Table 4.1 Numerical Summary of Impacts by Assessment Criteria

Item	Positive	Negative
Total Number of Impacts Listed	30	69
Total Number of Major Impacts	10	30
Total Number of Minor Impacts	20	39
Of the Major Impacts		
- No. Critical Magnitude	2	9
- No. Critical Intensity	1	7
- No. Critical Scale Accumulation	NA	7
- No. Irreversible Effects	NA	6
- No. Increased Instability	NA	19
- No. Unsustainable Productivity	NA	19

The following chapter looks at the range of resources that may be affected by the regional projects It also carries out a specific impact matrix analysis of each of the main regional schemes.

4.2 Construction Resource Demands

The most considerable demand on resources of FCD projects will be the drain on current and future foreign exchange and local financial resources. There will also be a considerable demand for construction materials, management and labour. It will only be appropriate to analyze these during the feasibility studies and once the details of a proper regional plan become available. The following are some comments which have relevance for the types of studies which ought to be considered during the feasibility study stage.

Hard Rock, Aggregates and Sand

The option of alternative supplies is still uncertain. Geological surveys have found large deposits of hard rock at 130 m. depth located at Modhyapara in Dinajpur District. Sources of poor quality river gravel aggregates are quarried from government owned river bed area along the Teesta and the northern border hills. The Piedmont deposits are found as lenses in Panchagarh and Lalmonirhat Districts at depths down to 5 m but are very limited in their availability. River gravels are more typically collected from limited sources mainly in Greater Sylhet.

High grade sands for concrete are available in exploitable quantities in the piedmont areas of the northern region and in the upper reaches of the Brahmaputra and the Meghna. Good quality sands also occur locally to the Teesta river. Building sand in the NWR is usually a mixture of local river sand mixed with high quality sand.

Demands for both materials will compete with the needs of alternative users. High quality sand also potentially has a limited renewal, depending on the rate of erosion and recharge. Large short-term demands for building sand might affect the medium-term economic viability of existing lease sites. The project induced demand and competition with existing users will need to be assessed. These sites should also be surveyed to establish if sites of historical or archaeological interest may be affected.

Fuel and Energy

The primary requirement of the projects for fuel and energy will be in the processing of construction materials. Kiln burnt bricks will be required for building and road construction. The shortages of hard rock and river gravel deposits in Bangladesh mean that broken bricks are most commonly used as a source of aggregate in concrete. These are obtainable from privately owned brick works scattered throughout the region. Brick demand will have resource implications. Firing of bricks in seasonal kilns predominantly uses local timber resources that are heavily exploited even though there are official restrictions on the use of these.

The kilns also use imported coal from India. Local coal deposits exist in three locations in the NWR. Deep deposits at Jamalgonj in Bogra District are not economically viable to extract. Deposits at Barapukuria in Dinajpur District have undergone feasibility study and may be developed in the near future. Further deposits known to exist at Khalaspir in Rangpur have yet to undergo detailed mining study. These resources are sufficiently large to supply all the needs of the full plan if implemented. It is clear whether timely development of these mines would allow supplies to come from these local sources in the period of proposed construction. Local natural gas supplies, as an alternative fuel, are not available in the NWR.
The brick field sites provide income for the land owners selling clay or timber and generate local employment until the site resources are used up. Further employment is generated in the breaking down of bricks into aggregate. Surveys of brick fields along the road from Nagarbari-Sirajganj-Bogra-Fulchari (Pastarkia, C. 1991) showed that brick fields are established on rented land close to a source of suitable clay. They only operate in the dry season and use single or multiple burners with sectional chimneys. The units are constructed of brick and earth. A single chimney kiln can produce around 130 000 bricks from each firing, with an average of five firings a season. In spite of 1984 prohibition on the use of timber to protect dwindling timber resources in the country timber is still the main fuel used throughout virtually all the brick fields although an estimated 20% also use some proportion of coal. Assuming one cubic metre comprise 500 bricks the fuel requirements needed to produce 1 000 cu.m. of bricks would be 115 tonnes of coal or 285 tonnes of timber.

The total requirement for brick of all the NWR projects would amount to a minimum of around 14 500 cu.m. This would need almost 1 200 tonnes of coal or 4 100 tonnes of timber. It would be the equivalent of the annual output from 11 single chimney kilns. As the phasing of these works will be spread over a considerable number of years supply problems are unlikely to occur. Of more concern is the cumulative impacts on timber and land resources when these projects are taken together with the additional works proposed for the BRE which could have a demand for up to 87 000 tonnes of timber. These fuel issues might be looked at in more detail during the feasibility study stage.

Impacts of Development

The development of a brick field temporarily takes land out of production and it is not unusual for the field to be abandoned after use with mounds of discarded bricks becoming grassed over. Where surface clay deposits are available the thickness is sold and farmers can continue with cultivation at a lower level. Where excavation for buried deposits occurs the deep borrow areas are not brought back into any form of productive use.

The overall loss of land is not regionally significant for the initial construction phase. This impact will be cumulative over the years to come, as maintenance or re-building of works will continue for as long as this technology is applicable.

Of far more significance is the continued denudation of local timber stocks from local village and homestead groves consisting of fruit, shade and bamboo. The extensive use of bamboo in the urban construction and other timber using industries and the use of their roots in the brick fields has been raised as a source of concern in the media. The total national growing stock of bamboo was estimated in 1984 to be 1.8 million tonnes in private ownership and 0.78 million tonnes in state forests. It has been estimated that village forests in the early 1980s were being exploited at twice their sustainable yield while the gap between demand and supply (a fourfold factor in the early 1980s) is widening continuously. A total reduction of national village grove resources of 35% between 1981 and 2 000 has been forecast (MOEF/IUCN 1991).

Contract specifications, conditionalities and close supervision during construction on specified coal fired bricks will be the most effective ways of mitigating for this potential cumulative impact. However, this mitigation itself could involve the loss of local income and employment if the contractor used larger brick works away from the area of construction or where the coal resource was imported from India.

4.3 Impact of Groundwater Development

The impact of groundwater development could include the physical or the bio-chemical dynamics of the groundwater system. The physical responses may include:

- reduced aquifer recharge
- reduced drainage to low lands;
- implications of flood protection on the groundwater balance of high lands and the possible need for additional supplementary irrigation during the monsoon season;
- effects on rural water supply.
- effects on river seasonal base flows

Reduced Aquifer Recharge and Potential

Analysis showed that groundwater levels are a close reflection of flood levels during the monsoon season. With flood control and the consequent reduction in flood levels, the groundwater levels will also show a reduction in level similar to that of the flood levels. Post monsoon groundwater tables recede to levels in January which are nearly identical to those existing pre-FCD. In the latter part of the dry season, which coincides with the main irrigation season, virtually no difference in groundwater levels are observed for no flood control or full flood control conditions.

The impact of flood control on the potential recharge and the upper limit of the resource availability was assessed for three basic conditions; no flood control, partial protection, and full flood control. The difference between no flood control and full flood control is very marked, particularly for upazilas with a large proportion of F1 land, which, under full flood control is assumed to be fully protected from flooding. The mean reduction in potential recharge for all the thanas studied was 30%, in the case of full FCD. The difference between no flood control and partial protection is only minor (3%), but is dependent on the assumptions being made.

The dramatic reduction in potential recharge should not be directly related to a reduction in groundwater resource potential, since other factors, such as land availability and well technology, often control the limits on resource development.

Analysis of the upper limits of groundwater resource development potential showed that 16 of the 70 thanas studied, constraints to full development from groundwater may exist. The mean maximum development as a percentage of NCA for these areas was 85%. Under full FCD this reduced to 75%.

An analysis was also carried out of the upper limits of groundwater resource development potential for full FCD conditions. A further 10 thanas showed a reduction in resource potential, which is in all cases caused by the reduction in usable recharge. These thanas lie in the Lower Atrai basin and on the Mohananda basin. Thanas along the Teesta show no reduction in groundwater resource development potential due to full FCD. It should be noted that these constraints relate to deep tube wells (force mode units). The development limits that can be reached by shallow tube wells (suction mode development) are generally unaffected by the flood control measures since their upper limit is below that of force mode units.

Groundwater salinity forms no constraint in the Northwest Region to its use for irrigation and water supply.

Reduced Drainage to Low Lands

Localised drainage is strongly controlled by local relief. Elevation differences between F0 and F4 land can be in excess of three metres. After the monsoon season a rapid decline in flood levels occurs. Falls in the groundwater levels on highland lag behind those on lowlands. The localised groundwater level differences can cause lateral drainage from highland to lowland.

Surface water in lowland areas used for irrigation of local boro could originate from local drainage of highland areas. With development of groundwater a more rapid decline of water levels in the highlands will occur reducing drainage to the lowlands. Conditions may alter to the extent that the lowland surface water bodies start to contribute to the aquifer (a reversal of the natural process).

Extensive flood protection may also cause the type of drainage described above to occur during the monsoon season. This may have an implication on the rice crops grown on the high lands, particularly during dry years when supplementary irrigation may be needed during the monsoon season, particularly for T. aman.

Effect on Rural Water Supply

The optimum development of groundwater resources requires in nearly all cases the use of village hand tubewells fitted with Tara pumps, which allow for a maximum lift of 15 m. This 15 m is measured from village level.

The areas already affected by seasonal lower of water tables are shown in Figure 2.3. This also assess the potential for future problems based on the ability for further development to occur. These problem are main related to the Lower Atrai.

It is of great importance that the response of the water table in village areas is continuously monitored in Thanas which experience a rapid increase in tubewell development. Contingency planning for replacement of village hand tubewells presently fitted with No 6 pumps needs to be considered.

Effect of Groundwater Development on Base Flow to Rivers

Reduction in the water tables and earlier drainage of water to lowland could effect the levels of the dry season base flows to rivers. This could have important implications on the availability of water for LLP irrigation, the other users of these dry season water bodies (bathing, fish, etc) and for the water available for the continued flushing of pollutants throughout the year. The model analysis for the NWR indicated that dry season groundwater tables are little affected by FCD measures.

4.4 Biological Trends

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 indigenous tree species and forest areas have all but gone; to be replaced by homestead and horticultural varieties. This has severely impacted the larger mammals and land animals and woodland flora. The once extensive areas of wetland reedbeds and seasonal grasslands have been extensively transformed; first, into grazing for domestic livestock (the time scale of this event spans many generations) and then, more recently, into irrigation lands under the protection and influence of flood protection works (a time scale of less than 20 years). These areas were once extensively used by a wide diversity of resident and over-wintering migratory birds and other land animals. Only remnant systems can still be found in a few haors of the north east region and the coastal areas of Bangladesh.

These areas also provided the most diverse form of habitats for an enormous range of wildlife, particularly in the dry season. Many species of fish have becoming scarce through over-fishing and impeded migration due to embankments, regulators and irrigation canals. Other forms of aquatic flora and fauna have also gone through a rapid change. The most notable population explosion resulted from the introduction of water hyacinth to Bangladesh. In spite of apparent problems in borrow pits and unflushed water bodies it is resourcefully used for many productive purposes in the local fishing, agriculture and craft industries.

The extensive change to the species and population structures, the major shifts in the spatial distribution and the removal of many key species from the food web have also had many secondary impacts that as yet have been poorly researched and documented. The changes to the seasonal and spatial diversity of habitats directly affects the ability for many specifically adapted species to remain. The extent of human presence and disturbance has fundamentally affected the breeding, feeding and resting sites of many species. This has led to the widespread disappearance and, increasingly, extinction of species.

The abstraction of water from beels, the prevention of flushing and migration paths, the lack of refuge and diversity of breeding sites and the damming of the seasonal rivers are all critical pressure on the remaining resource base. Since the beels, and not the rivers, are the primary centres of the diverse ecology, this final stage of influence is very likely to lead to, (what will be seen by future generations to be) the final demise of the biological system as it had evolved to date. The floodland fisheries already show many signs that suggests a collapse to a fraction of their present level within ten years unless a drastically changed and improved fishery and wetland management programme can be implemented within the immediate future.

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 each will contribute cumulatively to the continued loss of the few important habitats that remain to support the species diversity.

In the NWR the transformation of the landscape and wetlands has been more complete than in other regions and the "natural" system and its floral and faunal associations have basically disappeared. Habitats for most terrestrial wildlife that cannot easily adapt to the human environment have already gone. There are, nevertheless, 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 proper resource study to specifically survey, assess, zones 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 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. Investigation of these relationships is vastly under-researched particularly from drawing on the wealth of indigenous knowledge which resides in the countryside and far less in the research institutes. With rural survival now so completely dependent on a mono-cropping agricultural system, to know so little of the functional relationships between the component species and systems and reflect this in policy and resource management support services to local communities is unsustainable.

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.

4.5 Project Impact Assessment

4.5.1 Approach

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 4.2 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. There are also important to interpret whether the resource management options are likely to be sustainable.

Flood control problems and interventions in the NWR are particularly complex and are not subject to simple technical solutions. The derivation of "numbers" in the matrix is, in some cases, highly sensitive to interactions between the physical, biological and human categories into which the matrix is divided. The matrix approach by definition starts by undertaking a divisible analysis; i.e. as though the answers in one category will be independent of answers in another. For issues dominated by interactions, the numbers which result usually highlight contradictory answers. Iteratively this is one of the main purposes of the impact analysis. However, matrices have become a standard form of summary presentation. In these cases the numbers presented must be viewed with understanding and caution.

The problem is best illustrated by example. The following shows a typical case where problems of indivisibility of analysis occur and where the matrix numbers are purely a starting point for interpretation. This example also how the technical tactics selected to solve one problem create a responsive reaction beyond the original intentions to solve problem:

Problem:	Flood levels, timing and duration lead to economic damage, social disruption and constrain new cropping patterns
Project Strategy:	FCD or CFD Polder to delay or exclude rise of flood
Physical Tactics:	Full and/or partial embankments
Divisible Analysis of Physical Response:	Lower or delayed peak water levels inside polder, higher water levels outside
Social Interaction:	Varying inequalities of water levels inside and outside, certain risk of public cuts
Holistic Analysis of Most Likely Actual Physical Response:	Uncertain water levels and no change in peak levels inside or outside

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.

4.5.2 Physical and Biological Impacts

Flooding and Drainage Conditions

The analysis of effects of the projects on flood timing, frequency and duration have been taken from hydrographs showing the internal water levels in years representing the 1:5 and 1:20 conditions. The effect is assessed on the assumption that no public cuts would occur. However, for all the projects and options involving embankments, the hydrographs of levels on the inside compared to the outside showed evidence that the risks of public cuts are high. The degree of reliability of any subsequent analysis which assumes that public cuts would not occur is thus uncertain.

The study considered many options for improving the flooding and drainage conditions of the Lower Atrai and removing the adverse effects of the existing polder schemes. The model results indicate that any confinement or poldering leads to some localised rises in water levels that makes the situation.

Table 4.2 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

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
SOCIAL EFFECT											
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 FCD Embankments
Lower Atrai 1 = Green River and Partial Protection — L. Atrai 2 = Green River with Max. Feasible FCD
Hurusagar 1 = 1:20 Years FCD 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 FCD without Drainage Compartments — Gaibandha 2 = 1:20 Year FCD with Drainage Compartments
Teesta R. Bank 1 = 1:50 Year FCD, River Training and Regulators (N.B. option = "do nothing")
Teesta L. Bank 1 = 1:20 Year FCD, River Training and Regulators — Teesta L. Bank 2 = 1:20 Year FCD, 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.

Any projects will thus involve trade-offs in reducing damage and risking public cuts; which themselves are a primary source of economic damage and social disruption.

The continued implementation of FCD projects, particularly the Barnai project, will make the future situation worse than the present. The configuration of the Green River, as analysed in this impact assessment (scenario A), also includes two potentially detachable sub-strategies of partial protection in existing polders, and retired embankments on high ground to protect areas which only suffer damage occasionally. The model results shows that both strategies cause a significant rise of localised water levels. This is due to the fact that to achieve partial protection for the stated agricultural

objectives requires embankments that are not too dissimilar from full FCD embankments. By comparison, the implications of the full FCD scenario would be to cause a rise of twice as much and raise the risks of public cutting accordingly.

The project showing the least response to the FCD works were on the Teesta left bank; the reason being that flooding which occurs outside of the active river channel arises from impeded drainage of water coming from Indian overland flow and not from spillage from the Teesta. Any embankments would tend to further impede this drainage. Whether this embankment can be justified is questionable.

The most significant drainage improvements are associated with the fully excavated Bengali drain. However, this option would create up to 19 million m^3 of dredged material to dispose of. The material could be unsuitable for use in FC embankments or for spreading on surrounding agricultural land. Sampling and analysis of these materials has not yet been carried out. Land filling of low lying ground would seriously affect wetland status and reduce the water storage capacity in the areas of fill. Transporting this material for disposal into the main channel of the Brahmaputra would be costly, and would create a number of technical problems for the phasing of construction.

If the drain were not excavated overall drainage improvements would be less and would be worse behind the embankments. Similar problems of impeded drainage behind embankments would also downgrade the full FCD options in Mohananda, Hurusagar and the Lower Atrai.

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 Bengali drain would open these channels to the Brahmaputra. The risks of capture of the Brahmaputra down the Alai or the Bengali 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 Bengali 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 Lower Bengali 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 once it can established that the break-through of Brahmaputra can be prevented.

Impact of developments in Lower Atrai

The impact on the Atrai system will be an increase in the sediment movement which could lead to erosion in the Mohadevpur area. At the junction of the Fikirni with the Atrai, more sediment would pass down the Atrai and less down the Fikirni. The sediment movement down the Barnai would be reduced. An increase in channel width of between 5 and 15% could be expected with larger changes occurring in the reach from Jotebazar to Singra and particularly at the Railway bridge area where the changes could approach 40%, the development of meanders and corresponding increases in channel depth of 5 to 12%. Reduced discharges in the Fikirni would lead to long-term siltation in the river. The reduced sediment input to the Fikirni may affect the timescale of this process. A reduction in channel width of 10 to 12 % could be expected and a corresponding reduction in depth of approximately 10%. This would have an adverse effect on water levels in this area.

Impact of sealing the BRE breaches

The rivers of the Middle Bangali basin will return to conditions similar to those that existing in the early 1980's if the BRE is effectively sealed. It is unclear whether Bangali is 'in regime' with the increased flows and sediment which passes through the breaches in the BRE. It is not possible to predict what the impact on river morphology will be. If it were 'in regime' the likely impacts 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 sediment deposition will be reduced in the areas immediately behind the breaches and also in the areas adjacent to the breach channels. Sealing the BRE will not impact the morphology of the Brahmaputra.

Impact of sealing the Teesta Right Embankment

If the river moves to the south-west then breaches will occur and 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 where, if the TRE is to be effective in reducing flooding down the Ghagot, it is imperative that the TRE separates the Teesta from the Ghagot. It is necessary to prevent any further moving westwards. Unfortunately this critical location coincides with one of the unstable reaches.

The proposed FAP 1 protection of the BRE might be applicable to establish a number of hard points. 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. If spillage from the Teesta into the Ghagot is prevented the results suggest that, in the long-term, the channel would reduce significantly in both width and depth and the river course would become much less tortuous than at present.

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. FCD 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.

Hydrology and Groundwater

Replacement of village pump technology, and deep setting of STW, are strategies that are already being undertaking in some areas. This response would be a legitimate mitigation for FCD schemes to carry out. The resulting change in village water supply technology would also solve other health problems. Existing poor water quality is often due to pollution in the vicinity of the hand pump and the fact that traditional pumps do not draw water from sufficient depth to take full advantage of natural filtering in the soil profiles. Also, when water tables are drawn down below the suction limit of these pumps, local communities seek drinking water from other dry season sources which all have a high seasonal risk of biological and chemical contamination. 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 FCD projects show a negative impact due to the changed drainage conditions behind embankments or the increase rate of drainage associated with the Bengali drain. 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 Bengali drain.

There has been considerable debate on the risk of pollution of groundwater and water bodies from agro-chemicals and fertilisers. The surveys of this study do not suggest that a current problem exists. There is some evidence that low background levels of pesticide in water bodies and DDT accumulation in the food chain do exist. This reflects the historical and continued use of DDT in public health and agricultural programmes. It also reflects the generally low use of such chemicals in agriculture as a whole. 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.

Soil Quality

Localised problems for soil quality developing as a result of FCD and I 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 issues involve potential changes to physical structure, organic matter content, moisture holding capacity, fertility, erosion hazards, panning and toxicity. The biological and soil chemistry processes of nutrient capture, release and assimilation in the food chain in the wetland, irrigated or terrestrial condition will also be affected. 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. All the problems noted can be dealt with by good management practices. However, irreversible changes to the role of wetland functions would result if the traditional approach to FCD 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.

Biological Resources

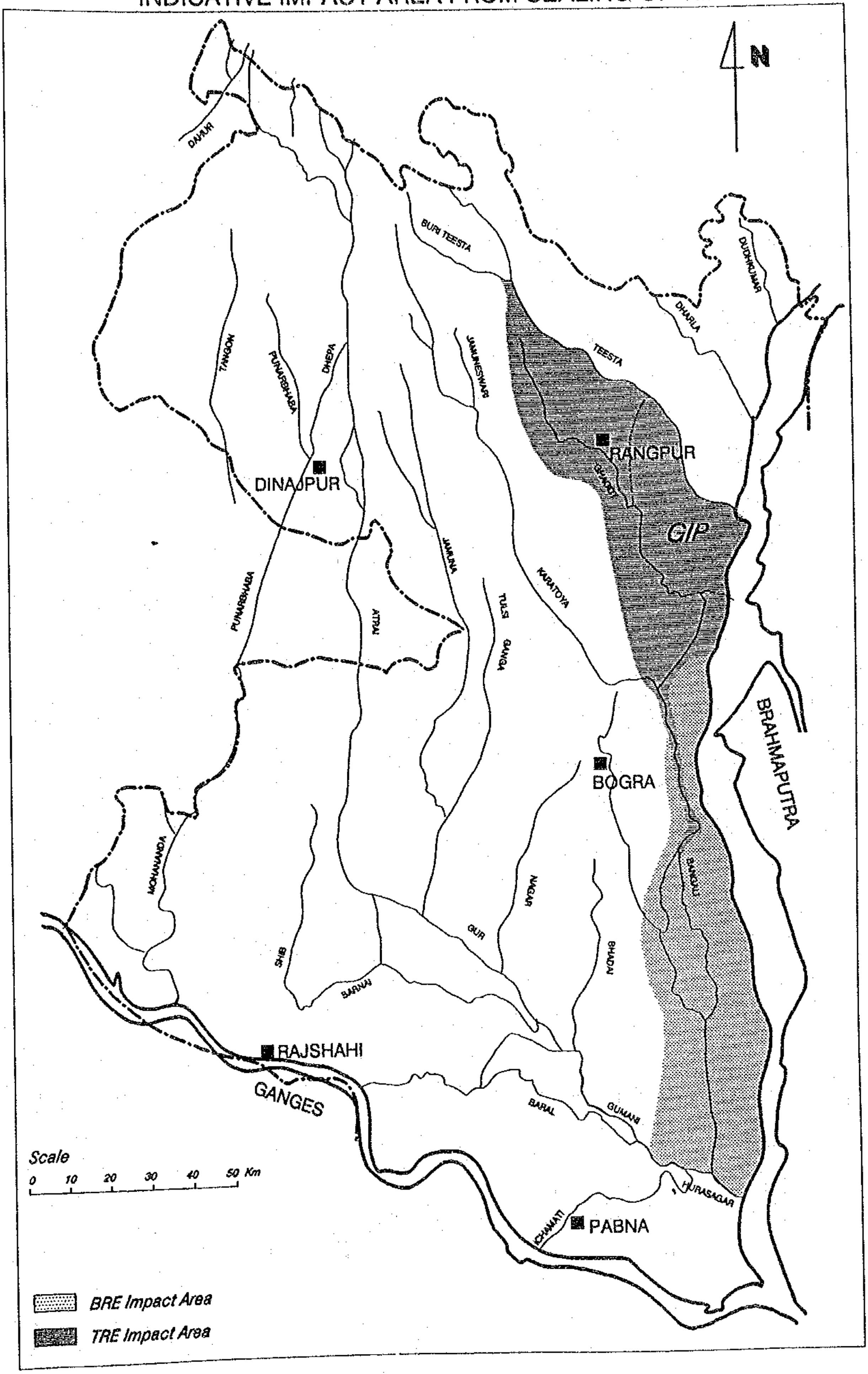
The results of the impacts on biological resources and processes shown in Table 4.1 indicate a number of important positive impacts. These are directly related to the impact of the Bengali drain. This would significantly dewater the target area upbasin of it. This would lead to a notable shift in favour 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 but would require a more flexible environmental management strategy that is not a feature of FCD schemes at the current time.

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. These processes include the basic energy recycling between floodplain and river; the removal, dilution and assimilation of organic and inorganic pollutants and toxicants; the seasonal destruction of habitats suitable for disease vectors and pests; the maintenance of diverse habitats for bio-diversity, biological control of pests and providing diverse natural products of significance (i.e. nutritional diversity, survival strategies, traditional medicines, crafts, shelter, construction, tools and cultural activities); the recharge of water bodies and groundwater to higher ground; and the geomorphological processes of land, floodplain and delta formation.

The Bengali drain 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 it's first construction. This impact is not part of this study but comes under FAP 1. Figure 4.1 indicates the zones of influence of sealing the TRE and BRE.

Figure 4.1

INDICATIVE IMPACT AREA FROM SEALING OF TRE AND BRE



4.5.3 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 given in the Volume 1 - The Regional Plan Main Report.

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 Bengali drain, 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 FCD 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 full FCD 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 in the full FCD options for Mohananda, Hurusagar and the Bengali drain 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. The least effective would be the schemes with no embankments, such as Mohananda (option 2). In all cases, the traditional approach to FCD 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 FCD 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 FCD 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.

4.5.4 Social Impacts

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

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

The FAP 12 and 2 studies have established that 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 roll-on, 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 were recorded from the Sonail and Gaibandha areas.

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 cut a path 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 operational 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 FCD 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 FCD schemes within this.

In the cases of the embankment options for Mohananda, Lower Atrai, Hurusagar, the unexcavated Bengali drain 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 GIP 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 Bengali drain which appears to achieve its particular drainage objectives.

The positive impact recorded for the GIP has to be clearly understood. The effect of the improved drainage cells of Option 2 will be to distribute flood water across the project area that currently severely impact areas at the natural drainage outlet at the Manos regulator. Thus, a clear improvement in the equity of the distribution of flood waters would be achieved. 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.

Gender and age impacts have been separately categorised in the detailed matrix analysis given in Appendix G. These are also discussed in Volume 12 - Social Impacts. 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 given here 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.

4.5.5 Public Health and Nutrition

The most significant risk due to the project interventions are those from water-related diseases. Broad foci of cholera, severe diarrhoeal disease, goitre and vitamin disorders are 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. FAP 16 have a detailed research programme in this area and results should be forthcoming in 1993.

The impact assessment has approached the ranking from the viewpoint of those projects which would most likely change the conditions or distributions of habitats suitable for disease vectors or for water-borne diseases. The development of surface irrigation from the Teesta barrages will already increase the risks of spreading the prevalence of malaria that already exist. The known vectors of malaria are also known to be present both here and in Gaibandha. Therefore, as all the northern projects would likely 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 Gaibandha (Option 2) may result in a worse condition than that of Option 1.

The presence of cholera raises similar problems and has been flagged on the same grounds. The current restrictions on access to data and research on cholera in Bangladesh are a severe restriction to good planning. Its existence in Bangladesh is widely known and closer integration of research would assist minimising the spread of this serious problem. In this case, the need to have clear criteria for design and operational features of the schemes is paramount. Similarly, all additional methods of environmental management should be designed into the complementary programmes.

Malnutrition, economic deprivation, poor sanitation and under-resource 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 FCD 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 FCD projects to continue to actively contribute to this state of affairs without well-targeted and proper mitigation, and funded directly within the project costs, would be unacceptable. This effect argues even more strongly for an integrated water management strategy and a Green river concept for the Lower Atrai.

4.5.6 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 GIP, 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 GIP.

4.5.7 Other Impacts

The building of the Jamuna bridge will bring a significant range of potentially cumulative impacts. These have been 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 Bengali. 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 on fully embanking on Brahmaputra linked to unforeseen changes associated with 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 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.

4.6 Mitigation and Complementary Programmes

The study overall has revealed the complex range of interactions and consequences involved in flood alleviation in the region. While many key impacts have been anticipated, other unforeseen outcomes undoubtable remain, that careful monitoring and future re-appraisals will deal with.

The conditions and effects of schemes show distinct regional variations in their effects on the natural and the human environment. This is an accurate representation of the complexity of the region. The effects are both immediate (resulting from the study itself), medium term (construction impacts) or long term (operational impacts). Some can be easily rectified and others will be temporary. However, others are severe and involve risk and uncertainty.

Despite the urgency of the human and economic conditions, and the impact which floods have, the assessment indicates that critical thresholds might already being, or may soon be, exceeded which could trigger sudden changes. These potentially irreversible alterations could directly affect the resource base on which the basis and quality of the life in the region depends.

The issues include economic poverty, resource poverty and poor public health profiles. These must become integral planning criteria in determining the future management strategies of water and the floodplains. The biological problems include an alarming depletion of the stock of floodplain and wetland resources. It is these resources, and the functions that the floodplains perform, that provide the basis on which the current generation, and future generations, depend for their survival.

Serious policy questions are indicated, on such issues as public equity and the trade-offs which must be decided on to reach a sound overall strategy. These trade-offs make the selection of technological tactics difficult. Even more difficult is the choice of the most appropriate strategy for sustainable development. These are not choices which the Consultant can make, as the issues and trade-offs are not just technical or economic in nature. They are sufficiently important that policy makers, and the general public, need to make difficult choices on selecting tactics and strategy whilst being properly informed.

While quantification and valuation are impossible due to the lack of basic data, the real long-term costs in terms of social cohesion, the quality of life and their contribution to future economic wealth cannot be discounted simply because they cannot be easily valued in the economic analysis. There undoubtable is a real price which is already being paid in social, physical and ecological terms.
The first stages of mitigation concern the next phase of pre-project planning. The following conclusions have been reached:

- The measures that were once seen as the mitigatory and complementary responses to FCD interventions, should themselves become the main thrust to achieve sustained development. The reason being that FCD is a necessary, but not sufficient tactic which, has in the past proved to be the impediment and not one that serves the needs of the area, either hydraulically, socially or economically. It is also significant that flood problems rank high on the critical agenda of local people.

- Careful consideration and review is needed by policy makers and donors of the full range of potential impacts presented.

- A continued re-assessment is needed of the role, resources and planning of environmental research and planning inputs during the feasibility, detailed design, construction and post-construction phases of the FAP planning.

- A broader perspective is needed which can result in better planning and greater coordination to address the linkages between development activities on and off the floodplains, inside and outside potential projects, between rural and urban areas, between different regions and between different sectors in the economy.

The mitigation and complementary programmes identified from the analysis have formed the basis of the environmental management planning which follows in the next chapter. Table 4.3 provides an outline of the main mitigation measures at a project level and their lines of responsibility.

Table 4.3 Summary of Mitigation Measures

Impacts	Mitigation	Responsible Agencies	Scheduling	Residual Impacts
Drainage congestion inside embankments	- Local monitoring and community feedback - Excavation of khals and installation of regulators	BWDB	Immediate and ongoing survey for O&M	Considerable if proper water management strategy avoided
Deterioration of water quality	- Provision of groundwater for domestic purposes - Health and sanitation programs - Extension programs and resources for IPM to reduce use of toxic chemicals - Improved controls and management of toxiC chemicals	BWDB, DOE, DOH, DPHE, DAE, NGOs	Ongoing programmes, early coordination	None
Soil quality problems due to inappropriate management	- Promotion of crop diversification and bio-fertilisers - Implementation of rural energy programme	DAE, BWDB	After project development	None
Reduction of grazing habitats due to cropping intensity	- Improve grazing facility on waste land, roadside, embankment by growing forage grasses - Stall feeding and use of sugar byproducts	DLS	After project development	None
Reduction in quantity and quality of floodplain habitats and functions	- Integrated water management technology and designs to permit river-floodplain two way interaction - Excavation and maintenance of drainage line - IPM extension programs and industrial pollution controls	BWDB, MOEF	Initial planning phases, other programmes ongoing	Mitigation unlikely to be fully effective, loss will continue
Restricted access for fish to and from flood plain	- Regulators open April-May and August-October to permit fish passage - Design of regulators which facilitate fish passage - More diverse restocking of floodplain habitats and research for new hatcheries - Community sanctioned and induced control of fishing effort to reduce impact on young stocks	BWDB, DOF	Initial planning phases, other programmes ongoing	Mitigation unlikely to be fully effective, loss will continue
Increased threats to rare and endangered species from habitat loss	- Use of regulators to permit inflows to flood plain - Excavation and maintenance of khals to ensure inflows to key wetlands - Protection of key wetland habitats through protected area management and community based conservation programmes	BWDB, DOF, Thanas, DOE, IUCN, AWB	Initial planning phases, other programmes ongoing	Critical status already reached, lead in time will likely result in high residual impacts
Loss of biological diversity through loss of wetland habitats and monocropping	- Maintenance and restoration of key habitats - Community based environmental management programmes	BWDB, DAE, DOF, Thanas, IUCN, NGOs	Initial planning phases, other programmes ongoing	Considerable lead time needed, high residual impacts likely
Over exploitation of village timber resources from construction brick and brick aggregate demand	- Contract specifications and conditionalities to ensure coal or gas fired kilns, and supervision of works	BWDB	Detailed design	None
Public cut risks and adverse external impacts	- Full public participation to establish design limits and system requirements	BWDB, Thanas, NGOs	Immediate and on-going monitoring	None
Displacement of households by embankment construction	- Resettlement inside embankments - Flood proofing measures for exposed settlements - Reduction in required setback through improved embankment design and construction	BWDB, BRDB, Thanas, NGOs	Initial planning and pre-construction phase	Many if not properly timed or planned

Impacts	Mitigation	Responsible Agencies	Scheduling	Residual Impacts
Resource tenure and equity outcomes disadvantage resource poor and landless	- Improve resource tenure regulations, resource rights, together with credit and legal aid programmes - Income generation programs - Integrated programme for char and khas lands	Thanas, Union, NGOs	On-going	Effectiveness unlikely. Poverty enhancement for some likely
Potential loss of navigation	- Full navigation network and marketing surveys to establish desirable integrated system needs	BWDB, IWTA, Consultants	Feasibility and detailed design	None
Increases in water-related disease incidence	- Community based vector and habitat control programs - Adoption of integrated water and environmental management policy - Community based health and sanitation programmes	BWDB, MOEF, DOH, DPHE, DAE, Thanas, NGOs	Immediate surveys and on-going monitoring	Indeterminate
Reduced food diversity and nutritional input due to impacts of cropping patterns, access to resources and loss of floodplain fisheries	- Maintenance of sustainable floodplain production systems fishery through integrated water and environmental management programme - Revision of jalmahal leasing system to ensure more equitable access to wetland resources - Establishment of culture fishery programs for landless groups based on more diverse species	BWDB, DOF, DOE	Immediate and throughout project development	Potentially none if strategy commitment given and full community participation encouraged.
High flood risks from extreme flooding events	- Early warning systems, media and institutional	BWDB	Immediate	Many if not addressed
Higher flood risks for people within setback areas	- Resettlement of affected households inside embankments - Flood proofing for exposed settlements	BWDB, BRDB, Thanas, NGOs	Initial planning and pre-construction phase	None if all people can be relocated
Embankment failure	- Disaster preparedness and warning systems - Quality control, supervision and inspection - Vegetation planning	BWDB Thana/Union Forest Dept	On-going after commissioning	None. Secondary positive effects likely
Liquefaction risks	- Detailed geotechnical surveys of foundation materials and identification of potential weak spots for contingency mapping and planning	Consultants, BWDB	Feasibility through construction phases.	Extreme events cannot be avoided but planning response will mitigate problems.

CHAPTER 5
ENVIRONMENTAL MANAGEMENT AND MITIGATION PLANNING

"Life on earth is the outcome of ecological balance. Only though maintaining bio-diversity could human life be protected."

Mosharraf Hosain Shahjahan, State Minister for Irrigation, Water Development and Flood Control, October 5, 1992.

5.1 Strategic Planning

It is often assumed that the primary impediment to development in the floodplains is monsoonal flooding and that this could continue to be solved by structural means. The NWRS has conclude that the major part of the flooding problems on this generation are actually the man-induced damage due to the FCD schemes built over the last 30 years. This generation of FCD planning also assumed that major issues like sanitation and fish production could take care of themselves, or under the FAP could be mitigated. As a result the TORs provided little scope to formally research, re-examine or test such assumptions. The evidence of studies undertaken by FAP so far have identified critical linkages which cannot be avoided in FCD planning and show that FCD can only serve rural development needs when the idea of controlling floods is replaced by the more realist approach based on water management. This strategy would then conform to what local people already do and desire. This would result in far more flexible system approach which could more easily respond to the highly complex and dynamic condition on the floodplains.

No previous FCD projects have substantively addressed either social, ecological or inter-sectorial objectives. All future pre-feasibility and feasibility planning needs to address water management tactics and strategies for diverse objectives, and not just limit their objectives solely to negative aspects of flood related problems. Many of the adverse impacts of the FCD schemes already evaluated, and the assessments of the plans proposed, relate to these wider objectives. While FCD planning remains dependent on the traditional approach of FCD engineering and agricultural planning, improvement under the FAP are unlikely to result.

The avoidable outcome of this generation of FCD projects have now been clearly identified with the advantage of hindsight. These deficiencies are well exemplified by the polder schemes of the Lower Atrai. The concept of the Green River is a first stage of a process; first, to remove the deficiencies of the old schemes; and, second, to open up a future path for development which otherwise could not exist or be sustained. Such an approach would comply fully with the objectives of government policy. It also reflects the increasing emphasis being expressed in the coordination of the FAP for flood alleviation strategies to become more compatible with the wider needs of sound overall land, water and environmental management.

The regional plan presents a potential long-term stream of wide-ranging interventions across the floodplains of the NWR. A similar regional planning exercise is unlikely to be commissioned again in the near future. Given the rapid changes that are already apparent from the study of events of the last two decades, there are strategic issues which need careful consideration, debate and clear setting of priorities before decisions on how to proceed are taken. Development works proposed under the plan will probably not wait for certain basic research programmes to be completed. However, the future strategy must evolve directly on from the lessons of experience gained in the Lower Atrai, elsewhere within Bangladesh, and internationally.

The selection of flood alleviation tactics and their formulation into a regional strategy need sufficient knowledge of the likely outcomes. The study has established a public need for alleviating the flood risks and damage from the major rivers. Technically viable schemes to achieve this have been analysed and will require further study and refinement in future feasibility studies. The ability to enhance agricultural production directly through flood alleviation strategies is less certain. The direction of water development planning must now address a range of other objectives. To achieve this the strategy must be evolved and refined to fit with new national policy and with the priorities and aspirations expressed by local people.

Other sectors will either, be adversely impacted by FCDI or, complementary programmes or projects in these sectors are required, if FAP is to achieve its objectives. The critical linkages noted were with the needs for public health, navigation, water supply, fishing, pollution controls and management, and a caring management of the biological environment; all of which need to come under the caretaking and responsibility of local communities as far as possible. Significantly greater resources need investing to plan and design mitigatory measures and appraise these linkages during feasibility studies.

Sustainable development and poverty alleviation through FCD interventions can only be achieved if the most important adverse impact areas, such as navigation, public health, pollution and natural resource management are integrated into the earliest stages of design and planning. All of the impact assessments of FAP studies so far have highlighted the priority which needs to be given to these strategic policy issue.

While some adverse effects of the proposed schemes can be mitigated, planned for, and costed into the economic analysis, it is unclear how various mitigation could be dealt with effectively under the current institutional arrangements of the FAP. Mitigation and complementary programmes that include significant inter-sectorial planning and implementation capacity are the most difficult. To ensure that these objectives could be met would require a shift in emphasis of planning criteria at the next stage.

Technical solutions for increasing food supplies and protecting farmland and assets from damaging floods will interact with an existing social and ecological context. Yet, these environments are where water and floods remain an elemental influence, and benefit, for survival strategies and production systems. Recognising the importance of the floodplain functions and processes must not be lost in the search for solutions to reduce the risks associated with floods.

The terms of "environmental soundness" and "sustainability" are now being widely used. However, the remain largely undefined in either scientific or policy terms. Proper environmental and engineering planning cannot proceed effectively until the national environmental policies both generally, and for the FAP specifically, are clarified.

5.2 The Green River Strategy

The underlying approach of the Green River appears the best strategy to alleviate the problems of the Lower Atrai. It has the capacity to remove the adverse impacts of existing schemes, but only if the system becomes designed to certain minimum social and economic criteria. One without the other can only lead to either, unattainable objectives or, unsustainable projects.

This approach would also open up many new development opportunities which would be complementary to, and could take advantage of, the benefits from the Jamuna bridge. The key is to switch the regional strategy to full inter-sectorial water management where a reduced emphasis on flood control will revitalise many features of the economy lost to the strategy adopted in the past.

If flood alleviation projects are to contribute in a sustainable way to development it will have to ensure certain basic minimums. The system must be designed from a detailed understanding and be confident of avoiding the risks of public cutting. This can only be done with an extensive strategy of public discussion debate and agreement.

A strategy, confident of its operational sustainable and its reliability as an investment, must first establish the maximum acceptable differences in season water levels for communities located throughout the system. These criteria could only be known through extensive survey and public participation beyond the resources of this study. The surveys indicate that these differences can be quite small. Typically this happen if there are strong expectations that the differences will get imminently larger, or if fishing livelihoods depend on fish migration at that particular time (the latter may require no difference in levels, but simply the presence of an obstruction).

Agreement would have to reached on the minimum acceptable controls possible on the rise and rate of flow into embanked areas to serve the needs for agriculture, fisheries and navigation. At the same time a publicly agreed strategy of flood proofing and disaster response must also be worked out across the system. This approach will only achieve an equitable and sustainable outcome if the approach is extended to include all the remaining FCD projects.

The strategy must allow the floodplain to remain open to all normal flows with the potential to control the rate of rise only up to that which is publicly acceptable to those on both sides of the embankment. This will not be without problems. The sociological surveys identified that, apart from in the charland, there was little indication of communities acting collectively, except in the very important case of cutting embankments, when threatened by floods of a severe nature. Char dwellers helped each other to dismantle homes and move possessions prior to severe flooding. But for embankment dwellers and those residing on the mainland flood survival strategies are very much carried out by individual families. Attempting to elicit collective responsibility met with negative responses. This has important ramifications for finding community solutions to flood strategies and particularly for future operation and maintenance of flood control systems, since collective action by communities will be necessary for this aspect of the flood action plan.

5.3 Regional Planning Objectives

These conclusions of the analysis of flood alleviation possibilities in the region have direct implications for the role and approach of the Environmental Management Plan (EMP). This cannot be taken as a simple addition of mitigating activities to alleviate the adverse effects of a certain water development plan predicated simply to control floods and assist agriculture. It presents the next stage of regional research and planning to ensure that a comprehensive water management strategy evolves being sustainable in economic, social and ecological terms. This plan would be predicated on support for the existing efforts of local communities to plan, manage and save water for all its uses. It would respond to, and reflect the views established in the rounds of public participation, their priorities to see flood alleviation strategies generating employment, improving health and nutrition, and widening their access to resources.

Irrespective of removing the problems of the existing schemes and, with or without the implementation of the regional plan of projects, flood proofing and disaster preparedness programmes need to be given higher priority. The integration of the existing embankments into this strategy needs to consider their other productive role in development and disaster response. Also, a proper strategy of disaster response is required in conjunction with the studies of embankments on the left and right banks of the Brahmaputra and the Teesta and Brahmaputra charlands.

The planning of integrated water management will require the coordination of action and strategies from a number of agencies to establish basic criteria for the next phases of planning to establish the design features and rationale for system operations. The main institutions involved will include those responsible for FCD and I, public health, road, rail and water transport, wetland and agro-ecological research, forestry and environment policy.

Any strategy must reflect the dynamic and complex ecological, social and economic framework into which the water development programme is to be set. Planned management must ensure that the nature of these processes are properly understood. To achieve these long-term objectives will require considerably more research. It will require the recruitment and training of staff with new backgrounds and education. It will also require an new management system approach to coordinate, supervise and monitor the programme. The objective will be to improve the management of natural resources in ways that are sustainable and which re-introduce the value of diversity directly into the planning and design of schemes. This strategy has the potential to aid agricultural development, to improve nutrition, to reduce risks to public health, to improve water quality, and to make better economic use of the productive resources in the environment FCD and I are to be found.

5.4 Institutional and Community Framework

The EMP provide a strategic approach to maintain the productive resource base intact for future generations of users. It involves avoiding or mitigating the adverse impacts of FCDI interventions. FAP projects in the NWR would be only one of many activities affecting the quality of life and environment in the region. To be effective environmental management also needs to be linked and coordinated, not only with FAP projects in other regions, but also with other sectors.

The National Environmental Policy and the NEMAP lay out the general direction and issues for an integrated approach to environmental management. The potential scope of a such a plan at the regional and national level is wide; but it also needs to be specific. It needs to directly appreciate and support the daily decision-making world of individual environmental managers at the level of agricultural and fishing communities and industrial managers. It would involve policy and fiscal measures to act as incentives and dis-incentives and the investment in resources and training to create a cadre of committed staff. It will also require the active involvement of the media, the NGOs and local people if it were to have any chance of success. Many of these issues go beyond the TOR of this study.

An integrated research, monitoring and management system is required which can deal with key environmental variables. New types of specialists, management concepts, and an active commitment to a new strategies, will be required. This will take time to organise and mobilise and even longer to establish as a corner-stone of the operating procedures of a future schemes unless given the most serious policy and financing support. These outcomes would integrate engineering designs to serve the needs of water management in a systems approach to improved sanitation, water quality and ecological management with all the attendant economic and social benefits that this could bring.

Many mainline ministries will be involved. Support would also be required from other national and international institutions, research institutions and environmental agencies. Considerable emphasis would be needed on the close involvement of these institutions, together with the public and the media in the planning, implementation and monitoring of water resource projects.

The agencies involved would include:

International Border Issues	:	Joint River Commission (JRC)
Flood Control and Drainage	:	Bangladesh Water Development Board (BWDB
Irrigation Development	:	Ministry of Irrigation, Water Development and Flood Control (MOIWDFC)
Agricultural Development	:	Ministry of Agriculture (MOA)/Bangladesh Agricultural Development Corporation (BADC)/ Bangladesh Agricultural Research Council (BARC)
Watershed Management	:	International
Land Use Planning	:	Ministry of Land (MOL)/Ministry of Agriculture
Livestock Management	:	Ministry of Fisheries and Livestock (MOFL)
Fisheries Management	:	Ministry of Fisheries and Livestock (MOFL)
Local Management	:	Ministry of Local Government, Rural Development and Cooperatives (MOLGRDC)
Flood/Disaster Management	:	Ministry of Relief and Rehabilitation (MORR)
Public Health	:	Ministry of Health and Family Planning (MOHFP)
Water Quality Monitoring	:	Ministry of Environment and Forestry (MOEF)
Industrial Investment	:	Ministry of Industry (MOI)
Pollution Monitoring and Controls	:	MOEF/Private Sector
Urban Planning and Controls	:	No single body, UDD
International Support	:	e.g IUCN, IRRI, ICLARM

5.5 Resource Conservation, Management and Zoning

The preliminary zoning of sites of special interest are shown in **Figure 5.1**. In addition, regular water quality monitoring at the sites shown in **Figure 6.1** should be supported to enable a better understanding of the implications of pollution control measures associated with FCDI projects and the costs of raising pollution control standards in spite of these. The sites have been addressed under the following classification

Natural Beauty or Recreational Value

One site of interest reportedly lies at the extreme northwest border of the region.

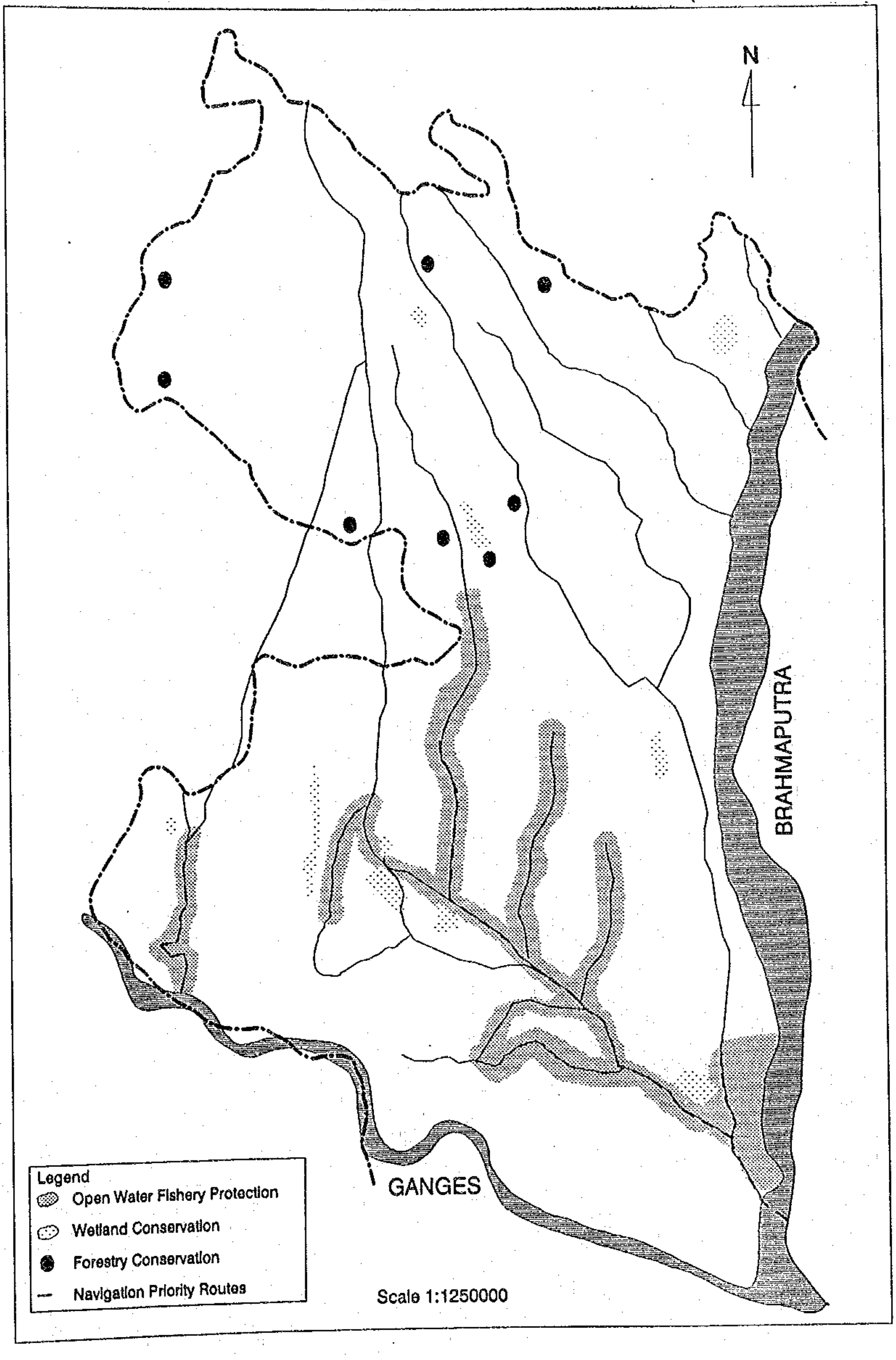
Special Scientific Value and Worthy of Protection and Conservation:

a. Remaining habitat sites for migratory birds: The surveyed sites established on that the riverine zones of the Teesta and Brahmaputra are important. A properly staffed and timed ornithological survey and reporting network are required to establish a future need and response.

b. Sites of high value for open water fish ecology: The surveyed sites indicate the degradation across all the sites visited. All floodplain resources need a coordinated regional strategy. Selection of particular sites to focus on should only be a research tactic. Special sites for immediate work should concentrate on surveys of the northern rivers and floodplain systems to identify special habitat significance, and in the Lower Atrai Chalan Beel deeply flooded areas.

Figure 5.1

REGIONAL ENVIRONMENTAL MANAGEMENT ZONES (POSSIBILITES)



c. Remaining sites of natural forest: These all lie outside of the main planning units where scheme planning and surveys were carried out. No information can be provided on the status of these sites.

d. Sites of cultural and historic value: The GIP surveys and the regional reviews confirm the widespread distribution of important national and local sites of cultural and historic importance. All future feasibility studies should be obligated to review the sites in their area using professional trained staff or consultants.

Worthy of Special Environmental Management & Monitoring

While pollution sources of industrial, agro-chemical and concentrated sewage and wastes remain essentially localised the long term risk and local hazards must be addressed. The proposed monitoring programme will address these issues.

5.6 Construction Management

Construction policy will be taken up in further detail at the feasibility study. At that stage a range of topics would be appraised including service facilities, labour policy, public health and safety, contractor's site installations, services and pollution control, operations and disturbance, rehabilitation and reclamation provisions, social problems and consultation with local authorities. Timely preparation of land acquisition and compensation programmes are vital.

5.7 Urban, Industrial and Other Development

A new urban or industrial development is on-going. Some major projects are also in the planning pipeline to develop the mining sector of the NWR. The role of the Jamuna Bridge could change the context of these considerable. Coordination is needed to ensure that conflicting interests do not arise and so that future water quality and water management problem do not arise. Of considerable significance to local industry would be the availability of low cost navigation networks. The fate and future of this lies directly with the BWDB to resolve the major losses caused from the last decades of ignoring this important sector.

5.8 Water Management Planning

Biological controls and ecological management alone cannot be regarded as being sufficient or wholly effective to deal with the adverse impacts of traditional FCD and I technologies. Only coordinated water management planning and operations, involving a number of authorities and strategies will suffice. This must address the dynamic ecological, social and economic environment in which a project is to be set. Planned management must protect water quality, public health and both terrestrial and aquatic productivity through reproducing the natural wetland functions and processes and by enhancing these by supporting community based environmental management techniques.

Water management system planning would allow more flexibility of response to a particular hydrological or societal situation. It could permit decisions on where the water should be routed, and how much, and when. Such decisions might be based on specific local requirements for aquifer recharge, soil moisture or irrigation demands, soil fertilization processes, public health needs,

migratory fish pathways or flood storage. All these would have to be worked out in accordance with specific local desires, actions in the public benefit, the technical and physical capacities for control and storage, or in response to flood crisis situations in upstream or downstream basins.

It is most significant that, on the ground, the basic societal management of the landscape and water flows already reflects exactly this approach. The constraint within which most have to work is the illogic of FCD schemes design around unattainable objectives. The NWR has already been land levelled by the hands of generations of farmers and mostly in this century. This has the effect of retaining and slowing water flow from rain, overland flow or river spillage. This has hydraulic and farming advantages created from micro-engineering. Every year cross dams are erected to impede the drainage of water out of the system as the dry season approaches. This effectively sustains the river productivity and advantages fishermen, local boatmen and irrigators alike. If the future FCD planning were to use this as its basic template, it would support and assist the emergence of a more meaningful partnership between local communities, national interests and international assistance.

The history of FCD planning and institutional support has produced plenty of evidence that interventions over the last three decades have created increased social and economic tensions. While these were perhaps unforeseen outcomes in the 1960s they do not remain unforeseen for the current round of long term planning which FAP is responsible for. Such outcomes will surely be seen as both politically, socially and economically undesirable and unnecessary for the future. The true costs of ignoring these implications to society and future generations may outstrip any reductions in flood damage created by FCD.

5.8.1 Public Health

The loss of access to free sources of protein, vitamins, minerals, and oils would be difficult to mitigate. Most options would require the affected groups to raise extra income. The losses have important ramifications for various health problems including general anaemia and lowered resistance, eye problems and difficulties for pregnant and nursing mothers.

Mitigation could be by three approaches. The first would need a carefully planned and targeted health and nutrition monitoring and action programme integrated with each project. However, as malnutrition is a major national issue, irrespective of FCDI developments, these programmes ought to be part of the general regional development strategy. The second would leave the planning bodies and donors to coordinate and ensure that the general health sector plans were addressing the specific problems which FCDI might exacerbate. The third approach would be for replacement culture fisheries to be placed under the direct control and targeted towards these specific social issues and groups, and not developed or leased as commercially orientated businesses. The practical problems of targeting programmes are probably insurmountable and unrealistic to consider, unless there were a strong political commitment, particularly at the local level.

Current disease conditions are seasonally controlled by the annual cycle of flood events, drainage patterns and the seasonal changes in temperature and humidity. These provide physical limitation on the ability for habitats and breeding cycles to be maintained throughout the year. Certain diseases are favoured by this condition and others are restricted by it. Local micro-climatic changes brought about by dry season irrigation, and by the drying out of the environment through flood control, will alter the balance of habitats and their suitability for, either the existing, or new disease and vector regimes.

The prediction of impacts on health is difficult, as it depends upon whether project designs avoid or create poor drainage and stagnant pools of water. There is a high international and national priority being given to provide people with access to clean water. It would seem appropriate that the FAP projects should have this as a specific objective which it plans for.

There is insufficient knowledge at present to predict, for any particular mix of local conditions and FCDI interventions, when, and if, changing disease or vector profiles might become a problem. More research is required on the disease and vector species, habitat requirements, seasonal limiting factors and their geographical distribution within the region. There is a scaling problem involved in the thresholds which have to be crossed in terms of species and disease transmission from region to region and area to area. The transformation of habitats would also depend on the scale and proximity of FCDI interventions. The risks and potential future costs are, however, potentially too great to ignore. FAP 16 research may help clarify some issues.

5.8.2 Channel Morphology, Navigation and Breaches

Continued access for major and minor navigation is crucial to the viability of both community services, commercial and marketing activities and fishing needs. There should be no scheme which does not place navigation criteria on an equal footing to the needs for agriculture. The proper planning of access for boats applies as much for fishing communities and fish landing as it does for general communications and travel. Careful survey of routes and landings points will be needed to enable both locks and the careful siting of bridges to maintain the logic of route directions. Wherever structures are located sedimentation problems downstream will need to be dealt with by careful design and operation of the system or by a costed dredging programme and strategies to flush or remove aquatic weeds.

If roads and embankments were well-designed as a continuous system with multi-purpose objectives in mind, they could form a linked system for the movement and management of fish stocks, as well as maintaining lines of access for navigation and evacuation of water hyacinth to open water. Such an approach would involve some redesign to avoid road/bank erosion, but might prove viable when the multiple benefits are taken into account.

Sedimentation problem will also be associated with the confinement of the flood paths of most rivers. The construction of any embankments that will contain the natural flood spreading pattern will lead to changing sedimentation, scouring and bank erosion characteristics. Special care over monitoring these schemes will be necessary. Continued dredging may be one option, but disposal of this material will create problems in the long-term.

Embankment breaches and extreme events will likely occur in the lifetime of the project. Coordinated and designed means of removing water quickly from behind embankments in feasibility studies needs integrating with the non-structural measures. Induced drainage problems will occur inside embankments. Detailed topographic surveys and drainage planning for small scale drainage structures is required. Continued monitoring of problems in practice (inside and outside schemes) and installation of small structures after main works completed would be a recommended mitigation.

5.8.3 Soil Quality

There are a range of minor impacts identified which are likely to occur in very specific local sites. As soil surveys and planning continues these sites might be identified and a selective monitoring programme established. In the longer term improved local soil testing facilities can be set up supported by local extension services.

The moisture loss on high ground and homesteads associated with FCDI projects will require the monitoring of water table and impacts. Small-scale irrigation technologies and agro-forestry programmes for homestead might be associated with the water supply programme recommended. Where water tables fall, conversion to deeper tubewells would, in any case, be required. This would have the added advantage of avoiding the present health risks known to be associated with polluted shallow groundwater.

5.8.4 Water Quality

The water quality problems which may be encountered and should be planned for. These could include algal blooms, pollution from faecal bacteria and pathogens, increase in pest and disease vector breeding sites, agro-chemical pollution of surface and groundwater water, industrial pollution, loss of biological diversity and controls reducing water quality problems, and the proliferation of aquatic weeds. The intensity of problems can be expected to increase in drought years when the concentration of nutrients by evaporation is greatest.

The intensity of problems may also increase under the influence of FCD because an open draining system has been converted to a closed controlled drainage system. This means that water levels are continuously lower due to the absence or reduction of inflow. Reduced flow means a decline in turbidity which allows a greater depth of penetration of sunlight and a possible stimulation of algal production. This would be further aggravated if fish and aquatic and amphibious organisms feeding on micro-organisms were not managed and protected as part of the strategy.

HYV cropping, induced by FCDI and current extension methods, demands good control of pests and diseases to ensure economic feasibility and debt repayment capacity. If modern agro-chemicals are left to provide the only answer problems will accumulate with major long-term risks to local ecology, water quality, the food chain and human health. Farming systems support currently lacks the research and institutional means to extend alternative integrated pest control management systems. Government is already aware of this and a shift to non-chemical means of pest control are already being researched.

It is unlikely that the short-term maintenance of high yields using intensive chemical approaches in agriculture would cover the costs of the long-term degradation of these other productive resource systems. A sacrifice of rice yields may be advisable yet if planned well these losses will be more than recovered by the reduced input costs and the gains made in other productive ventures in paddy culture, such as fish and bullfrog culture which themselves aid pest control measures.

Other sources of pollution are the discharges of industry and sewage and waste from domestic sources. These impose both chemical and biological problems with potentially serious health and ecological risks if not planned for and managed properly. Oil-based pollution is spreading with the conversion of the transport, agricultural processing and farming systems to engines. This involves more spillage and exhaust gases. The industrial complexes involving newsprint, tanneries, jute mills, sugar mills are discharging mercury, lead, chromium arsenic and iron into the water network which FCD projects under FAP will intervene in. Concentrated discharges of sewage greatly increase the biological oxygen demand. All these sources of pollutants seriously affect water quality for the proper functioning of the aquatic, terrestrial and human ecology.

5.8.5 Pollution Management

The management approach should seek to integrate different methods to minimise the conditions which can lead to poor water quality. This would concentrate on physical and biological management techniques to counter-act or remove the causes of poor water quality in situ. This would include the protection and stocking of fish and other fauna to encourage the uptake of nutrients, potentially toxic micro-organisms and disease vectors in the food chain. This policy should be encouraged in the main drainage systems, in the fields and in the standing water bodies. Encouragement would be given to systems of harvesting of these fauna and useful vegetation to remove biomass and pollutants from the system. The only sensible measures for the management of industry is for the treatment and payment at source. The setting up of these capacities, both in terms of staff and finances, is a considerable task beyond the terms of reference of this study. The MOEF would be the main body to liaise with donors on these issues.

All agro-chemicals are part of an industrial trade network which actively promotes the expansion of their markets and sale. Commercial interests should not be allowed to interfere with good farming practices and the preservation of a healthy environment for future resource users. Public education through agricultural research and extension, as well as the role of the media and NGOs, all have a role to play in combating these problems. As part of the FAP projects donors could specifically fund and support such programmes.

No FCD schemes should be allowed to proceed to implementation unless their capacity to adequately drain and, if need be, flush areas of potential risk had been carefully studied. Similarly, no schemes should proceed until they have shown adequate analysis of the implications of their agricultural chemical use on the enrichment and degradation of the ecological and economic systems that they may affect, either within schemes, or as a result of passing on problems to downstream areas. The direct effects of schemes on the drainage mechanisms for sewage and industrial pollutants should also be clearly analysed and planned.

Further research into the dynamic interactions with climate, seasons, flora and fauna could establish other biological control and management mechanisms. This research work of ecologists and other specialists should be coordinated under the MOEF. It could call upon the a range of other institutions to assist, such as BRRI, the Fisheries Research Institutes, and the Engineering Research Institutes. International assistance could involve specialists supplied through such organisations as UNEP, IUCN, AWB and ICLARM.

Deterioration of environmental sanitation conditions and the protection of water quality for downstream users are not just responsibilities associated with BWDB projects. Improved public health, sanitation and proper waste disposal provisions in the villages and towns are vital if a deterioration in the quality of life is to be avoided. Where embankments intervene in the flood and drainage regime and divert external sources of nutrients and pollutants directly downstream and out into the sea, the impacts on the estuarine and marine resources and economy must be assessed.

Major improvements to sewage disposal, industrial pollution and agro-chemical pollution would be advisable with or without the FAP projects and must be seen as a complementary programme. Nevertheless, pollution planning data is virtually non-existent and feasibility study provisions to collect relevant data should be considered, as well as the urgent needs for direct support to a proper regional and national monitoring and training programme.

5.8.6 Wetlands and Aquatic Flora and Fauna

The remaining wetlands sites have a number of potentially important roles apart from their productive use in water supplies and crop production. They maintain an important habitat for a diversity of aquatic flora and fauna and provide sites for resident and migratory birds. Detailed research is required into the role of aquatic flora and fauna. This should include research into the life histories and habitats of those major and minor species which are valuable as a source of economic products, poor people's protein, vitamins and oils, and which provide important biological controls on pests and diseases. The surveys of this study have begun this process and the data base should be built upon.

Fisheries already play an important role in providing employment, generating exports, enhancing water quality, sustaining public health and aiding nutrition for the poorer groups. Various indigenous species readily consume vegetable detritus, eat the algae responsible for undesirable blooms, control the growth of water weed, and eat pest and disease vectors which affect humans and livestock. Apart from the locally consumed range of minor species and the commercially marketed major species of fish, there are other important economic aquatic fauna which sustain livelihoods as described in **Chapter 3**. Crustacean shell materials are already used in lime making and major new industrial uses for crustacean shells are being developed based on chitin and its products. There are many potential uses in the chemical, medical, pharmaceutical and food industries whose economic values could be a significant loss if habitats and bio-diversity were threatened by short-sighted FCDI planning. Some of the most notable uses being developed are their roles as food preservatives and their applications in the treatment of sewage, paper mill effluent, food factory waste and purification of water. In the medical field it has been found to have uses in accelerating wound healing and for skin grafting. The cosmetic industry has found uses for chitosan as have the hi-fi and acoustic industry.

To sustain the varied forms of survival strategies, commercial opportunities and feeding systems which minimise disease and pest problems is vital, and should not be threatened by FCDI development. While the data base is limited, the important areas which could be identified have been have been included in the zoning plan. Integrated management for economically and socially important aquatic fauna is mainly based on the preservation of suitable habitats and the avoidance of pollution or over-exploitation. The approach taken has encouraged the maximum research into the engineering and regional planning options for maintaining these. The main possibilities are shown below:

- Engineering the means to maintain the capacity of migratory species to move from floodplain to river. The viability of this appears uncertain. Effective management planning would require a better understanding of the ecological and engineering requirements of the major and minor species.

- Engineering the means to maintain the capacity of resident floodplain species to move to and from beel, khal and floodplain integrating these systems with paddy culture and IPM systems.

- Specifically allocating minimum wetland and floodplain sites as fisheries development areas while still allowing rabi and boro cropping on suitable lands.

- Specifically reserving strategic wetland areas under a protected area network that would never be brought under flood control.

The lessons of worldwide experience show that preservation of habitat diversity and the simultaneous management of composite species utilisation of a wealth of ecological niches can lead to productivity figures far beyond those of low diversity, low species systems. Preserving inundation channels and

proper integrated management of seasonal water bodies is critical to achieving these benefits for food diversity in as much as the same criteria apply to land use and agriculture. The levels of biological productivity of plankton, the seasonal levels of turbidity and sedimentation and flow rates are key factors controlling the quality of water bodies and their productivity. Whether this translates into a sustainable system of production that, in turn, can be advantageous to the alleviation of poverty and malnutrition is totally reliant on the legal and tenurial system accompanying it. Leasing of water bodies to commercial interests, and the dispossession of poor people and farming communities used to a common property resource access regimes, will usually result in dividend to the rich and influential, raise stocks of export generated foreign exchange but, at the same time, add to the rising tide of poverty. inequality and social unrest, which will ultimately translate into political conflicts and major costs to society as a whole.

Wider distributed dividends will result if more farmers can also be turn into fishery managers. This would be develop through multiple forms of integrated fish farming, each suited to a range of different water levels in the seasonal system of flood and flood recession. Deep water paddy cum fish production will have different requirement to beel or paddy on F2 and F3 land. Monsoonal fisheries will be different to dry season paddy-fish system. Each will have their variations on pest and disease vector control, but each will also generate, not only food and nutritional diversity, but also income diversity, greater returns per hectare and reduces the need for expensive high energy use inputs of fertilisers and agro-chemicals.

Fertilisation of the paddy-fish fields can come from the prior manuring with aquatic weeds clogging the drainage lines, from promotion of algal and planktonic growth and from the manure output of livestock, particularly chickens and ducks, each of which also have their own income and employment benefits for the participation of women and children. The recycling of sewage in areas close to urban centres offers further variation on this theme of encouraging diversity.

These systems also would produce a wider diversity of seasonal employment and may lead to a great convergence of interests between farmers and fishermen; thereby reducing social tensions already featured in areas where FCD and I have been implemented.

5.9 Research and Management Coordination

The scope of future environmental management and monitoring will require properly coordinated units within the MOEF and the BWDB. At the present time there is a considerable reliance on consultants to carry out single discrete studies. While it may be possible to rely on the inputs of international and national consultants for some initial planning surveys and studies, this approach should only be a short-term strategy. The work requires coordination by personnel properly trained in the environmental monitoring, planning and management. The overall coordination would be with the MOEF, but other organisations involved in FCDI, agriculture and the quality of life should plan to improve their capabilities to reflect this more comprehensive and inter-linked approach to water resource development. Recommendations have already come from the MOEF for environmental cells to be set up within the main government institutions.

The analysis has highlighted the need for international coordination. The Joint River Commission and the National Water Council are the two bodies concerned with cross border issues and cooperation in planning and water management. It is unlikely that Bangladesh can have any direct influence on planning in the upper catchment, but should be in a position to know the potential ramifications of changing patterns of development, population, land use and industry in these areas.

5.10 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 7, 9, 10 and 12 and in summary include the items given in the Table 5.1.

Risk is inherent in the planning and operation of any dams, which is what embankments in Bangladesh effectively are. Their associated risk and hazards are becoming standard components of project assessment to assist the appreciation of policy makers. An embankment building programme is by nature a long term strategy and thus must be maintained with integrity if the strategy is to make sense. The experience in Bangladesh is one where integrity of embankments is the exception, rather than the rule. The costs of maintenance are high and the costs of poor maintenance, in terms of damage from breaches, even higher. The decision to embank can only be justified when conventional hydraulic and economic analysis is supplemented by risk and hazard analysis. Currently this is nowhere being done within the FAP analysis and a system of accountability associated with the designs and decision making should be built into the system, as it is for international dams.

The current insulation of the planners from the real problems on the ground is less available to those farmers inside schemes who become increasingly indebted to pay for HYV seeds and inputs, or for those whose fields become obliterated beneath un-cultivable sands delivered by high-velocity river waters splaying through the breached embankments. The risks have to be assessed as fully as possible and made explicit to policy makers and donors alike.

Risk and uncertainty are largely inextricable. Risk usually refers to events which can be assigned statistical probabilities and to chance events; some of which may have predictable recurrence intervals. Uncertainty in the context of this planning study might be taken to refer to the lack of relevant scientific data; the use of flawed data (constantly changing datum levels in the modelling is a typical example); the dearth of environmental modelling or simulation tools; and the present crude understanding of complex ecological processes.

This impact assessment can offers little quantitative guidance to decision-makers and suffer similarly with respect to the assessment of risks and hazards. It is the level of uncertainty inherent in the project planning which severely limits defensible quantification. In one area of seismic analysis and risks of liquefaction was the impact assessment able to summon a more scientific approach. The details of this are given in Volume 7 and are also discussed below.

5.10.1 Physical Risks and Hazards

The primary hydrological and hydraulic planning has been carried out on an fixed range of time series data. There is little option to accept that this is the best indication of how the system has work in the period covered by the data had the intervention which are being analysed been implemented in this historic time frame. Whether this historic data is at all relevant for assessing the variability of the future is a question often little posed or dwelt on. There are a multitude of reasons why the future return periods may differ from those which have been derived from the historic data. The critical changes would be those that shifted the base assumptions on the boundary conditions or that shifted the moving averages. A slight shift in the base average can lead to highly significant changes in return period. While this appear a deviation into mathematical abstraction it is nonetheless these figures which determine the level of protection to human safety and the cost of these investment that will be the flood action plan.

The type of conditions which would affect the base analysis would be associated with climatic change. Three conditions of change have to be noted:

- Above average events which exceed the design criteria, but do not lead to structural damage.
- Extreme and catastrophic events that will need emergency measures and consideration of both structural and non-structural contingency plans.
- Changing global climate patterns that will affect the base conditions of the existing situation on which the design criteria for projects have been designed.

These, and coincident events which exceed the design criteria, would compromise the sustainability of the engineering structures and lead to damage within and outside of the protected areas. This would significantly increase the costs for maintenance and rehabilitation beyond those assumed in standard project analysis. The principles of persistence and discontuity (well-known natural phenomena used in chaos theory) imply that in an economic sensitivity analysis of extreme events, the system would have to be failed more than that suggested by the return period, as a grouping of these events results from the persistence principle.

Climatic Change

Climate change is a subject which has grown in prominence in recent years, but there is in most cases insufficient data or other evidence from which reliable forecasts of future conditions may be made. The hydraulic modelling studies and the overall approach of the study should provide reasonable guidance for potential development over the immediate planning horizon. Debate and speculation about changes in the longer term will continue and research efforts in this direction will also intensify. The factors to be considered are numerous, and their future changes so uncertain, that any attempt to quantify the likely effects on the region would be at best extremely tenuous. The most realistic approach to assessing potential long-term effects would probably be a sensitivity study. The areas under which climate change might be considered include.

Rise in Sea Level

Historic data indicate a phase of global warming. There is fairly widespread agreement that a rise in sea levels is likely in the medium term. There is much less of a consensus on the magnitude of such a rise. The effects of sea level rises of one and a half metres would create backwater, impeded drainage and morphological effects at the confluence of the Ganges and the Brahmaputra. A rise in sea level in the range of typical climate change scenarios is unlikely to have any significant direct effect on the North West Region, but other areas of Bangladesh are liable to suffer very severe consequences, and this may be expected to have indirect social and economic effects throughout the country. Unless these events were to happen in a much shorter time span than is currently being forecast, it seems unlikely that provisions have to be made in the feasibility planning stage of the current round of projects in the NWR. The full FAP and the projects in the south of the country are unlikely to be able to ignore these questions.

Table 5.1 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

Changes in Rainfall

There is less consensus about probable future changes in rainfall, both in terms of absolute quantities and in the spatial and temporal distribution of such changes. An increase in rainfall in the region would have obvious implications on flood inundation levels; conversely, a reduction in rainfall might affect the types of crops being grown, and the economic appraisal of flood protection and other development schemes.

Temperature Change

Similar comments apply to temperature changes which could significantly affect snowmelt, and its contribution to flooding in the region. Changes in amounts, rates and timing of snowmelt runoff from the Himalayas could significantly affect flood peaks in Bangladesh. Increases in temperature to 40 degrees Centigrade would likely inhibit the growth of rice.

Other Atmospheric Changes

Rising levels of both atmospheric carbon dioxide and ultra-violet radiation are closely linked to the process of photosynthesis and biomass production. Existing research has not provided any conclusive evidence of the likely direct of change with respect to rice. With increased carbon dioxide biomass and seed production can increase but this effect can be neutralised by increased radiation. Rice paddies emit significant quantities of methane which is itself a gas that contribute to global warming and ozone depletion.

Coincidence of Events

The significance of the coincidence of flood peaks on the Ganges and Jamuna are referred to in Volume 10 Chapter 2; various aspects of climate change could influence the likelihood of such coincidence in the future, together with timing of local runoff in the region, and in the long-term this could significantly affect the return period of particular levels of flood inundation.

Siting of Embankments

Siting embankments is another example of risk assessment taken internally within the design process. A number of major problems exist in the design standards, the suitability of construction materials (and thus the sustainability of structures and embankments) given the highly dynamic geo- and hydro-morphological systems they intervene in. High rainfall events peaked in time intervals less than those assumed for planning behind or upstream of embankments can lead to their demise. Engineering structures and their operations across the borders can lead to peak flooding which is unrelated to the natural hydro-graphs which the designers work from. Changing river courses mean that real costs can escalate substantially above those estimated at the time of original design. If they are built close to existing main channels, they are subject to being severely eroded by a high recurrence-interval flood. If this occurred early in the embankment's life, the whole initial costs would have to be written off.

Seismicity and Embankment Liquefaction

There are a number of hazards where analysis of their implications should take place. None are easy to evaluate mathematically. Earthquakes, for example, may or may not be predictably distributable on a recurring interval scale. Their intensity of destruction may also be related more to their coincidence with other events, such as the coincidence with the monsoon and flood peaks, coincidence with high rainfall years or coincidence with mass wasting events and other morphological threshold events, either upstream or within the delta.

The secondary effects have already been witnessed after the major quake in Assam in the 1950s which rapidly aggraded the bed of Brahmaputra by around 1.5 meters. This phenomena was probably responsible for the sequence of peak flood events in 1954, 1955 and 1956 (which led to the setting up of the IECO studies in the 1960s and the initiation of the major era of embankment building by this last generation) and for the severe deterioration of navigability in the Jamuna.

Earthquakes could also result in the breaching of manmade or natural reservoirs in the upstream catchment in India and the Himalayan states. This could create major sudden increases in stream discharge that could conceivably overtop or destroy embankments that had withstood the direct seismic shock. Flood wave analysis on any of the existing or proposed dams is not available to assess these implications and stresses the need for a catchment and international cooperation in dealing with the issues of hazard assessment.

Local embankment materials are at particular risk to liquefaction as evidenced by the geological surveys of the FAP 2 and FAP 3.1 study. These largely unconsolidated, sandy-silt materials of low cohesive strength would result in widespread slumping failures in the next high-energy seismic event. Even if such an event occurred during the dry season, the direct effects of embankment failures might only be minor, but the integrity of the system would have failed for the following season unless a widespread programme of immediate rehabilitation could be mounted. If the rivers were high, the outcome could be catastrophic with considerable loss of life and property over and above that which would have occurred without the embankments.

To actually find out the implications for the GIP and the main embankments on the Teesta, Brahmaputra and Ghargot, the seismic and liquefaction model results were combined in the geotechnical studies to assess which areas of the surveyed soils which would liquefy under a statistical extreme event. The general indications are that many areas of the embankment would hold but that slumping would occur in areas of unsuitable materials. The implications are that, if the event were to coincide with the monsoon flood period the type of slump breaching would cause considerable damage in the path of the floodwaters.

Two options for mitigation are possible:

- To always undertake adequate surveys and laboratory analysis of foundation materials to avoid the localised use of unreliable materials or,

- To prepare early warning systems and disaster contingency planning for areas considered to be of risk.

The first option implies considerably more survey and design work than is usually the case in Bangladesh and would result in higher construction costs for haulage of suitable materials to sites where high risk materials were otherwise to be used. The second option implies accepting the potential risk but also actually preparing for the event. As this event will occur a hazard response through organised relief programmes and rehabilitation works will be required.

The approach presented in Volume 9 would be the first stage in preparing a disaster preparedness programme. Similarly, the nodal points in the system of the Teesta indicate where changing courses are most likely also indicate sensitive node in the system. The assessment opens up ideas for other options for planning. These might be to ensure a strict quality control over the use of embankment materials in weak sections or to reduce the standards overall so that compete slumping occurred to disperse the flood water more quickly over a wider area.

A proper safety and hazards analysis being carried through for a contingency plan of disaster preparedness and response should be a minimum requirement for any FCD scheme. The major embankments (as dams) should meet international standards, at least to assess and plan for the risks and hazards where loss of life can be expected. This study has been insufficiently resources to undertake any detailed planning of these factors. These should be considered at the next level of investigations.

5.10.2 Resource and Habitat Alterations

The conditions of habitat alteration of significant to the project would be those leading to a cumulatively faster rate of morphological change and, thus, increase in the likelihood of rivers changing their course. The pattern of upstream catchment habitat alteration is not sufficiently well known or understood to make clear predictions as to the likely effects on the Brahmaputra or Teesta. Other features related to mass wasting or seismic events appear to be of far greater significance.

It is clear that Bangladesh and the regions around are going through a phase of major landscape, floral and faunal alteration with a great loss in genetic diversity and a restructuring of the food chain linkages. Ultimately the main loosers in this is mankind itself. The implications involve loss of survival strategies, livelihoods, traditional medicines and the quality of life to highlight a few issues. The GIP area has already gone through the worst of this degradation and will suffer as much as anywhere else. Proposals to revive a caring approach to environmental management where local people are assisted and empowered to regain control over their future diversity of resources has been proposed. The basis of this conforms to the national environmental policy of May 1992, the thrust of the National Conservation Strategy (draft 1991) and the World Conservation Strategy (IUCN 1991)

5.10.3 Socio-economic Risks and Hazards

The regional projects are specifically intended to alter the cropping pattern of conservative farmers whose planting strategies have traditionally been "risk-averse". Given the chance of ordinary floods damaging crops in their lower-lying fields, farmers habitually avoid the substantive investments necessary to raise HYV cultivars, hoping for a bumper crop. Knowing that the odds for this are not good, they instead sow traditional, low-yielding cultivars that may or may not reach fruition: if the planting survives the floods and produces a modest harvest, so much the better. But if it doesn't, the investment was small enough that the loss is bearable.

The basic rationale for the proposed interventions is that the likelihood of crop survival in marginal zones can be raised sufficiently by the projects, that even a cautious and risk-averting farmer will consider that the odds have sufficiently changed in his favour, so that HYV inputs are now justified. Most of the quantifiable benefits hinge upon this eventuality. The process being initiated is an expectation that engineered reduction of agricultural risks will induce farmers to upgrade their production systems. Contingency elements imply risk-taking. The current assessment of the probability of farmers actually shifting to HYV indicates that enough will shift production strategies to recommend higher-ranked projects for feasibility studies, but only if it can be established that those living outside the embankments will not find conditions worse and cutting becomes inevitable.

Farming Systems

The discussions on sustainability have already noted a number of cumulative changes associated with the Green Revolution technologies, changing intensity of resource use and habitat alteration. These affect biological conditions and status of soils and water bodies to the extent that critical thresholds have already been passed in the GIP area with respect to wildlife and naturally occurring tree and terrestrial floral cover.

The debate on the social, economic and biological impact of these technologies is intense and involves many powerful commercial and academic interests. Independent reviews of the patterns and trends associated with mismanagement of these systems in the environment are reasonably clear on the net detrimental and cumulative impacts. Examples of land and water pollution and resource degradation from the industrial complexes that support the commercial trade and use of oil-based agro-chemicals are now documented from every continent and virtually all countries. With the wealth of experience that has now accumulated Bangladesh has the opportunity to avoid and minimise the hazards which have undermined the future resource productivity elsewhere.

The traditional farming systems are based around risk minimisation strategies. The intensification of agriculture and uptake of irrigated HYVs leads to specialisation, indebtedness, shifting in the access to resources and a greater dependence on external factors. Thus, while the overall increase in productivity and seasonal employment may appear to show overall gains, the real situation of continued marginalisation and entitlements to food and resources may get worse for more amongst the resource poor. For instance, increased seasonal employment is unlikely to provide better nutrition throughout the year.

Options for integrated resource management have been offered in this study as a future direction to be taken up for detailed planning.

Migration

The process of migration of people's has taken unprecedented turns at a global level over the last two decades. Traditional definitions of refugees have now to cope with the explosion in numbers of displaced peoples who fall into categories of environmental refugees, economic refugees and those suffering persecution and human rights abuses. The phenomena has become so widespread that its effects cannot be ignored in virtually any realm of national planning. These effects are less easily seen at the scale of most projects and predictions of the impacts at the project level are impossible. The most significant feature that will affect conditions in the project will be the status and displacement of people caused by the continued westward movement of the Brahmaputa or the south westward movement of the Teesta.

5.10.4 Upstream Impacts

The erosion of watersheds due to landslips, glaciation and soil erosion have the effect of forcing the river watershed backwards and can result in river capture. The main threat to water flows and river typology in Bangladesh within the long term planning horizon may come from the Arun (Kosi) river flowing between Mount Everest and Kanchenjunga. This 6,000 metre trans-Himalayan gorge, with its headwaters in Tibet, is a few kilometres from the west-east course of the Tsangpo on the other side of the Tibetan Himalayas. The steep gradient and erosion strength are very likely to capture the Brahamaputra and divert its outflow into the Ganges catchment at some stage.

Tectonic movement, Himalayan and delta orogeny, and successive phases of uplift and subsidence cause various degrees of river migration. This process continues unabated and in time scales that cannot be ignored in planning. The last three hundred years have witnessed major migration and changes of course of the Ganges-Padma, the Jamuna-Brahamaputra and the Teesta. The Teesta valley experienced 40 occasions between 1891-1965 when cloudbursts produced more than 250mm of rain within 24 hours and also with peaks of 400mm. In October 1968 three days of incessant rain produced 1500mm of rainfall that caused landslides that blocked the river causing heavy flooding.

Similarly, glacial lakes outbursts in the Himalayas can also occur. Where lake outlets become blocked with glacial rock and sediments, as the snow melt sets in vast columns of water can build up which eventually burst through sending plugs of sediments and flood waves down the valleys. These produce a non-random distribution of sediment transfer into the Brahamaputra system.

Major flood events are not just associated with periods of high rainfall, but are also influence by upstream construction and management of embankments and barrages in India. Mass wasting and snow melt characteristics in the upper catchment also play a fundamental role. The 1950 Assam earthquake induced mass wasting of upstream hillsides and river embankments which collapsed in to the Brahmaputra suddenly. This led to sudden morphological changes and plugs of sediment which created immediate and disastrous flooding in Assam and Bangladesh. The debris was transported through the Jamuna and increased the levels of the 1954, 1955 and 1956 floods. Measurements at Bahadurabad indicated that the dominant low water levels during the 1950s increased from 11.9 to 13.4 m which since the 1960s has shown a trend of gradual decrease. This one major natural event led to short-term changes in bed levels of 1.5 m.

The Brahamputra and Barak in Assam are embanked over 3,400 km with 700 km in India. Some of these embankments date back to 17-18th century. The rivers from the immediate hill catchments carry considerable sediment that is deposited into the braided channel and raises bed levels. Retired or new embankments have consistently had to be constructed. The cutting off of floodplain in Assam and India denies the river these areas for sediment deposion and flood storage. These materials pass down the system to Bangladesh. The additional sediments provide a major benefit of more rapid delta and land formation at the estuarine and coastal zones. The additional dis-benefit is the temporarily higher floods.

A number of proposals have been made by upstream state to create flood storage structures. If dams were ever built they would provide flood moderation advantaging Bangladesh. Cheaper alternative being considered involve a series of check dams on smaller tributaries before starting on major dams on the main rivers and would improve drainage from behind existing upstream embankments and develop dry season irrigation. Any such plans would inevitable affect the base flows and sedimentation characteristics of the Brahmaputra.

There is an unclear position with regards to possible degradation of the vegetation cover in the upstream catchment. The most important conclusion for the immediate planning is that the high sedimentation levels of the Brahmaputra, whether natural or induced in their origin, will not decrease. The complex morphology of the Brahmaputra will therefore continue.

The conditions of char dwellers would the directly affected but the mainland in the NWR less so. None of these considerations have been possible to accommodate or integrate into the planning for the NWRS as there is an insufficient data base. They have, to an extent been, dealt with through the sensitivity analysis run on variations in the Jamuna water levels that also attempt to provide a policy impact of the Jamuna bridge and major FCD embankments on the left bank of the Bramaputra.

5.10.5 Multiple Project Impacts

There is now considerable evidence that much of the damage associated with flooding is incorrectly attributed to natural hazard. The evidence of the Lower Atrai and Sonail embankment scheme are good examples of the role of breaches and cuts in embankments. Within the GIP area flood damage was not reported as a major constraint in the District Gazetteers until after the BRE and TRE were built and breaches occurred. It is noteworthy that the development throughout the region of roads and railways have effectively compartmentalised the whole region.

The GIP has the same configuration with the scale running from national to town to village to household sized roads and raising transport paths. Virtually none of these are considered to be appropriately designed to pass the river and rainfall waters that build up in the system. Even if one section were improved this would lead a greater quantity passing on down the chain into a system within Bangladesh that is always effectively constrained in the flood season by sea level and the flows in the main rivers. It is thus logical that flood storage throughout the system is the only way that an equity or improvement is likely. This has been the hydraulic conclusion for both the GIP and Green River scenario for the Lower Atrai.

Upstream the Brahmaputra has been embanked for a considerable numbers of years which in itself has contributed to the additional flooding and passing of sediments into Bangladesh. A similar scenario is seen on the Teesta. In the case of every embankment there is a response from the river system of changing water levels through confinement, changing morphology and the reactions of the people who live either side of them. Each additional project adds to these effects. Given that there is as yet little rational inter-state planning or even inter-regional planning under FAP, there should and are serious questions being raised on the sense of the potential massive expenditures and human effort that these undertakings imply when it is not clear what they achieve overall in terms of safety, flood control of reduction in damage. The GIP is just one project that will potentially formalise the cutting of natural drainage paths within the area and again rehabilitate the previous attempts to control the Teesta and Brahmaputra. The response of these massive rivers is very likely to be the same as its recent history, leading to another succession of breaches and retirements and changing river courses that have been indicated by the morphological assessment to be within the period of economic planning time frame.

5.11 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 such a plan would effects. 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.

All the projects in the current plan are built to a variously set design criteria. 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.

5.12 Recommendations and Future Work

A number of recommendations have been made in this study to indicate the key areas for detailed future work which would result in proper zoning and response for water, human and natural resource planning. These can be summarised as follows:

- To incorporate planning and management criteria to sustain development potential by conserving resources through proper zoning and integrated use of resources.

- To finance and plan flood proofing measures which 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 this 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.

- To undertake detailed surveys and public participation for integrated navigation networks to allow proper access for boats for fishing and cargo landings and transhipment as well as for general communications and travel. Special studies are required of the role of boats in general development assistance programmes and particularly disaster response.

- The most significant hazards will involve events associated with, or occurring coincidentally with, the monsoon season. Full disaster preparedness and response programme are required and 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.

- To mobilise public participation and support for a partnership between local communities, government and donors in planning and effecting flood action plans and disaster response should be given more emphasis. This would help resolve many contradictions of interest and ensure better management and caretaking of the infrastructural base for flood control. The role of and liaison with local women's committee is seen as central to community issues for flood preparedness.

- To undertake detailed planning and integration with existing programmes for the provisions of potable village water supplies and appropriate technologies to mitigate FCD and I effects in the Mohananda, Barind and Lower Atrai areas.

- To undertake detailed planning and integration with other FAP studies for the provisions of flood proofing, clean and potable village water supplies, latrines, food storage and improved sanitation for the char and embankment dwellers in the Teesta and Brahmaputra systems. Such improvements would reduce the risks of disease and these people's current susceptibility to post disaster problems.

- To undertake agro-ecological and nutrition studies to establish how FCD and water management operations can address the over-riding development problems of poor nutrition by improving the nutritional diversity in the farming systems and the access of the resource poor to these products. Targeting of development resources, agricultural planning and water management into addressing the issues of malnutrition would improve the resilience of those most at risk. This requirement applies both to minimising post disaster problems, as well as to more productive development roles.

- To undertake detailed planning of the new uses to which the embankments of the Lower Atrai can be put. This might include flood refuges, settlement sites, forestry/agro-forestry or vegetable/medicinal herb production areas. The use of extended berms on new embankments for similar productive purposes seems essential as a minimum design criteria on the main river embankments. Some of the issues are already under research and these results must be widely taken account of.

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

- To maintain a monitoring programme on confined rivers where rising bed levels would lead to high future flood damage risks.

- To undertake detailed studies of the problems and responses to impeded drainage behind embankments. This should include management options to assess both public health and sanitation programmes, community measures and the potential for the productive management of this water resource into the dry season.

- 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.

- To resource research and monitoring to allow integration of natural resource and water management planning for maintaining the critical wetland processes and developing programmes of 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.

- To immediate resource the existing FAP 16 proposals for a wetland needs assessment. This should move as rapidly as possible 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 FCD schemes.

- To develop multi-purpose water management criteria for the design and operation of FCDI projects to maximise the biological and economic diversity of the productive resource base in agriculture, to reduce pest and disease risks and to minimise the build up of nutrients, aquatic weeds and pollutants within engineered schemes.

- To resource and expand the existing research and NGO involvement in paddy-fish and IPM programmes. The focus of this study would need to look at sustaining and developing the "free goods" deriving from wetland processes and enhancing the diversity of economic aquatic resources from integrated resource use in the totality of paddy landscapes.

- To resource surveys of the fisheries species, habitat, migration and biological systems of the NWR fisheries. This should distinguish between the differing systems of the rivers and floodplains of the north west, the Teesta floodplains, the Jamuna floodplains and the Lower Atrai. Current FAP 17 inputs in the NWR are concentrated in the Lower Atrai only. This research should feed directly into engineering studies for appropriate structures and seasonal systems for water control and management to enhance the survival of these fishery systems. The work should clearly distinguish between the biological and economic significance of the floodplain and river systems.

- To establish of a proper institutional basis to coordinate the research and water management planning for the NWR.

- To ensure that feasibility and detailed design studies undertake timely surveys to deal with the problems of land acquisition, compensation and resettlement.

- To establish a financing facility to ensure that proper and timely surveys of important cultural and heritage sites in future studies. Also to integrate into planning the research and, if necessary, protection of cultural and heritage sites.

CHAPTER 6

ENVIRONMENTAL MONITORING AND FUTURE STUDIES

6.1 Aims and Objectives

The NWRS has found insufficient basic research data to allow an appreciation of the likely magnitude of changes in key parts of the ecological and socio-economic systems. The basic monitoring capabilities and the availability of trained staff to carry out environmental monitoring are also in short supply. Without trained staff and proper facilities the long-term programme will take time to establish. Major training expenditures will be needed and some investments in field and laboratory facilities will also be required.

The primary aim should be twofold. First, to ensure that adequate baseline studies are carried out in future feasibility studies. Second, to feed this programme into a longer term institutional monitoring programme. Without a baseline catalogue of "before project" situations it will be difficult to detect future change and assess its implications.

The objective of the programme will be:

- to provide the operational facilities, personnel, technical and analytical skills, and the necessary finance to carry proper monitoring.

- to provide the means to increase the database on, and understanding of, natural seasonal and annual fluctuations in key environmental parameters and inter-relationships.

- to provide the means of reporting results to the relevant Government authorities and the general public.

- to provide a mechanism where the management of a variety of isolated project activities may be seen and managed as an integrated resource management system.

The benefits will include the means to assess water quality and management of supplies for potable uses and for irrigation and fishing inside and outside of project areas. It will identify the minimum management needs for important wetland and river bed resource users and ecology to maintain future development potential and conservation of resources. It will help identify the main pollution sources and assist a programme of pollution control at source where the real costs are borne by the polluters and do not become a hidden cost paid by other sections of society. It will also ensure that industrial producers, in time, price their goods at the true market values which would include the pollution protection costs.

The current approach is reactive, rather than preemptive. The increased emphasis on monitoring would help move the system to avoid problem by proper environmental management criteria being built into schemes at design. Baseline surveys by the Ministry of Health using its research institutes have been shown to be a vital component of all future projects. These will have to use monitoring to assess the ongoing needs for environmental management techniques.