largest single element within this expenditure is sealing of the BRE, a priority which FAP2 supports.

Expenditures for flood proofing and an Environmental Management Plan (EMP) are included in the short-term plan. These expenditures will support components such as raised shelters on charlands, and ecological monitoring in the Lower Atrai, which will be evaluated before further expenditures can be estimated. It is important to initiate these works early in the plan.

Table 8.3 NW Region: Financial Requirements of the Short and Medium Term Plans (Tk. million)

Name of the project	Years														
	Short Term					Medium Term									
	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-2000	00-01	01-02	02-03	03-04	04-05	05-06	Total
A. ONGOING BWDB PROJECTS	1062.93	1758.55	1529.01	1543.50	1800.00	1800.00	1200.00	842.80							11536.79
B. PROPOSED BWDB PROJECTS	19.7	473	876.6	1186.1	2051	2391	1139	736	427	36					9335.6
C. PROPOSED FAP PROJECTS (Excluding FAP2)	194	1033	965	1032	539.8	723.7	716.7	677.8	600	600	600	600	600	600	9482.0
D. FAP-2 PROJECTS															
Gaibandha		41.7	54.4	218.1	399.8	470.2	230.5	91.3	35.6	41.7	60.3	26.5			1670.1
Sub Reg Plan		50	50												100.0
Polder C&D		20.2	20.2	20.2	51.6	120.4	137.6	34.4							404.6
Little Jamuna R B		3.4	9.1	15.1	6										33.6
Polder 3					9.8	13.3	31	35.4	8.8						98.3
SIRDP						7.7	7.7	7.7	21.9	51.2	58.5	14.6			169.3
Polder A&B							16.2	16.2	16.2	41.3	96.4	110.2	27.5		324.0
Teesta Left Bank							22.6	22.6	22.6	64.5	150.4	171.9	43		497.6
Flood Proofing		20	20	20	20	20									100.0
Environmental Management Plan		10	10	10											30.0
Sub-Total (FAP2)		145.3	163.7	283.4	487.2	631.6	445.6	207.6	105.1	198.7	365.6	323.2	70.5	0	3427.5
TOTAL	1277	3410	3535	4045	4878	5546	3501	2464	1132	835	966	923	671	600	33781.9

Source: Consultant's Estimates and BWDB.

Notes:
1. Costs of compartmentalisation in NWR has been assumed as the same as the ongoing project at Tangail.
2. In the absence of estimated cost, parametric cost has been assumed for some projects.
3. Estimates for flood proofing and the Environmental Management Plan are for initial programmes only. Future Expenditures would be assessed after evaluation.

The plan expenditures appear to be reasonably in line with the National Water Plan. For the remaining 3 years of the Fourth Five-Year Plan period, the regional plan expenditure is about Tk 8.4 bn, compared with a total plan expenditure for the whole FFYP period of Tk 48 bn. Proportionate to population, the share of the NW region appears reasonable. The plan expenditure for the region in the Fifth Five-Year Plan period is almost Tk 17 bn, but expenditures thereafter would be lower.

Table 8.4 shows the associated O&M requirements which, unlike the plan investments, continue to increase throughout the period. O&M costs of completed projects are included, the most notable being the Pabna Project Phase I. In general, the highest O&M expenditures are allocated for the largest investment projects, i.e. Teesta and North Rajshahi Irrigation Projects and the BRE. Total O&M requirements over the regional plan period are Tk 6.8 bn, i.e. 20% of the total plan investment expenditures over the same period.

8.7 Institutional Issues

Institutional arrangements for implementing and monitoring the plan are under consideration in a number of quarters, notably FAP26. Issues to be addressed include the following:

a) the planning function for the FAP programmes, and in particular the relationship between FPCO and WARPO, formerly MPO. At the present stage of development of FAP, considerable reliance is being put on outside consultants, and FPCO is too short-staffed to be able to handle more than the administrative management of the programme. There is a need to put in place a local organisation who can manage the planning of FAP on a continuing basis and provide continuity between major studies and implementation, such as between FAP2 and FAP2.1 and 2.2. This will inevitably need consultants and other organisations to become involved. An additional factor to be considered is that FAP is mainly concerned with planning for the flood season (FAP2 is explicitly directed towards this) whereas it is becomingly widely recognised that there is a need to take an over-year view of water resources management. It is recommended that consideration should be given to reconstituting WARPO as an influential agency concerned with water resources planning, and that it should incorporate the planning functions of FPCO within it. There is probably a need to consider long-term consultancy support (on a limited scale) to assist WARPO in becoming effective.

b) co-ordinating planning with other on-going BWDB work. There are many other active programmes working on flood control development in the NW region (such as EIP, SRP) and initiatives under FAP need to be co-ordinated with the work done with these and other programmes through the Directors of Planning Schemes, and the Chief Engineer, Planning. The need will also arise to monitor the implementation and subsequent operation of the projects, to verify how they work and to confirm that they complement one another and do not involve conflicting measures in adjacent areas.

c) co-ordinating BWDB work with other complementary components of flood control development. Such components include agricultural extension, fisheries, navigation, health and environmental monitoring. In many cases, mechanisms for such co-ordination are not yet developed and FAP projects will have an important role to play in contributing to this process. Possible institutional arrangements for implementing a project such as the Gaibandha Improvement Project are discussed in the Gaibandha Final Report.

d) A further element of implementation, which also links to the aspect of sustainability, is the development of appropriate methods of "beneficiary participation". Traditional notions of beneficiary participation are perhaps not applicable in a highly-polarised society like Bangladesh, nor to CFD developments which by their nature impact directly on those outside

Table 8.4 NW Region: Operation & Maintenance Requirements of the Short and Medium Term Plans (Tk. million)

Name of the project	Year														Total
	Short Term					Medium Term									
	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-2000	2000-01	01-02	02-03	03-04	04-05	05-06	
A. ONGOING BWDB PROJECTS	15.8	17.1	29	31.2	35.4	35.4	46.4	46.4	166.4	166.4	166.4	166.4	166.4	166.4	1421.5
B. COMPLETED BWDB PROJECTS	124.89	125.94	136.25	136.40	138.40	139.50	139.70	139.708	139.708	139.70	139.70	139.70	139.70	139.70	2058.8
C. PROPOSED BWDB PROJECTS					10.1	10.1	48	76.6	114.8	151.3	281.3	281.3	281.3	281.3	1807.3
D. PROPOSED FAP PROJECTS (Excluding FAP2)				60	60	95	105	115	125	135	161	171	181	191	1530.0
E. FAP-2 PROJECTS															
Gaibandha											50	50	50	50	200.0
Sub Reg Plan															
Polder C&D							12	12	12	12	12	12	12	12	96.0
Little Jamuna R B				1	1	1	1	1	1	1	1	1	1	1	11.0
Polder 3											4	4	4	4	16.0
SIRDP												6	6	6	18.0
Sub-Total of FAP2				1	1	1	1	13	13	13	13	67	73	73	341.0
F. RELATED EXPENDITURES	0.5	0.5	0.5	1	1	1	1	1	1	1	1	1	1	1	13.5
TOTAL	141	144	166	169	236	282	341	392	500	546	702	766	782	792	6752.1

Source: Consultant's Estimates and BWDB the protected area. However, methods must be sought to minimise social conflict, as evidenced by embankment cutting and inoperative structures, in the planning, construction and operation of schemes. An important step lies in public consultation. Public consultation is a difficult concept to apply on a regional scale, except through elected representatives in parliament, as was carried out for FAP2 at the end of 1992 (a report of this meeting is given in the Annexes to the Final Report). However it can be more successfully applied at the local level, as discussed in detail in relation to the Gaibandha Project (details are given in Volume 11 of the Draft Final Report). Here again elected representatives,in this case union chairmen, can play an important role, but there are also other important methods of public consultation and participation at the local level, particularly direct meetings with groups of villagers. Problems of politicisation of issues are of course likely when MPs and elected representatives are involved: however this is the inevitable price that must be paid for democratisation of development, and in the long run is likely to lead to more successful and sustainable development.

e) Institutional issues relating to flood proofing are being addressed by FAP23. A programme of flood proofing should be instituted wherever possible.However, great care will be needed with the institutional arrangements for flood proofing so as to avoid the situation where central or local government has to take a major role. If this happens, the problem of lack of investment in the maintenance of the facilities is likely to occur, as it does with flood protection facilities. Villagers already have coping mechanisms to deal with floods, and one of the most important tasks required is to identify relatively low-cost ways to support their coping strategies and make them more effective.

f) A particular aspect of implementation concerns construction procedures, especially with regard to earthworks. It is important to carry out earthworks using manual labour as far as possible, in order to spread the benefits of investment to the landless, but great efforts must be made to improve the standard of construction. The emphasis must be on timely commencement of work, use of sound material, and satisfactory compaction and construction techniques. The use of labour contracting societies has generally resulted in better quality work, and the expansion of the LCS system is recommended. However, it must be accompanied by adequate support and supervision from NGOs/BRDB and technical staff.

g) It is important to ensure that, as far as possible, the social and environmental impacts of the plan are positive, for as many people as possible. Aspects of this are discussed in Chapter 7. It is also necessary to take a long-term, national view on the portfolio of projects being developed under FAP, in order to assess the Plan's overall sustainability. This would relate to such matters as the increasingly wide-spread use of intensive agricultural inputs, overall distributional effects of state-led investment between land-owners and landless, and downstream effects on a national scale.

8.8 Sustainability - The O&M Problem

There is general agreement that poor O&M is a major factor preventing the success of FCD projects. A great deal of interest is now being shown by Government and donors in trying to improve this situation. Within the FAP programme, two key components are FAP13, the O&M study, and FAP20, the Compartmentalisation Pilot Project. The latter is charged with developing a Local Water Management Board with responsibility for operation and water management. Outside the FAP, both EIP and SRP are developing sound approaches to the problem.

It is the practice to refer to O&M together. The two processes, though related, are distinct and will be treated separately here.

Operation

The problems of operation of completed facilities are made difficult by the nature of the topography in Bangladesh. Although land slopes are in general very low, considerable differences in micro-topography exist, so that it is possible to find adjacent parcels of land with level differences of 0.5m or more. Such differences can make the difference between farmers who want drainage because their crops are submerged, and those who wish to retain water because they fear moisture stress. Often it is not possible to accommodate this variety of needs because of the flat topography. In such circumstances it is inevitable that conflicts of interest will arise and that the process of operation will become a complicated process of political bargaining and negotiation. It has often been noted that gate committees are in fact dominated by influential landowners; this process seems likely to continue, given the structure of agrarian relations in Bangladesh, and CFD planning must take account of it.

Various factors are pertinent here. Firstly, it seems that at present there is very little tolerance for flooding caused by embankments. It has been remarked that head differences of as little as 0.3m are sufficient to lead to public cuts. Thus the first priority must be to improve drainage, since such improvements are not so obviously a source of disbenefit to others, and are anyway more difficult to sabotage. Secondly, in planning improvements, it is desirable to start, as far as possible, from the downstream end, so that such disbenefits are in any case minimised.

Maintenance

Maintenance requires an inventory of the assets to be maintained, procedures and programmes for the maintenance tasks, and resources (staff and funds) to carry them out. In the case of CFD infrastructure, BWDB have recently had an inventory of assets completed. Whilst this is still incomplete, it is nevertheless a useful first step in determining the magnitude of the overall maintenance tasks. Every effort should therefore be made to continually improve this asset register, and develop from it an estimate of maintenance (and rehabilitation) requirements.

Maintenance procedures and programmes for FCD facilities are simple, well-known and understood. The mechanical equipment involved is fairly basic and does not require sophisticated technical know-how. Earthworks maintenance, such as embankment repair and khal re-excavation is already a common activity, particularly under the Food-for-Works programme.

Funds for O&M

A significant constraint on effective O & M is shortage of funds. At present funds come through cash allocations from BWDB's revenue allocation or through FFW programmes. BWDB is legally not able to raise charges for CFD directly: most of their O & M allocation is in any case connected to establishment charges.

Various alternatives are now under consideration to improve this situation. Amongst these is investigation of methods of charging beneficiaries directly. This of course requires that the facilities function effectively and are accepted by the beneficiaries. A complementary measure is to involve the local councils, who are locally accountable through their elected representatives, to be active in mobilising resources locally. Charge rates for FCD provisions are clearly difficult to establish since benefit levels are debatable.

Institutional Arrangements

Apart from funds, people are the most important resource in O&M. It has been noted that many O&M posts, particularly at the kalashi level, are unfilled, and that BWDB has difficulty in fulfilling the institutional role of O&M adequately. A variety of measures have been proposed to redress this situation. One is "beneficiary participation". The long-term sustainability of the project facilities depends on the participation of the people in their proper operation and maintenance.

An additional approach is to widen the scope of institutions involved in the O & M process. Possible institutions include BRDB, LGEB and the NGOs. The two latter are the most likely candidates for such involvement, though in both cases their experience to date has been fairly limited in the water resources sector; they also have very limited financial resource and budgets.

8.9 Future Action

Two priority projects should follow directly from the North West Regional Study (FAP2). These are implementation of the Gaibandha Improvement Project (FAP2.1) and Feasibility Studies for Priority Projects and Sub-Regional Planning in the Lower Atrai (FAP2.2) under the green river concept.

The implementation of the Gaibandha Improvement Project is described in detail in the Gaibandha Final Report. This involves an intensive period of further planning and detailed design leading to a programme of river training works, CFD and areal development.

Work in the Lower Atrai involves a feasibility study for the restructuring of Polder C and D together with sub-regional planning involving as least the following :

- further development of the sub-regional hydrodynamic model used by NWRS, as a planning tool;
- systematic public consultation throughout the Lower Atrai, to complement the rapid rural appraisals, MPs' meeting and ad-hoc consultations already held.
- liaison with FAP16 on wetlands needs assessment and FAP17 on fisheries development in the lower Atrai;
- monitoring the performance of the Naogaon and Barnai projects;
- co-ordination with other programmes working in the Lower Atrai, notably EIP on the redesign of Bogra Polders 2 and 3.

Terms of Reference for FAP2.1 and FAP2.2 should be prepared as soon as possible, with a view to commencement in late 1993.

APPENDIX 1

EXISTING FCD AND FCD/I DEVELOPMENT

Table 1 *Existing/FCD and FCD/I projects in the Region*

Name of Projects	Related River	Type of Develop	Existing Facilities				Funding Agency
			Projects Area(sq.km)	Length of Flood Embkt.(km)	Nos. of Regulators /Sluices	Length of Drainage Canal (km)	
Regional:							
Brahmaputra Right Embk.	Jamuna	FCD	2258	210	31	-	IDA
Ganges left Embk.	Ganges	FCD	-	92	-	-	IDA
Lower Atrai:							
Pabna Project Phase-I	Hurasagar	FCDI	1967	160	48	93	ADB
Chalan Beel Polder-A	Atrai	FCD	306	-	-	-	IDA
Chalan Beel Polder-B	Atrai/Barnai	FCD	321	103	7	69	IDA
Chalan Beel Polder-C	Atrai/Barnai	FCD	436	138	11	81	IDA
Chalan Beel Polder-D	Atrai/Sib/Barnai	FCD	531	134	17	115	IDA
Hurasagar	Atrai/Bangali	FCD	365	12.5	2	77	IFAD
SIRDP	Atrai/Bangali	FCD/I	974	55	14	44	IDA
Nagor Valley	Atrai/Nagor/L.Jamuna	FCD	358	59	12	7	EIP
Rakdaha-Lohachura	Atrai/L.Jamuna	FCD	747	13	15	30	EIP
Tulshiganga	L.Jamuna/Tulshiganga	FCD	251	150	19	-	EIP
Potnitola	Atrai	FCD	20	24	4	-	IDA
Chilimpur	Atrai	FCD	36	17	3	-	IDA
Faliar Beel	Atrai	FCD	27	1	-	-	EIP
Nagor River	Nagor	FCD	154	24	1	-	EIP
Karnahar-Barabila	Barnai	FCD	50	30	6	6	EIP
Bhedra Beel	Nandakuja	FCD	130	-	-	47	EIP
Upper Atrai:							
Punarbhaba Flood embkt	Punarbhaba	FCD	70	16	6	-	IDA

Name of Projects	Related River	Type of Develop	Existing Facilities				Funding Agency
			Projects Area(sq.km)	Length of Flood Embkt.(km)	Nos. of Regulators /Sluices	Length of Drainage Canal (km)	
Karatoya/Bangali/Ghagot:							
Nurrullar Beel	Karatoya	FCD	166	31	4	5	EIP
Sonail	Alai/Brahmaputra	FCD	57	19	3	-	EIP
Satdamua-Katler Beel	Ghagot	FCD	21	19	9	0	EIP
Gajaria-Ichamati	Ichamati/Karatoya	FCD	102	-	2	48	
Gangnai river project	Karatoya	FCD	39	-	1	16	IDA
Panchanala-Kaya beels	Karatoya	FCD	24		7		IDA
Sarala chalunia	Karatoya	FCD	12				IDA
Sowra beel prject	Karatoya	FCD	25				EIP
Naleya Beel	Karatoya	FCD	55		3	20	-
Sardagari	Karatoya	FCD	36		2		-
Teesta:							
Sati Nadi	Teesta	FCDI	141	26	7	-	EIP
Teesta South Embkt.	Teesta	FCD	768	119	1	503	EIP
Mohananda:							
Morichar Danra proj.	Mohananda	FCD	56	12	2	5	IDA
Bhitabari-Damos	Mohananda	FCD	140	2	1	16	EIP
Singri-Boni & other beels	Mohananda	FCD	37	1	3		IDA
Bhatia beel scheme	Mohananda	FCD	30	-	2	20	EIP
Shomespur beel scheme	Mohananda	FCD	14	2	2	-	IDA
Kumiradaha	Pagla	FCD	26	-	1	2	IDA
Tokerdanra beel scheme	Pagla	FCD	20	5	1		IDA

Source: 1. Updating of the Inventory of Water Development systems, June, 1991, BWDB/UNDP
2. Data from the Executing offices of BWDB in the Northwest Region.

Remarks: 1. Projects Covering less than 12 sq.km are not included.

Table 2 On-going FCD and FCD/I projects in the Region

Name of Projects	Related River	Type of Develop	Existing Facilities				Funding Agency
			Projects Area (sq.km)	Length of Flood Embkt. (km)	Nos. of Regulators/Sluices	Length of Drainage Canal (km)	
Lower Atrai:							
Barnai	Barnai	FCD	566	50	44	448	IDA
Tulshiganga Left	Tulshiganga	FCD	120	28	10	-	EIP
Naogaon Polder-I	Atrai/L.Jamuna	FCD	461	64	5	74	IDA
Badalgachi	L.Jamuna	FCD	140	37	6	1	EIP
Upper Nagor Valley	Nagor	FCD	41	27	12	5	IDA
Upper Nagor River	Nagor	FCD	130	37	10	-	EIP
Jamgaon Danra	L. Jamuna	FCD	74	-	-	15	EIP
Protappur Scheme-I	Nagor	FCDI	51	-			SRP
Upper Atrai:							
Atrai-Kakra	Atrai	FCD	52	42	39	11	IDA
Teesta:							
Teesta Irrigation	Teesta	FCD	2,223	-		80	SFD
Kurigram FCDI	Teesta/Dharla/Dudkumar	FCD	1060	169		119	IDA
Buri Teesta	Teesta	I	90	-	-	-	SRP
Bangali Karatoya:							
Gangnai River	Karatoya	FCDI	39				SRP
Karatoya left embkt.	Karatoya	FCD	-				EIP

Source: 1. Updating of the Inventory of Water Development systems, June, 1991, BWDB/UNDP
2. Data from the Executing offices of BWDB in the Northwest Region.

Remarks: 1. Projects Covering less than 12 sq.km are not included.

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Table 3 Proposed or Future Projects in the Region (not under FAP)

	Name of Projects	Type of Develop	Project Area (sq. km.)	Project Cost (MT.)	Funding Agency
1.	Pabna Phase II	I	689	2581	ADB
2.	Baral Basin Phase I	FCDI	648	300	CIDA
3.	Upper Tulshiganga Right *	FCDI	120	60	EIP
4.	Upper Tulshiganga Left *	FCD	80	50	EIP
5.	North Rajshahi Irrigation	I	722	4980	JAPAN
6.	Kurigram North (New)	FCDI	413	596	"
7.	Kurigam South (New)	FCDI	635	-	"
8.	Rehabilitation of SIRDP	FCD	630	-	(Note 3)
9.	Ghagot Right Embkt. *	FCDI	150	130	EIP
10.	Gajaria/Ichamati	FCD	163	590	SRP
11.	Kamarnai Project *	FCD	17	11	SRP
12.	WCS of greater Dinajpur	FCDI	56	329	SRP
13.	LLP Scheme Dinajpur	I	23	162	SRP
14.	Rehabilitation of Morichar Danra	FCDI	102	61	SRP
15.	Nagor River Project (Redesign)	FCD	154	2	EIP
16.	Nagor Valley (Redesign)	FCD	358	4	EIP
17.	Sonail Embankment (Redesign)	FCD	57	1	EIP
18.	Rehabilitation of Sowra Beel	FCD	25	3	EIP

(1) Data from the Executing offices of BWDB in the Northwest Region.
(2) Funding Agency is yet to be confirmed in some cases.

* Parametic cost by comparison with similar projects.

Table 4 Names of Completed and Ongoing Irrigation Projects

Sl. No.	Name of Projects	Project Area (sq.km.)
	Completed	
1.	Pabna Project (Phase-1)	1846
2.	Buri Teesta Irrigation	118
3.	Tangon river	71
4.	Buri bundh	32
5.	Pathraj bundh	25
6.	Bulli bundh	31
7.	Gangnai river	39
8.	Protappur	42
9.	Belamati river	24
10.	Pam river	12
11.	Shaheber bundh	16
12.	Kathgiri Nelsa Danra	12
13.	GWD and LLP projects in Northern district of Bangladesh (DTW-381, LLP-310)	523
14	North Bengal Tube wells (DTW-900)	446
	Ongoing	
1.	Teesta Barrage Project (Phase-1)	1826

1. Projects less than 12 sq km. in area have not been included.

Table 5 Ongoing O&M of Projects under SSFCDI

Sl. No.	Name of Projects	Project Area (ha)
1.	Damdama Khari	4750
2.	Singimari beel	1600
3.	Rahmatpur	5400
4.	Rajuria Maheshpur	427
5.	Toker Danra	1650
6.	Singri, Boni and other beels	9655
7.	Tulsiganga	1979
8.	Patnitola	1955
9.	Chilimpur	3557
10.	Jhanjhani Haldigachi	8174
11.	Teesta right embankment	7836
12.	Panchanala Kaya beel	2400
13.	Bahagali giria beel	345
14.	Sarala Chalunia	1250
15.	Chirir bandar LLP	389
16.	Pathraj bundh	1500
17.	LLP block-2	480
18.	Shomeshpur Danra	6000

Table 6 BWDB completed small scale projects

Name of the Project	Year of Completion	Type	Area	Cost Million Tk
Appurtenant Structure at Atrai under CBP Polder C	1987	FCDI	3846	1.0
Appurtenant Structure at Singra under CBP Polder C	1987	FCDI	3800	2.1
Belamati riverProject	1985	I	2429	2.0
Fatejangpur Kumargari scheme	1985	FCDI	1215	2.0
Tengaria Gobindapur	1987	I	900	1.3
Choto Dhepa Irrigation Scheme	1987	I	810	1.4
Regulator at Tangomari	1987	I	5061	2.9
Appurtenant structure for Kurigram project	1987	FCD	4453	1.7
Pam nadi Scheme	1985	FCDI	1215	1.1
Pam nadi WCS	1987	FCDI	1215	0.2
Bhabranga Dudkura Scheme	1986	FCDI	810	2.2
Shaheber Bundh Scheme	1986	FCDI	1619	2.2
Pathraj Bundh Scheme	1986	I	1215	1.5
Kathgiri Nelsh Danra Scheme	1987	FCDI	1215	1.7
Petki Nadi Scheme	1984	I	810	2.3
Buri Bundh Scheme	1987	I	3239	1.0
Belhara Barabari irr Scheme	1985	I	486	0.2
Appurtenant structure on Ganges Basin at Shibganj	1987	FCD	4858	11.6
Somespur Beel Scheme	1987	FCD	1417	2.3
Velkar Beel Scheme	1987	FCD	1296	4.0
Appurtenent Structure in Roktadaha Luhachura Scheme	1987	FCD	3320	2.8
Appurtenant structure on Ganges Basin	1985	FCD	7689	3.5
Baraputhia ghat Scheme	1984	I	1134	1.4
Appurtenant structure,BRE	1987	I	13010	4.2
Serajganj North Water Management Project(a)	1985	FCD	2834	1.8
Serajganj North Water Management Project(b)	1986	FCD	5466	0.7
PanchnalaKoya Beel Scheme	1983	FCD	1214	4.0
BahagaliGiria Beel Scheme	1987	FCD	1425	1.0
Rahmatpur FCDI project,Haripur	1979	FCD	2100	6.0
Regulator over Bidirpur Khari	1987	FCDI	4000	5.0
Sarala Chalunia Beel Scheme	1977	FCDI	1943	1.1
Siramali regulator	1988	FCDI	2735	3.6
Paschim Dhanigram regulator	1988	FCDI	580	3.9
Bhurungamari regulator	1988	FCDI	910	3.0
Bhulli Bundh Project	1978	I	2333	1.7

Table 6 BWDB completed small scale projects

Name of the Project	Year of Completion	Type	Area	Cost Million Tk
Pathraj Bundh Project	1960	I	2550	0.7
Water control Structures in Dinajpur	1982	I	8296	12.6
Akhira Drainage scheme	1988	FCDI	13000	11.5
Water control Structures at Kazipur	1981	I	283	0.1
Water control Structures on Khalider khal	1981	I	41	0.0
Water control Structures At Belahati on Iramati	1981	I	526	0.4
Water control Structures at Sonakania on Dublagari	1981	I	486	0.3
Water control Structures At Rathuabari on Dublagari	1981	I	405	0.3
Water control Structures at brindabonpara on Subil	1981	I	162	0.2
Water control Structures at Fulbari on sukdaha	1981	I	122	0.6
Water control Structures at Baithbhanga on sukdaha	1983	I	243	1.3
Water control Structures at Jugibhita on Naudahaor	1983	I	405	0.4
Improvement of Faliar Beel	1982	FCD	2720	8.1
Water control Structures at Bharahat on Harabati	1983	I	243	0.4
Water control Structures at Charbakhra on Naugola	1983	I	324	0.5
Water control Structures At Ramshala on Ramshala khal	1983	I	203	0.4
Water control Structures at Ambagan in Kishoreganj	1983	I	202	0.4
Water control Structures at Chilagacha on Chilagacha	1983	I	405	0.3
Water control Structures at Gajaria on Baniagaon river	1983	I	405	0.4
Water control Structures at Purba Delua on Karatoya	1983	I	203	0.1
Reexcavation of Chakal Tangorgari and Laxmipur Beel	1964	FCD	1088	0.4
Regulator in Bisha union	1977	FCDI	1943	0.7
Flood embankment and regulator at Jotebazar	1977	FCDI	5957	1.0
Reexcavation of dr. channel for Dixshi Beel	1963	FCDI	1502	0.3
Reexcavation of dr. channel for Jalkachara Beel	1968	FCDI	2720	0.4

Table 6 BWDB completed small scale projects

Name of the Project	Year of Completion	Type	Area	Cost Million Tk
Water control Structures at outfall of Dashbhanga khal	1982	FCDI	202	0.7
Water control Structures at outfall of Gachpara khal	1982	FCDI	202	0.7
Water control Structures at Dibigram	1982	FCDI	202	0.7
Water control Structures at outfall of Ratnai River	1982	FCDI	2024	1.9
Water control Structures at Bhatichara on mora Bangali	1983	FCDI	243	0.4
Water control Structures At Malibari over Lunga Khal	1984	FCDI	2428	2.4
RCC bridge at Jorgacha on Mora Bangali	1984	FCDI	1214	2.1
Water control Structures at Shazipur on Iramati khari	1984	FCDI	809	0.8
Brick masonry regulator on Gangnai river	1984	FCDI	2024	1.1
WCS of Serajganj North Water Management	1985	FCDI	NA	0.7
Tirnai river Scheme	1982	I	486	0.7
Versha river Scheme	1988	I	567	0.8
Tultia river Scheme	1986	I	223	0.0
Ramchandi river Scheme	1988	I	526	0.7
Appurtenant structures on Ganges Basin Scheme	1987	FCDI	4858	11.6
Shomeshpur beel dr scheme in Aghoria	1978	FCD	2347	4.2
Chiknai Ghechua Bundh scheme	1980	FCD	5828	9.0
Flushing Regulator on Mora Bangali	1986	FCD	16188	1.4
Re excavation of dry channels of Kamargari and other beel	1980	FCD	1619	0.4
Marichar Danra Scheme	1977	FCD	5569	4.6
App str on Damdama khari in Singra	1992	FCD	4750	5.4
App str in singimari beel in Nilphamari	1992	FCD	1600	11.5
App str in Rajuria Moheshpur in Kaharol	1992	FCD	427	4.62
App str on Singri Boni and other beels In Nawabganj and Nachol	1992	FCD	9655	10.06
App str in Patnitala project in Patnitala	1992	FCD	1955	23.15
App str in Chilimpur Chaligram project In Mahadevpur and Patnitala	1992	FCD	3557	19.43
App str on Jhanjhani and Haldigachi in Bholahat	1992	FCD	8174	16.05
15 WCS in Dinajpur & Thakurgaon	1982	I	8296	17.6
8 WCS in Parbatipur	1984	I	2226	6.8

Projects Prior to 1960 has not been included as these have outlived useful life.