Government of the Peoples Republic of Bangladesh
Flood Plan Co-ordination Organization

North West Regional Study (FAP2)

Gaibandha Improvement Project Final Report

Overseas Development Administration, U.K.
and Japan International Cooperation Agency

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Government of the Peoples Republic of Bangladesh
Flood Action Plan

NORTH WEST REGIONAL STUDY (FAP-2)

MOTT MACDONALD INTERNATIONAL
in association with
HYDRAULICS RESEARCH LTD.
HOUSE OF CONSULTANTS LTD.
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PREFACE

The North West Regional Study Final Report describes proposals for the Regional Water Development Plan and the results of the project preparation studies for the Gaibandha Improvement Project. It consists of the following volumes:

- Regional Plan Final Report
- Gaibandha Improvement Project Final Report
- Annexes to the Final Report

The Regional Plan Final Report is a revision of Volume 1, of the Draft Final Report. The Gaibandha Final Report is a revision of Volume 5 of the Draft Final Report. The Annexes contain the comments and responses on the Draft Final Report, together with additional supporting material.

The Draft Final Report, which was submitted in October 1992, consists of the following volumes :

Vol. 1	The Regional Plan
Vol. 2	Regional Data and Planning Units
Vol. 3	The Regional Plan - Engineering
Vol. 4	The Regional Plan - Initial Environmental Evaluation
Vol. 5	Gaibandha Improvement Project - Main Report
Vol. 6	Gaibandha Improvement Project - Engineering
Vol. 7	Gaibandha Improvement Project - Topographic Survey and Geotechnical Investigations
Vol. 8	Gaibandha Improvement Project - Environmental Impact Assessment
Vol. 9	Hydraulic Studies
Vol. 10	Hydrology and Groundwater
Vol. 11	Social Impacts
Vol. 12	Agriculture and Fisheries
Vol. 13	Economics
Vol. 14	Ecology
Vol. 15	Health, Navigation and Cultural Heritage

The first four volumes of the Draft Final Report describe the Regional Plan and aspects specifically related to regional planning. Volumes 5 to 9 are concerned with the Gaibandha Improvement Project. The remaining six volumes describe supporting studies relevant both to regional planning and the project preparation studies.

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GAIBANDHA PROJECT FINAL REPORT

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ACRONYMS AND GLOSSARY

ASI	Agricultural, Social and Institutional Programmes
BARC	Bangladesh Agricultural Research Council
BBS	Bangladesh Bureau of Statistics
BRAC	Bangladesh Rural Advancement Committee
BRDB	Bangladesh Rural Development Board
BRE	Brahmaputra Right Embankment
BWDB	Bangladesh Water Development Board
CFD	Controlled Flooding and Drainage
CIDA	Canadian International Development Agency
DAE	Directorate of Agricultural Extension
DOE	Department of Environment
DOF	Department of Fisheries
DTW	Deep Tube Well
EIP	Early Implementation Projects (Programme)
EIRR	Economic Internal Rate of Return
FAO	Food and Agricultural Organization of the U.N.
FAP	Flood Action Plan
FCD/F.C.D1	Flood Control, Drainage and Irrigation
FFW	Food for Work
GIS	Geographic Information System
GIP	Gaibandha Improvement Project
GLE	12 Ghagot Left Embankment
HYV	High Yielding Variety
LCS	Labour Contracting Societies
LGED	Local Government Engineering Department
LLP	Low Lift Pump
MIKE-11	Computer Model for River Routing
MPO	Master Plan Organization
NCA	Net Cultivated Area
NGO	Non-Governmental Organization
NPVR	Net Present Value Ratio
NWP	National Water Plan
NWRM	North West Regional Model
NWRS	North West Regional Study
O&M	Operation and Maintenance
PWD	Public Works Datum (Water Level)
R&H	Roads and Highways Department
SIRDP	Sirajganj Integrated Rural Development Project
SRP	Systems Rehabilitation Programme
SSFCD1	Small Scale Flood Control, Drainage and Irrigation Programme
STW	Shallow Tube-Well
SWMC	Surface Water Modelling Centre
WARPO	Water Resources Planning Organisation
WFP	World Food Programme
Char	A shoal in the active flood plain
Thana	Smallest administrative unit in Bangladesh

THE GAIBANDHA IMPROVEMENT PROJECT

SUMMARY

1. The Project Area

The project area lies south of the confluence of the major rivers, the Teesta and the Brahmaputra. It is bounded on its south and west sides by the river Ghagot, and on the far north-west by the Gaibandha to Kaunia railway line (Figure 1). The gross area is 57600 ha.

It has a population of 550000 people, at a density of just under 10 per gross hectare. It is thus more densely-populated than the average for rural Bangladesh. It is a very poor area, with high levels of landlessness, few employment opportunities, low levels of health and literacy and lack of infrastructure provision. Many people who have lost their land to the main rivers live in harsh conditions on the main embankments. Seasonal out-migration in search of work is extremely common.

Agriculture is the main activity in the region. Present cropping intensities are around 170%. The main monsoon crop is transplanted aman. Jute is also important in the area. Irrigation coverage is at present about 30% of the area, predominantly from groundwater.

Fishing takes place in the bordering rivers and in beels within the project area. There are also fish ponds within the area, but these are not as widespread as in some other parts of the north-west region because the porous soils means that the fish ponds are difficult to maintain. Total production at present is estimated at about 750 tonnes, of which 55% is capture fisheries.

Provision of infrastructure such as roads is generally poor. One thana (local government centre) within the area is not connected to a sealed road. Flood protection embankments exist along the Brahmaputra and Teesta, along part of the Ghagot, and downstream of Gaibandha on the Sonail scheme. The embankment along the Teesta, in particular, is breached over a long portion.

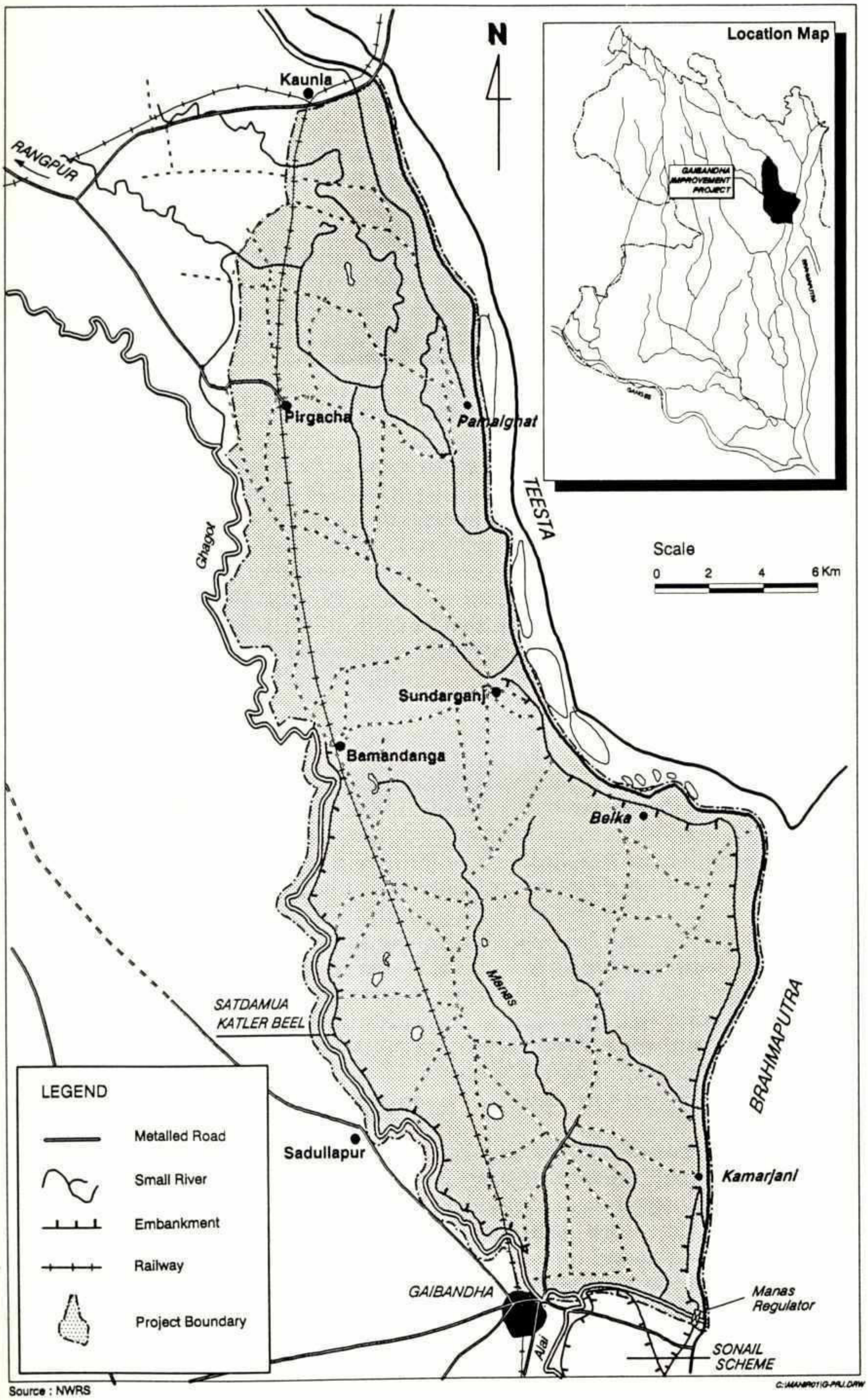
With the exception of the limited number of beels within the area, there are no large areas of persistent deep flooding. The land is intensively farmed and the biophysical environment has been modified as a result of this. Groundwater supplies are adequate and there are no serious problems of water quality. Health problems exist; these are contributed to by the poverty and dense population in the area. Navigation is at present not very widespread through the project area, and takes place only during the monsoon.

Gaibandha is a district town, and has the appropriate facilities and government structure. There are all or part of five thanas within the areas, each with their own appropriate facilities and local government structure. Several NGOs are working, on a variety of social and income-generating projects.

2. Flooding Problems

The flooding problems within the project area are set by the rivers surround it. These relate to flows through breaches in the Teesta right embankment (both within the project area and upstream), spill from the Ghagot left bank, breaches in the Brahmaputra Right Embankment (BRE), and drainage congestion at the downstream end. Erosion and breaches in the BRE cause serious localised problems but do not have extensive impacts throughout the project area since land slopes mean that drainage

Figure 1
Project Area



Source : NWRS

is from the project area towards the main river. However the Manas regulator which lies at the outfall of the Ghagot to the Brahmaputra is likely to be washed away next year. There is therefore an urgent need to decide on the necessary course of action to take, assuming that this will indeed happen.

A key aspect of flood protection development is that it has significant impacts on adjacent and downstream areas. Therefore additional areas have been considered in formulating the project plan. These include areas on the right bank of the Ghagot which are impacted by left bank developments. Downstream of Gaibandha the Ghagot flows into the Alai. Impacts of project works on floods in the Alai have also been considered.

An extensive round of public consultation was held to elicit the views of the public on flooding problems and possible solutions. These included formal and informal meetings with groups of villagers in different locations, together with interviews with district level officials, and formal meetings with thana officers and local chairmen. Meetings were also held separately with NGOs. These confirmed the general picture of flooding in the project area. A range of options were put forward during the consultation. There is effectively unanimous support for any measures which will control the major rivers in their present courses, prevent breaches and prevent further loss of land. At the downstream end there was also very widespread support for replacement of the Manas Regulator by a different arrangement which would not cause drainage congestion. Cuts regularly take place on the BRE just upstream of the regulator to relieve such congestion. Excavation of the internal rivers such as the Ghagot and the Alai was also suggested on many occasions, as a means of stopping spillage from these rivers. Elsewhere options were often set by local conditions and might be in conflict with options suggested by others in adjacent areas. For instance, those on the right bank of the Ghagot opposite existing the Satdamua-Katler-Beel embankment proposed an embankment on the right to protect them. This would further raise levels along the Ghagot and disadvantage the significant number of people living between the embankments.

3. The Range of Options

Following field investigations and the rounds of public consultation, a very wide range of structural options for alleviating the flooding problems were investigated. These covered sealing of the Teesta Right embankment at different locations, different embankment protection schemes along the Ghagot left and right banks and different configurations at the confluence of the Ghagot, Alai and Brahmaputra. Analysis of the impacts of these components, independently or in combination, was carried out using a hydrodynamic model specially developed for the study in order to determine the most favourable combination. Morphological considerations were also taken into account. Following this analysis a further set of refined options were produced, with the preferred set of measures on the main rivers but which differed in their treatment of internal drainage flows. One option left existing drainage patterns unchanged while the other eliminated cross-drainage basin water transfer through a form of compartmentalisation. A further option omitting any drainage regulator at the downstream end of the project area on the BRE was also investigated at this time. These were analysed using a 10 year design simulation of the hydrodynamic model in order to select the preferred option.

Besides structural options a number of technological options were also considered. These included an analysis of the factors affecting the choice between river training works, designed to constrain the major rivers in their existing courses, against bank retirement which accepts some loss of land to erosion. Another set of options related to methods of construction, and the choice between using a mixture of mechanical and manual methods, part of which would require relatively sophisticated technology which could only be operated by experienced contractors, and systems which rely primarily on labour-intensive methods appropriate to the large numbers of landless and poor people in the project area. The technological options were analysed separately prior to the formulation of the preferred plan.

4. The Base Option

The main components of the project which were carried forward to full analysis are as follows:

- Sealing of the Teesta right embankment both upstream and downstream of Kaunia, to-gether with necessary strengthening of the existing embankment and improvement of structures.
- Retirement of the BRE as necessary.
- Removal of the Manas regulator, and the construction of a new regulator at the outfall of the Manas to the Ghagot.
- The construction of a backwater embankment along the Ghagot upstream of its confluence with the Brahmaputra.
- Construction of a regulator at the head of the Alai river.
- An extension of the Ghagot left embankment upstream from Bamandanga as far as the Alai Kumari confluence.
- Compartmentalisation within the GIP area.

These are shown in Figure 2. The total cost for these measures in Tk 1670 million.

5. Associated Development

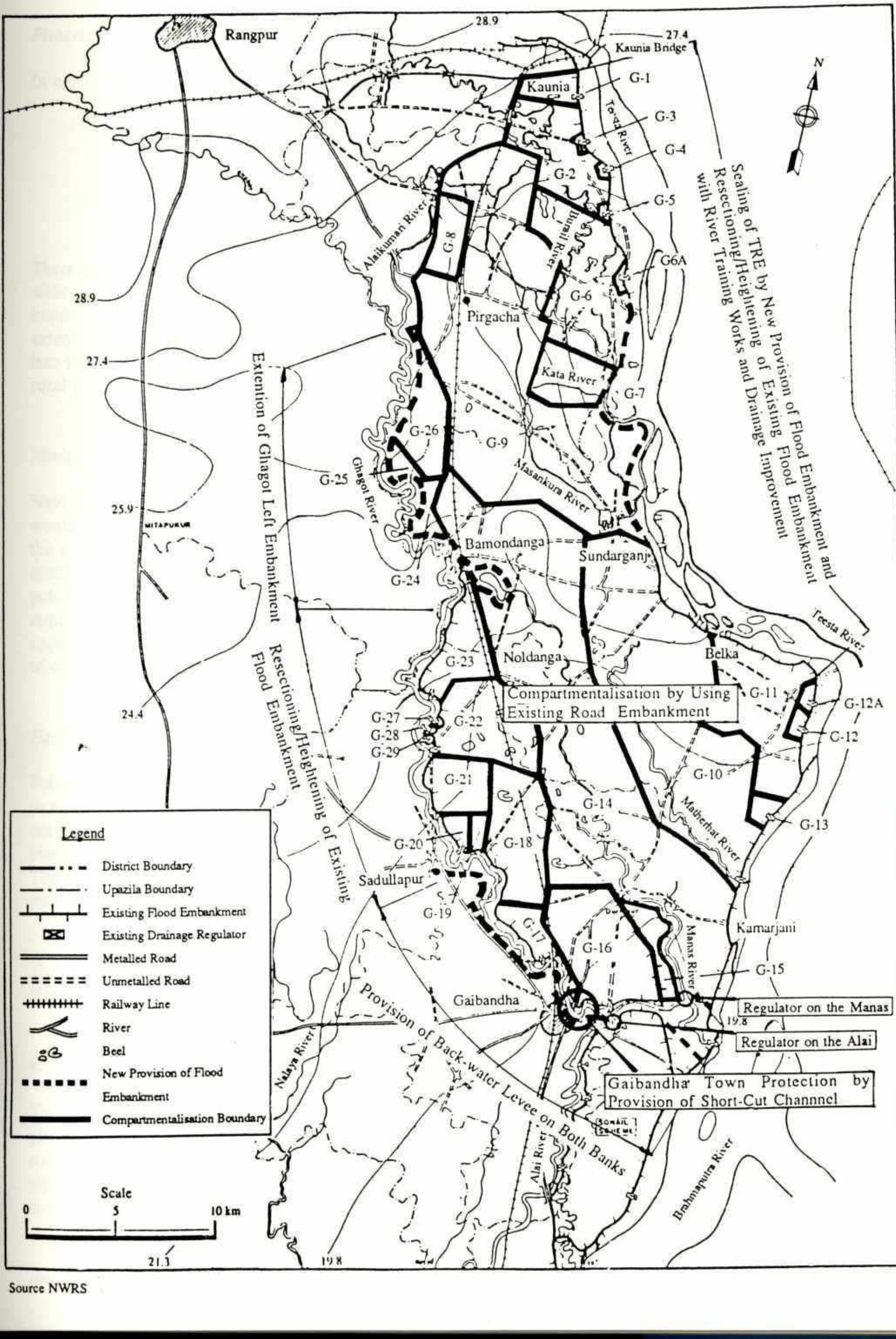
A number of important associated developments should be undertaken at the same time as the main project. These relate to flood proofing, fisheries, navigation, and health.

Flood Proofing

Flood proofing measures are recommended, primarily for those living outside the protected areas and on the chars in the Brahmaputra and Teesta, and also for important public infrastructure within the protected areas. Structural measures include raised platforms for family shelters, complete with sanitary latrine and tubewell, on the chars. On the main river embankments where many displaced families take shelter, there is also a need for sanitary latrines and tubewells. Boats could be provided for emergency transport in the event of high floods. In the protected area it is proposed to provide flood store-cum-shelters at three locations.

There are also important non-structural measures which can be undertaken in relation to flood-proofing, such as instituting early-warning systems, establishing embankment surveillance groups, creating food and fuel storage facilities and the like. NGOs have an important role to play here: such actions should be linked in with those undertaken on a regional or national scale.

Figure 2
The Project Plan



Source NWRS

Fisheries

In regard to fisheries, the programme should consist of the following components:

- preservation and improvement of khas water bodies,
- development of borrow-pit fisheries,
- modification of hydraulic structures to allow fish passage to the extent possible,
- enhancement of capture fish resources through public stocking programmes,
- support for fish farming opportunities.

There are other more general actions and programmes which should be undertaken as part of a nation-wide attempt to strengthen the fisheries sector. These include a new water body areas survey, improvement of fisheries statistics collection, enforcement of fisheries rules, strengthening of the extension service, and research into minor carp propagation. In addition the work being carried out into the development of rice/fish culture systems is obviously of great importance to the future of rural production in Bangladesh.

Navigation

Navigation has not recently been of importance in the Gaibandha area. However the project proposals would open a route for traffic from the Brahmaputra into the Ghagot and to Gaibandha. In addition, the advent of cheap and readily accessible engines for country boats has revitalised the sector, and consideration should be given to developing country boat routes inside the project area. Three potential routes have been identified and preliminary proposals outlined. Considerably more work is required, particularly to assess the work required on the internal routes, the trade off between the requirements for navigation, fisheries and perhaps irrigation, and to determine the optimum method of connection or transhipment between the country boats and the main river.

Health

Potential health problems have been identified, due to water-related diseases. The relative contribution to these problems of CFD measures and other factors such as poverty and population pressure has not been determined. However, there is a clear need for further studies during the next stage of planning and detailed design, and the incorporation of mitigatory measures if these can be identified. These are likely to relate particularly to flushing and drainage problems, and the avoidance of small stagnant water bodies.

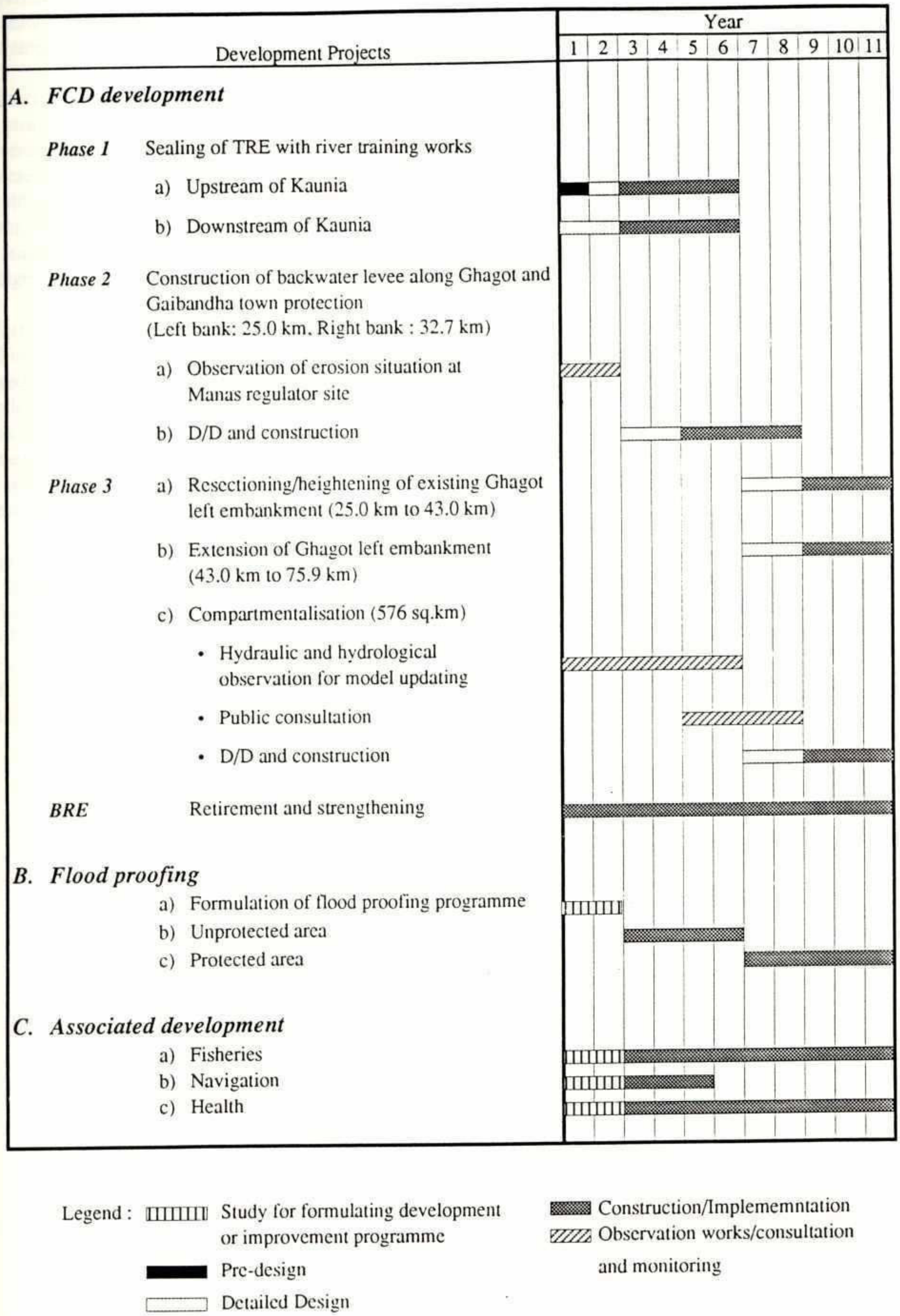
The estimated cost for flood proofing, fisheries and navigation is of the order of Tk 200 million. Health costs are not included, since they are not sufficiently defined at this stage.

6. Implementation

The implementation schedule for the full project is shown in Figure 3. It breaks the project up into phases, with the more urgent river training works being carried out as soon as possible, and other components which have lower returns (such as the Ghagot left embankment extension), or which need significant further planning and consultation (such as compartmentalisation) being left until later. An overall implementation period of eleven years is allowed, with a considerable period for further

Figure 3

Implementation Schedule



planning and detailed design before any physical works starts. This will make it possible to resolve important institutional issues and to begin the establishment of suitable groups of local people for the consultation process, and for involvement in construction and O&M. A programme for the implementation of the associated development is also included in Figure 3.

Institutional issues to be resolved relate to the overall management of the project, and the methods for promoting integration between the various institutions involved, specifically local people, agency representatives, local government and NGOs. The traditional model of a project committee with representatives from all concerned institutions is probably too large to be effective and some thought should be given to a much smaller co-ordinating committee, with key representatives from each sector. A project management unit (PMU) to provide technical support and backup will probably also be required. This could best be provided through a local consultancy group, perhaps with some foreign inputs.

A further institutional aspect to be considered is that there are on-going proposals for developments within the project area which have direct linkages with the proposed project plan; there may also be a need to make immediate decisions on actions to be taken if, as seems likely, the existing Manas regulator is washed away during the next monsoon. Thus some mechanism for co-ordinating on-going work and integrating with project proposals and institutions is needed in the short term. Such on-going or new proposals for work by others within the project area are likely to be a permanent feature of the work and are to be welcomed. The project should be seen as providing an overall sub-regional framework, within which a range of small-scale developments can take place.

Operation and maintenance continues to be a difficult problem to resolve for flood protection schemes. As the new works will not become operational for some time, there is the opportunity to consider a variety of different approaches, all of which must be based on a much greater degree of public involvement than hitherto. There is a possibility that the next stage of FAP13 could base a pilot project for O&M at Gaibandha, in order to develop new concepts and improved processes. Again, there will be a need for liaison with on-going projects, many of which are part of existing O&M initiatives.

7. Project Analysis

Analysis was carried out of the base option and a range of the other structural and technological options which were investigated. The results are given in Table 1.

Table - 1 Gaibandha Project Analysis

Total Project Cost (Including sealing of Teesta upstream of Kaunia)	Tk.	1670 million
EIRR of Base Option		10%
Annual Rice Output		335,000 Tones (+8%)
Total Annual Fish Output		675 Tones (-3 %)
Incremental Construction Employment		9.76 million days
Annual Agricultural Employment		20 million days (+6%)
Reduction in Annual Damage:		
- Crop		Tk. 37 million
- Infrastructure		Tk. 45 million
Sensitivity Analysis		Economic Internal Rate of Return
10% Increase in rice returns on Base Case		17%
20% Increase in all costs on Base Case		8%
Base Case with Bank Retirement instead of River Training (15 year)		6%
Base Case with Mechanical/Manual Construction		7%
O&M at 10% for River Training Works		6%

In respect of the technological options, analysis shows that river training works were to be preferred to bank retirement. The economic costs of river training are lower than for bank retirement, even allowing for the high cost of O&M of bank protection, not only because of the high cost of retirement itself but also because of the high cost of loss of productive land to river erosion. In this case the results of the economic analysis would be fully supported by social impact analysis. People living in the area affected by river erosion are unanimous in wishing the bank to be stabilised in its present location and there are no social conflicts involved in attempting to achieve this.

Analysis also shows that economic returns are lower for the mixed mechanical/manual methods of implementation, than for labour-intensive methods. Labour-intensive methods are considerably cheaper; although they take longer and have higher O&M costs, overall they have lower economic costs. They also have considerable advantages in creating employment for poor and landless people, and have greater potential in enabling public participation in the planning, design, and construction of the facilities. This should also have advantages in involving local people in the subsequent O&M.

On the other hand, mixed mechanical/manual methods result in a higher standard of construction and better quality facilities. This is important in view of the very low standards, particularly of bank compaction, which are commonly seen.

All subsequent analysis was therefore carried out of options involving river protection rather than bank retirement and labour-intensive rather than mixed mechanical/manual methods of construction.

Economic analysis was carried by comparing the economic costs of the project against its economic benefits. This analysis involves the full range of costs for all the works stated, plus periodic bank retirement of BRE. Benefits consist of increases in agricultural production, reduction in crop and infrastructure damage, and changes in fish production. Besides benefits within the project area, there are benefits outside, notably on the right bank of the Ghagot where flows will be reduced due to sealing of the Teesta upstream, and downstream on the Alai, where flows will be reduced due to the regulator on the Alai. Avoidance of losses due to river erosion by the Teesta has also been included as a project benefit.

The returns for the base option involving all components of the project are 10%. These benefits are fairly low because they are based on fairly low increases in agricultural productivity, (an increase in HYV t. aman over an area of 6362 ha, which is an annual incremental benefit of Tk. 70mm in economic prices). Significant benefits are also obtained from reduction in crop and infrastructure damage, amounting to about Tk. 37 million and Tk. 45 million per annum respectively. These benefits include damage reductions in the impacted area. In addition avoidance of losses due to river erosion is a significant benefit. In net terms there is almost no change in value of fisheries benefits, although there is a decline in capture fisheries and a projected increase in culture fisheries.

As with FAP projects generally, returns are very sensitive to benefits. A 10% increase in overall returns from rice production, which could be made up partly of increased area and partly of higher prices, would increase the EIRR of the base project to about 17%. Returns are much less sensitive to costs. An increase in all costs of 20% only reduces the EIRR of the base case to 8%.

Further analyses were conducted to attempt to identify the benefits generated by individual components of the project. The analysis is not precise since it is not always possible to separate out the benefits: however the analysis is broadly indicative of the significance of each component.

The base case, including all components, has an IRR of 10%. This includes provision for backwater embankments on the Ghagot river and a new regulator on the Manas river, to provide protection in the likely event of the current Manas regulator being washed away.

However, since these works will essentially fulfil the same function as the existing regulator, they produce no benefits over the present situation with the Manas regulator still in place. It could in fact be argued that the future-without condition should exclude the Manas regulator. Although the latter analysis has not been conducted, an analysis has been carried out of the base case excluding these replacement costs. The IRR increases to 12% in this case.

Other analyses were conducted of individual project components: these analyses included the replacement cost of the Manas regulator.

The sealing of the Teesta Right Embankment and construction of a regulator on the Alai river were analysed together, since it is difficult to desegregate agricultural benefits in the Alai basin. The IRR in this case is 11% (If Manas regulator replacement costs are excluded from this analysis, the IRR increases to 13%).

It is reasonable to conclude from the above analysis, however, that sealing the Teesta Right embankment, probably in conjunction with regulation of the Alai river, is the priority work and is on the margin of economic viability. This also justifies the proposed phasing of the overall project, since more study will be required to establish the precise design of compartmentalisation.

8. Project Impacts

The social and environmental impacts of the project are generally positive.

Sealing of the Teesta embankment and protection from the major rivers would be welcomed by all who live within their influence: other project measures such as the new configuration of the Ghagot/Alai/Brahmaputra confluence would tend to reduce existing social conflict, for instance downstream on the Alai.

Construction and increased agricultural output will generate employment for landless and poor people.

The rounds of public consultation that have already taken place have engendered a positive sense in the community towards the proposed development. If this can be continued into the detailed design stage, there is the possibility of fostering a genuine spirit of participation from the local people in further stages of planning, design, construction and O&M.

There are some potential social implications to the option of compartmentalisation. While the area of flooding is reduced overall, it is spread more widely than in the "without compartmentalisation" option. This may cause increases in water-related health problems; it may also lead to increased numbers of locations where head differences exist across embankments, so possibly increasing social conflicts and the potential for public cutting. The implementation schedule allows adequate time for analysis and consultation to eliminate such potential problems prior to construction.

The income distributional consequences of the project are likely to be adverse, since those with the largest landholdings gain the greatest benefit. However, the same is true of any projects based on land enhancement. Although the greatest increases in per household incomes are likely to go to larger landowners, significant short-and long-term benefits should also accrue to small farmers and labourers. Other potential benefits will go to fishermen, boatmen and char and embankment dwellers if the proposed associated developments are included in the project.

Adverse impacts on the bio-physical environment are relatively minor. Impacts on fisheries have already been noted: consideration should be given to mitigation measures, as discussed further in Section 5. There are no extensive areas of wetlands within the project area.

The other potentially important impact is on the morphology, not of the project area itself, but of the main rivers. The long-term morphological stability of a strategy which seeks to exclude the major rivers from protected areas, and so retain sediment within the main river channels, must be investigated.

Recommendations

It is recommended that GOB should proceed with implementation of the Gaibandha project immediately and should seek to secure the necessary level of funding for it. This should be done in the knowledge that a long implementation period is expected, and that considerable further work will be required before the exact physical configuration can be determined for some of the works.

The full project with all components should go forward to a period of detailed design and associated planning, with a view to implementation over the forthcoming eleven year period. It should be accompanied by the programme of associated developments in fisheries, health, navigation and flood proofing, in order to provide an areal development strategy for the project. The project as formulated has reasonable economic returns and highly positive social impacts. Adverse environmental impacts are relatively minor.

The works required for sealing of the Teesta are well defined and do not have complex relationships with other parts of the project. These can proceed to pre-design planning, physical modelling and detailed design immediately. There will also be a need to take early decisions on how to incorporate the on-going work of others in the Gaibandha Improvement Project, and actions to be taken in the likely event that the Manas Regulator will be washed away in 1993.

There is a need to put in hand immediately the necessary institutional structure for managing the implementation of the project. This includes setting-up the project committee and the project management unit, as a first step to taking more far-reaching decisions about institutional structures for the project.

Further investigations and studies that are needed include:

- hydraulic and hydrological observation for updating the model and improving it for the design of the compartmentalisation of the project;

- further rounds of public consultation, particularly related to compartmentalisation;

- analysis of fisheries, navigation and health aspects for incorporation into the areal development plan.

CHAPTER 1

BACKGROUND

1.1 The Project Area

The Gaibandha Improvement Project (GIP) is bounded on its north and eastern sides by the Teesta and Brahmaputra rivers. It is bounded on the north west by the railway line from Kaunia to Bamandanga, on the west and south-west by the Ghagot (Figure 1.1). The gross project area is 57600 ha, net cultivated area 49130 ha. It covers all or part of the following five thanas: Gaibandha, Sadullapur, Pirgacha, Sundarganj under Gaibandha district and Kaunia under Rangpur district.

An impact area was defined which was much larger than the project area itself (Figure 1.2). This was for two reasons. First, it is known that flood prevention schemes have important impacts outside their boundaries and that these must be included in an overall project assessment. Secondly it became apparent at an early stage during the project preparation study that a significant contribution to flooding in the project area was flows through breaches in the Teesta upstream of Rangpur. Sealing the Teesta embankment and preventing these breaches would benefit not only the project area itself, but an extensive area adjacent and downstream. The impact area extends south from Teesta towards the Karatoya/Bangali. On the east side, the major rivers form a suitable boundary since the impact of proposals for GIP will be relatively small on these rivers. However, people in the unprotected areas (river banks and chars) outside the main embankments on the Teesta and Brahmaputra were also included in consideration of the project. The gross impact area including the project area itself is nearly 200000 ha.

1.2 Background

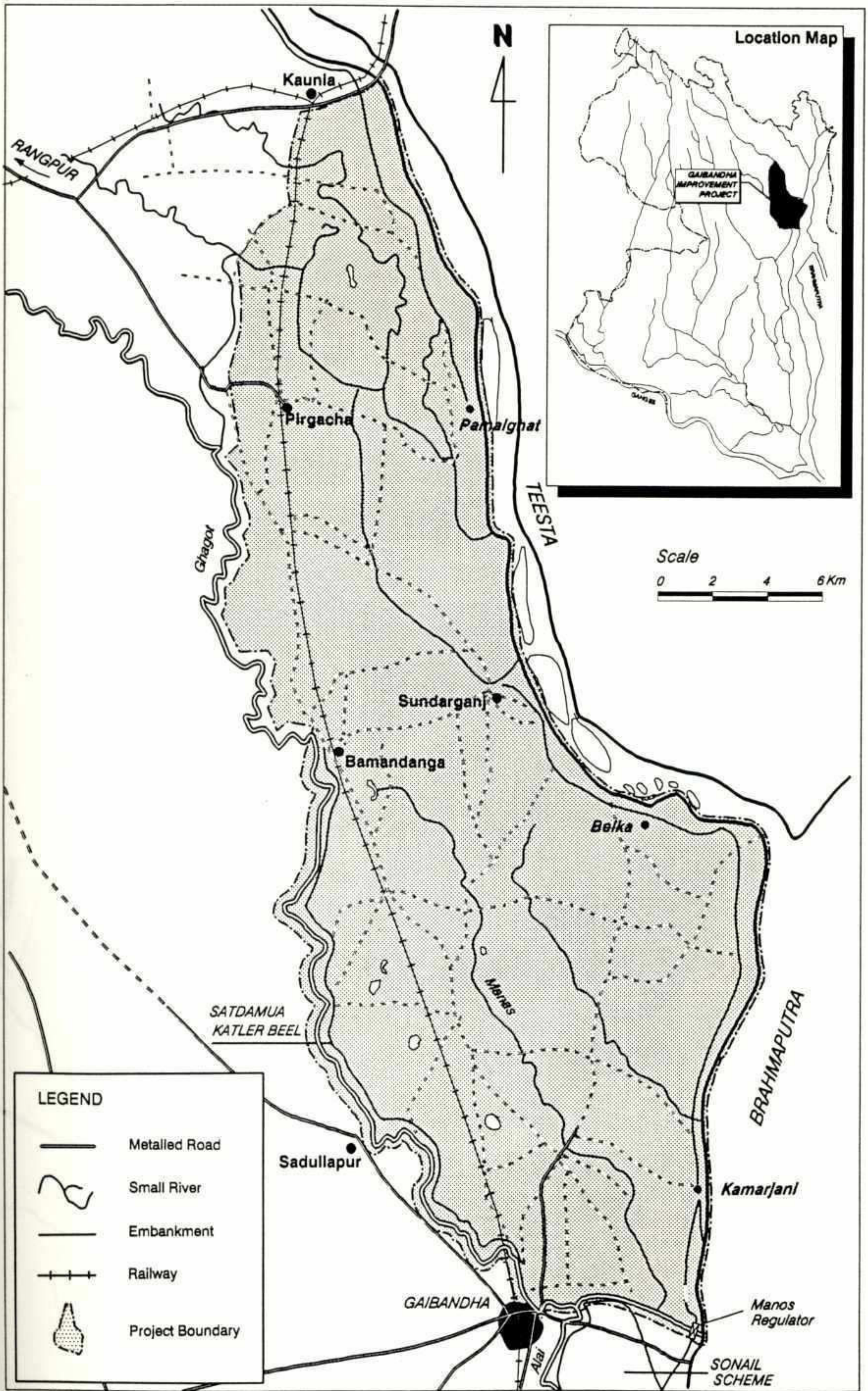
The preparation study for the project forms part of the North West Regional Study (NWRS), which is one of the major components of the Flood Action Plan (FAP). The overall aim of the FAP is to limit the damage due to flooding and to remove the constraint that this places on long-term growth in the country.

The overall objective of the North West Regional Study is to plan the flood regime to raise living standards in the region. The main aim is to provide a stable flood regime which will give local people the ability to plan how they will develop local resources. A second aim is the sustainability of the resulting resource development, relating to agriculture, fisheries, infrastructure (including navigation) and a range of environmental factors. The third aim is to provide security and protection to lives and property in the event of very severe floods.

The main part of NWRS commenced in January 1991. The period up to October 1991 consisted of analysis of major options for development, leading to the preparation of the Interim Regional Plan and identification of the Gaibandha Improvement Project as a priority for a project preparation study.

The second year of the study consisted of finalisation of the regional plan, together with preparation of the Gaibandha Improvement Project.

Figure 1.1
Project Area



Source : NWRS

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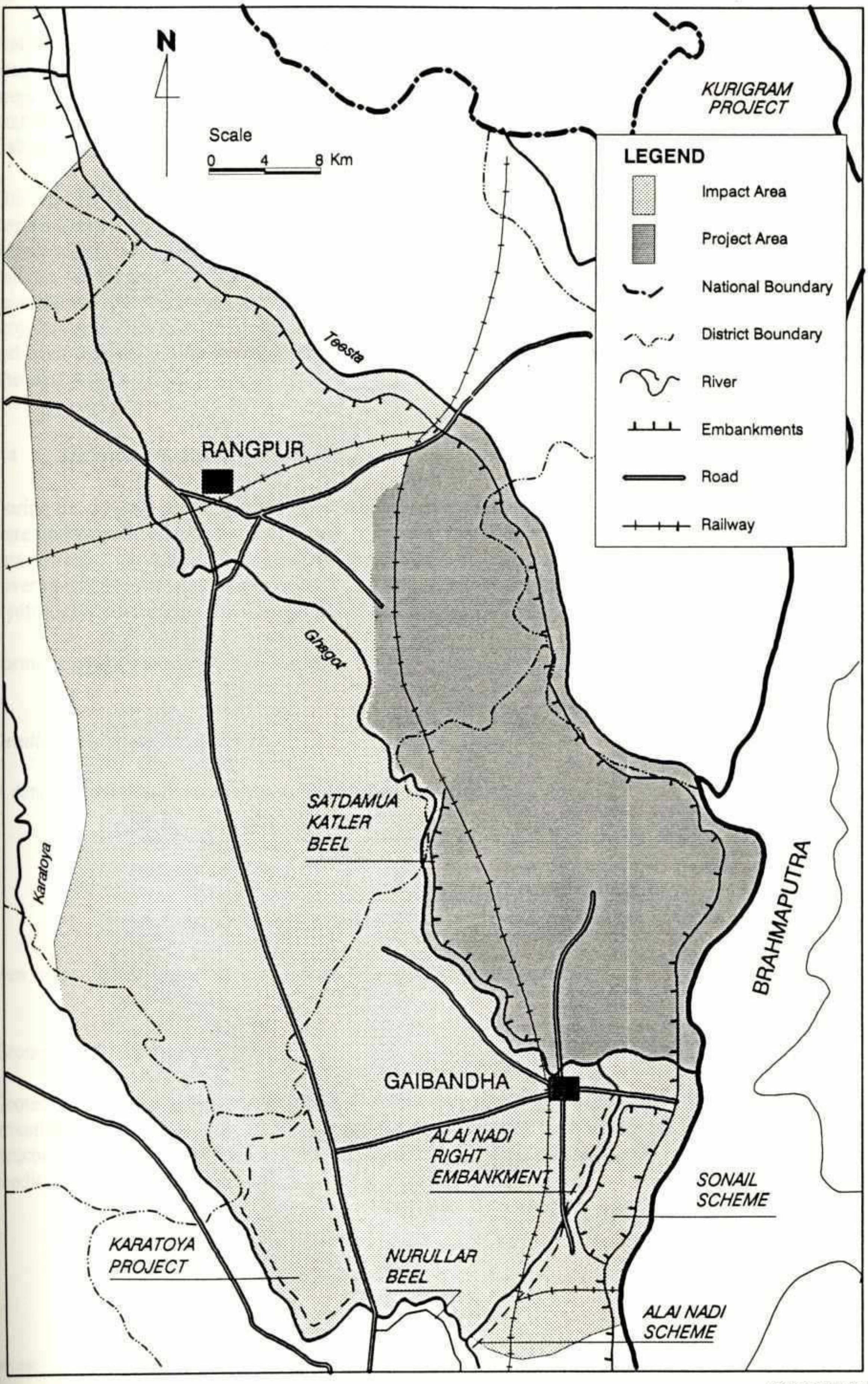
Figure 1.2
The Impact Area



Source : NWRS

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1.3 Relationship with NWRS

Fieldwork, planning and analysis for the Gaibandha project was carried out in co-ordination with the second phase of regional planning for NWRS. The same study team worked both on the project preparation and the regional plan. As far as possible, both studies made use of common datasets and background material. However, the level of field investigation and data analysis was more detailed for Gaibandha than for regional planning, for which projects were prepared at pre-feasibility level.

This report forms part of the final report of NWRS, and is the main report for the Gaibandha Improvement Project preparation study. It is a revision made following comments on the Draft Final Report which was submitted in October 1991. The draft main report was accompanied by three other volumes which are concerned solely with the Gaibandha project, namely engineering, topographic and geotechnical investigations, and environmental impact analysis. Detailed review of other aspects of the project preparation study (hydraulic studies, hydrology, social impacts, agriculture, fisheries, economics and environment) can be found in the appropriate supporting volumes of the Draft Final Report, which also deal with regional planning issues.

1.4 Surveys and Investigations

During the project preparation study a number of formal field surveys and data collection exercises were undertaken. In addition there were numerous informal visits and surveys. Besides these primary data collection exercises, a large quantity of data was collected from other sources. These included government departments such as BARC, BBS, BWDB (in particular WARPO and Surface Water Hydrology), consultants, NGOs and published material.

Formal surveys included the following:

Detailed Topographic survey

A detailed topographic survey was undertaken, comprising:

- river cross-section surveys,
- embankment surveys,
- plane table surveys at existing and proposed structure sites,
- levelling and traverse survey.

New maps of the project area at a scale of 1: 20000 were produced.

Geotechnical Investigations

Geotechnical investigations comprised field investigations and laboratory tests. The geotechnical investigations aimed mainly at confirming and clarifying the subsurface conditions at possible major structure sites, assessing the availability of materials for flood embankments, and clarifying the seismic condition in the project area.

Agro-economics

An agro-economic survey covered 6 villages with a sample of 35 farmers in each village. This provided much information on cropping patterns, input use, yields, and other socio-economic aspects. The agricultural information supplemented that collected in a region-wide farmers' survey in May 1991. A further agricultural survey focussing in the project area was carried out in November/December 1991.

Rural Sociology

Fieldwork techniques were a combination of structured questionnaires, rapid rural appraisals, pre-arranged village meetings, random transectional walks and meetings with officials at district, thana and union levels. In the structured questionnaires women as well as men were the respondents to ensure against gender bias. In some cases women were exclusively interviewed for special studies of women in floods. In nearly all locations where structured questionnaires were used a rapid rural appraisal was carried out later to fill in any gaps in knowledge and also to ask open-ended questions about community flood situations.

Structured questionnaires were used in 15 villages in or near the project area.

Fisheries

Field assessment of the fishing situation in the project area was carried out, supplemented by secondary data collection through DOF. In addition there was a specific study of beels and khas ponds in and around the project area.

Environment

The basic surveys undertaken included:

- collection of a set of dry season and early wet season water quality samples from rivers, beels and tubewells in an attempt to provide baseline data. These were analysed in a laboratory for both chemical and organic components.

- a review of the existing soil survey data to establish likely trends as a result of FCD interventions.

- a baseline inventory of fauna and flora in selected wetland sites with the aim of establishing any likely change as a result of project interventions. The survey covered two main beels and their surrounding homesteads and agricultural land and three transects across major river and char habitats. The latter cover one site on the Teesta, one site at the confluence of the Teesta and the Jamuna and one at the confluence of the Ghagot and Jamuna.

- collection of data on the present state of human health and nutrition in the area. This confirmed the serious problems with waterborne disease and nutritional related disorders in the study area. The greatest problem facing the use of this data is predicting likely future trends as a result of CFD.

- survey of archaeological and other sites of historical and cultural interest.

- a survey of the present status of navigation routes within the project area.

Public Consultation

A major exercise in public consultation concerning the project was undertaken. This covered several rounds of formal meetings with various villages in or near the project area, as well as meeting with district and thana-level officials. All these are fully detailed in Volume 11 of the Draft Final Report.

CHAPTER 2

PRESENT SITUATION

2.1 Socio-Economic Situation

This report was prepared before the results of the 1991 Population Census were released. In the absence of those data, the broad socio-economic situation can be understood from a variety of sources.

The total population living within the project area is 550 000 people, at an average population density of 9.5 per hectare.

Preliminary results of the 1991 Census give a total (unadjusted) population figure of 1.86 million for Gaibandha district as a whole, and a population density of 851 per sq.km. Annual growth rate of population over 1981-91 for Gaibandha district is 1.64% compared with a national average of 1.85%.

In thanas which lie within the project area, population densities are even higher than the district average. Table 2.1 compares three thanas in the area with national, regional and district figures over the same decade.

Table 2.1 Population Density per hectare (1991)

Area/Thana	1991
Bangladesh	7.81
NW region	7.51
Gaibandha District	8.51
Pirgacha	9.73
Sundarganj	8.92
Sadullapur	10.08

(BBS : 1991)

The Upazila Development Monitoring Project (1989) produced a number of key socio-economic and development indicators for thanas nationally. Included in this study were eleven in the northwest region which were comparatively analysed with the national indicators. Gaibandha town and Palashbari thanas were both included in the sample (Palashbari lies immediately to the west of the project area and would therefore share many of the same socio-economic characterícts). Details are given in Table 2.2.

Table 2.2 Key Socio-Economic Indicators (Selected Areas)

Indicator %	Rural Bangladesh	Gaibandha	Palashbari
Drinking Water			
Pond Water	9.03	Nil	0.20
River Water	3.10	0.20	2.40
Tubewell	76.82	74.20	80.60
Literacy			
Males	36.29	30.85	31.05
Females	22.29	16.89	17.69
Combined	29.55	24.05	24.66
Housing			
Pucca	1.41	1.00	0.20
Semi-Pucca	3.98	1.60	7.80
Katcha	94.61	97.40	91.40
Refined Activity Rate*			
Male	77.71	80.87	78.35
Female	7.66	7.60	8.09
Combined	44.15	45.64	44.75

* The Refined Activity Rate is the proportion of those over 10 years old who are economically active. The figures for females should be treated with caution as many young women working eg as domestic servants are not recorded.

Source: (UDMP: 1989)

Land distribution data are available by thana from the 1983-84 Bangladesh Census of Agriculture and Livestock. In the five thanas that fall within the project area, 14.5% of households had no owned land, and another 48% of households owned less than 1 acre. 68% of households were classified as small farm households (i.e. owning less than 2.50 acres). In terms of operated land holdings, 73.1% of all holdings were small holdings and accounted for 35.6% of operated land, 23.7% of holdings were medium holdings accounting for 46.6% of operated land, and 3.2% of holdings were large holdings accounting for 17.8% of operated land.

The area is, therefore, predominantly an area of small and marginal farm households, and over 62% of households own no land or less than 1 acre. However, in terms of operated holdings, about 64% of cultivated land is operated by medium and large households.

Data on landholding size were collected in an agro-economic survey of 6 villages. The data showed average landholdings for small farmers of 1.1 acres, medium farmers 3.6 acres, and large farmers 9.2 acres.

On average tenants sharecropped 0.5 acres and small farmers 0.25 acres.

In terms of occupational characteristics, a socio-economic survey carried out in 24 villages in Gaibandha district in 1987 by Early Implementation Projects (EIP) shows that farming and agricultural labour are by far the most important occupations, followed by petty trading. This finding is supported by the smaller surveys carried out by this study. The latter surveys suggest that those whose main occupation is agricultural labour get work on average 15-20 days per month, with the slackest period being July-November. Seasonal migration out of the area for employment elsewhere is a common phenomenon.

A particular characteristic of the area is the impact of river erosion. The westward movement of the Brahmaputra, and eroding tendency of the Teesta, have resulted in displacement of many households and loss of land. Some of these households have resettled along the main river embankments, some have resettled on emerging chars, and others have probably left the area altogether. This displacement has added to the problems of unemployment and tendency for seasonal migration, and the latter also puts an added burden on those household members, mostly women and children, who remain behind without a regular source of income.

High density coupled with other demographic and socio-economic features make the project area one of the poorest in Bangladesh. Its principal features can be summarised thus:

- low rates of literacy;
- poor housing;
- few good quality roads;
- poor drainage in the project area;
- high levels of male migrant labour;
- high rates of landlessness;
- large number of embankment dwellers.

2.2 Agriculture

Topography and Soils

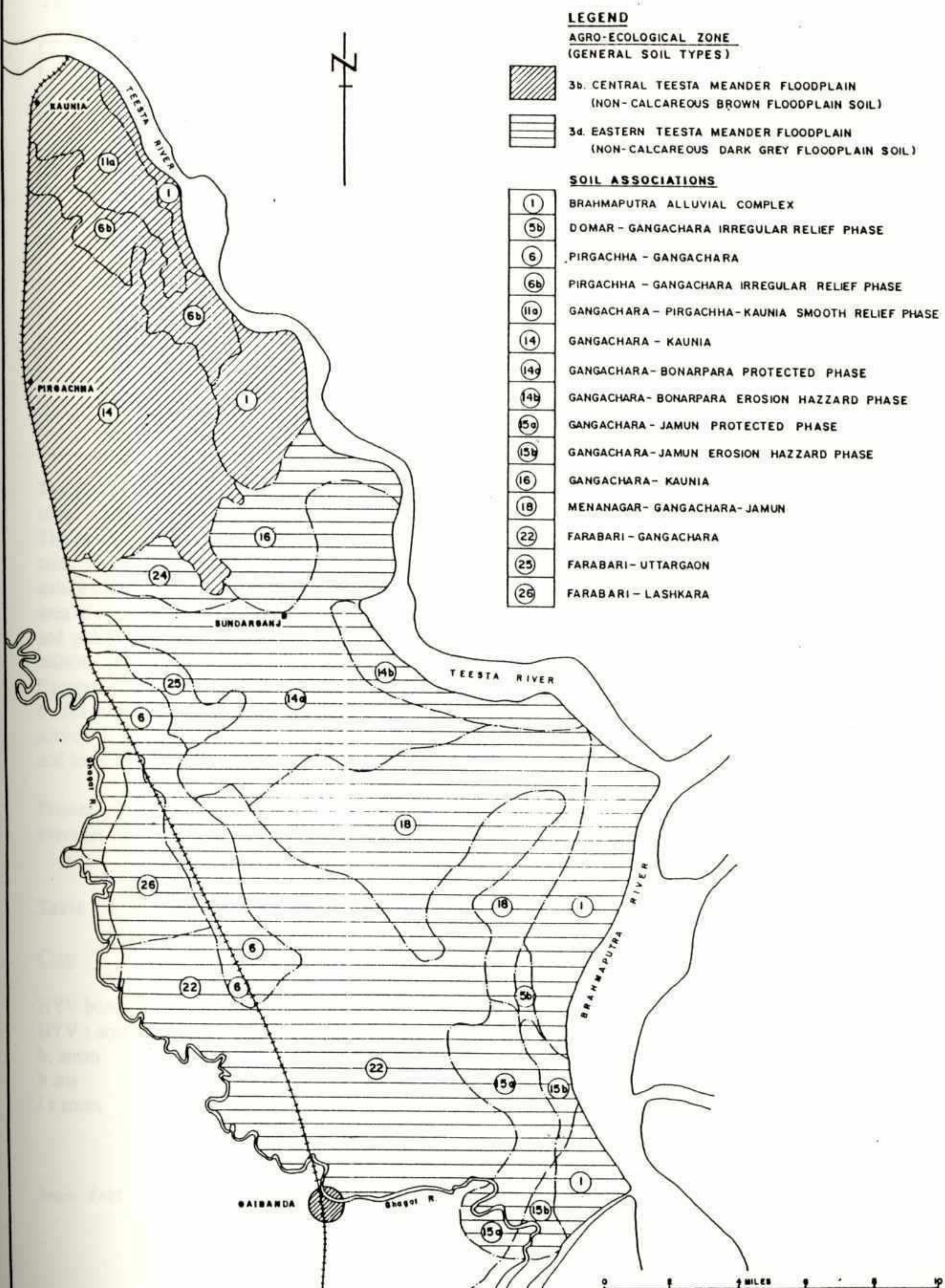
The topography of the area is of typical meander floodplain pattern and comprises gently undulating broad ridges and shallow basins with local areas of irregular relief near the river channels. Overall, it has a mild northwest to south-east slope. The soils of the project area are developed in recent and sub-recent alluvial floodplain sediments deposited by the river Teesta. Agroecologically, the project area falls under the central and eastern part of the Teesta meander floodplain (Figure 2.1).

The soils are of medium to medium-heavy texture. Unlike many of the soils derived from the Teesta alluvium, they dry out reasonably quickly after the rains have stopped. Therefore it is possible to prepare the land in time for the major rabi crop which is wheat.

Cropping Patterns

An agricultural survey was undertaken in the project area during November-December, 1991 to determine cropping patterns adopted by the farmers under the present situation (flood and irrigation facilities). A total of 132 farmers were interviewed randomly and in proportion to the area of each thana within the project area. The present cropping pattern of the project area based on these survey findings is shown in Table 2.3, and can be compared with the present cropping pattern as reported by BBS for 1989.

Figure 2.1
Agro-Ecological Zones and Soils-GIP



Source: Land Resources Appraisal of Bangladesh, UNDP/FAO, 1988. And Reconnaissance Soil Survey Report of Kurigram and Gaibandha Sub-divisions, SRDI, 1970.

Table 2.3 Present Cropping Pattern, (% of NCA)

Crops	Farmers' Survey 1991	BBS 1989
HYV boro	55	29
HYV t. aman	26	41
Local t. aman	58	43
TDW aman	1	-
B. aman	-	tr.
B. aus	4	20
Wheat	13	9
Must/pul	3	5
Jute	16	19
Potatoes	2	1
Vegetables/spices	3	1
Sugarcane	-	tr.
Total :	181	170

The table shows that, as in the rest of the region, rice is by far the most important crop: it occupies about 140% of the cropped area. Jute is important, its area is well above the regional average of 7%. The reason is its well established market and the number of buying centres operating in the project area. The wheat area is also above average for the region, due to the cool winters and the retentive nature of the soil which enables a reasonable crop to be grown on residual moisture. Conversely, the area of oilseeds and pulses is low: the predominant rabi crop, after boro rice, is clearly wheat. Oilseeds and pulses are, as a rule, principally grown on lighter soils and in climates where wheat is not a reliable crop. The small area of tobacco, most of which is concentrated in the north-west, near Rangpur, is taken to the large tobacco market in Rangpur. The agro-economic survey carried out in 6 villages, most of which suffer flood problems, generally confirmed the findings of the agricultural survey. HYV boro was found to be the most important crop, and the other predominant crops are HYV and local t. aman, jute and wheat.

Present yields in the project area are estimated in Table 2.4. They are about the same as regional averages except that jute and wheat, which is mostly un-irrigated, yield better than elsewhere.

Table 2.4 Present Crop Yields (t/ha)

Crop	Yield	Crop	Yield (t/ha)
HYV boro	5.0	wheat*	2.0
HYV t aman	4.0	oilseeds	0.6
b. aman	1.7	jute	1.9
b aus	1.3		
l t aman	2.3	pulses	0.7

* not irrigated

Source : FAP2

Irrigation

An estimate of the present irrigation development is the area has been made based on the BBS 1989 crop data for HYV boro, because HYV boro is the major recipient of irrigation. The data indicates that about 29% of the net cultivated area is now under irrigation by deep tube-wells (DTW), shallow tube-wells (STW), low lift pumps (LLP) and other indigenous methods like doons and swing baskets etc. Table 2.5 shows the increase and decrease in numbers of each irrigation equipment in the Project area based on thana data during 1984-90. It should be noted that the farmers survey carried out by FAP2 in 1991 and the socio-economic survey carried out in early 1992 both indicated higher levels of irrigation coverage, at around 50%. The BBS data has been used in preference, as covering a bigger sample.

Table - 2.5 Irrigation Equipment

Equip ments	1984 Total	1985 Change	1986 Change	1987 Change	1988 Change	1989 Change	1990 Change	1990 Total
DTW	375	+7	+46	-2	+10	+3	+14	453
STW	3283	+498	+532	+966	+64	+471	+393	6207
LLP	178	+3	+10	+23	+13	-79	-11	137
Others	400	-150	+7	-144	+115	+632	-98	762

Note: + = increase and - = decrease.

Source: FAP 2 Survey

Institutional Services

At present, the institutional services in the project area are mainly rendered by the Department of Agricultural Extension. The thana agricultural officers supervise the field level agricultural extension activities. The grass root level extension agent is the block supervisor who is responsible for extension activities; each block is sub-divided into eight sub-blocks. The extension methodology followed is the Training and Visit (T & V) system.

Constraints to Crop Intensification

In Volume 12 of the Draft Final Report the present situation regarding labour available at peak periods and facilities for land preparation were discussed. It was concluded that, overall, especially if an intensification of agricultural production is likely to take place throughout the country, present labour supplies, much of it migrants from other regions, may be inadequate. The problem of land preparation resources, especially the number and quality of draft animals, was also examined.

The situation for the Gaibandha project area is as follows:

(a) At present the area has surplus labour: people go to the area mainly between Bogra and Naogaon to seek employment. There is every reason to suppose that these same people would prefer to work nearer home. Consequently no shortage of manual labour is expected. However, it is necessary to emphasise that this judgement is qualitative, based on field visits and discussions, but no numerical data have been collected.

(b) The situation regarding draft power has also been probed. No numerical data are available but fewer of the farmers interviewed in the course of the May 1991 survey and later have reported constraints than in other areas.

(c) The additional production is expected to be rice and not a perishable commodity requiring rapid marketing before it deteriorates. Therefore no constraints due to the extra production spoiling need be expected, nor are additional processing facilities needed to handle the produce.

(d) However, the previous statement needs to be qualified. In view of the high rainfall in the area, and because some of the additional production will be boro rice, harvested during usually heavy rains,- the provision of additional drying facilities, in the form of suitable drying floors for the general public for rent, may well be necessary. However,this need is not dependent on the project, which will not affect the area of boro. No drying problems are expected for the increased t aman production; the area of b aus, the drying of which presents an even more serious problem than that of boro, will actually decrease.

Vulnerability to Flooding

The agro-economic survey of 210 farmers in 6 villages classified the farmers' land according to their description of it as highland, medium-hoghland etc. This classification corresponds quite closely with the FO, F1 classification used by MPO.

The villages were mostly selected for their flood-proneness, but even so it is notable that relatively little land was classified by farmers as highland (FO), a much larger proportion being medium-highland or medium-lowland (F1 - F2). Farmers were growing t. aman on both medium-highland and medium-lowland: t aman on medium-lowland is highly vulnerable to flooding.

Data collected during the survey indicated that even in relatively low flood years there is crop damage (a rather rough estimate suggests average t. aman losses of about 0.4 m.t./ha), a finding which is understandable if farmers are planting t. aman on medium-lowland.

This survey finding is also borne out by secondary data on crop damage (from DAE) which indicate that Gaibandha District generally suffess about the worst per ha. crop damage of any district within the Greater Rangpur District.

2.3 Fisheries In and Adjacent to GIP

2.3.1 Fish Production

Table 2.6 shows the official annual production figures for greater Rangpur District, for the period from 1983/84 to 1989/90. It appears that riverine and beel catches have declined by more than 80% and about 30% respectively, which generally accords with the opinions expressed by local professional fishermen. The subsistence floodplain fishery seems to have increased by more than 80%, according to the statistics, but not according to most local opinion which considers that catch rates have declined. Farmed fish production is shown as having increased by nearly 60%, which could even be an underestimate.

Table 2.6 Rangpur "Old" District; Fish Production Trends

('000 metric tons)

	Sub-sector	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89
(a)	Capture Fish						
	River	7.6	6.1	3.7	2.8	2.2	1.2
	Beels	2.5	1.3	1.3	1.2	2.3	1.7
	Flood Plain	8.8	9.8	13.4	14.4	16.2	16.3
	Total Capture	18.9	17.2	18.4	18.4	20.7	19.2
(b)	Cultured Fish						
	Fish Ponds	1.9	1.8	2.4	3.5	3.0	3.1
	Total Production	20.8	19.0	20.8	21.9	23.7	22.3

Source: Department of Fisheries, Annual Fish Catch Statistical Bulletins

Table 2.7 shows the estimated quantities of fish produced from the Gaibandha Project area during 1990/91, together with the areas of the fisheries concerned and their productivity rates. The flooding which results from breaches in the flood defence embankments along the Teesta, Brahmaputra and Ghagot rivers is usually of short duration and it is estimated that on a 1:5 year basis, a little more than 3000 ha will remain flooded to a depth of at least 0.3m for at least 3 months. This formula has been adopted by FAP 2 to define "fishable flood plain" during the study. Thus, within the project area there is fishable floodplain of no more than 3020 ha which is currently estimated to yield about 210 tons of mainly subsistence capture fish, or just over 28% of project area total fish production. There is additional production from a much larger area of floodland to the west of the Ghagot River, within Gaibandha District but outside the project area. The rivers produced about 70 mt. or around 10% of the total but are believed to be in continuing decline. Culture fisheries produce nearly 50% of the total and have some potential for further expansion.

2.3.2 Fishing Effort

There are reported to be about 2000 full time and part time fishermen, not counting the majority of the rural population in the flooded areas who work the floodplain seasonal subsistence fishery during the monsoon period.

There are up to five natural fish spawn collection sites along the right bank of the Brahmaputra centred on Kamarjani which appear to be the only such location in the project area.

There is a hatchery at Pirgacha and four more privately owned mini-hatcheries in the project area, and a total of 22 nursery units, two of which are government owned.

Table - 2.7 Gaibandha Drainage Improvement Project - Fisheries Data

	Water body	Area (ha)	Av. Prod. Rate (kg/ha/yr)	Production (mt)
(a)	Capture Fisheries:			
	Beels-Seasonal	180	180	30
	Beel-Perennial	200	400	80
	Rivers	1800	40	70
	Flood Plain	3020	70	210
	Other	n/a	n/a	100
	Total Capture Fish			490
(b)	Culture Fisheries:			
	Cultured Ponds	380	850	320
	Derelict Ponds	90	180	15
	Totals			335
(c)	Overall Total Catch			825

Source: Compiled from information provided by district and upazila DOF staff, fishermen and fish farmers.

2.3.3 Pond Fish Cultivation

Inquiries by FAP 2 fisheries staff during 1991 concluded that the project area contained relatively few ponds, and was not regarded as being especially well suited to fish farming. However, the total area of ponds was subsequently noted to be about 470 ha, of which some 380 ha were being actively cultured. Most of the cultured ponds are located in the northern section, in Kaunia and Pirgacha thanas and part of Sundarganj. Despite the embankments, it was found that much of the floodplain in the southern and southeastern sections, in Gaibandha Sadar, Sadullapur and parts of Sundarganj thanas is still liable to annual inundation and the resultant high risk of over-topping of ponds, even if only briefly, is a strong disincentive to expenditure on restocking.

2.3.4 Capture Fisheries

There are two important perennial beels at Bamandanga and Hurudanga, which between them support around 200 fishermen. In addition there are eight more, including Kachuadha Beel in Gaibandha Sadar, Maruadha Beel in Sundarganj and Satrail Beel in Sadullapur Thana which continue to hold some water throughout the year, (These beels are shown in Figure 5.3). Most of the other former beels within the project area have silted up or been drained so that they now dry out for part of the year and can no longer sustain permanent fish populations. Fishermen who used to harvest these beels were forced either to give up fishing and seek other work, or concentrate on the rivers where the fish stocks were also declining.

2.3.5 Fisheries Support Services

There is a district fisheries office situated in Gaibandha town and responsible for the whole of district but only for the southern part of the project area. The northern part which takes in parts of Kaunia and

Pirgacha thanas is the responsibility of the district fisheries office in Rangpur. Each district office should have a DFO, extension officer and a fish resources survey officer, whilst each thana should also have a TFO, assistant fisheries officer and a field assistant. It was reported that an additional post of extension officer had been sanctioned for each thana office, which will help greatly provided they are given the means to travel to all parts of the thanas concerned in order to perform their duties. Unfortunately there has been a general and long standing lack of transport and recurrent operating funds.

Development work now in hand includes beel restocking, the rehabilitation & exploitation of borrow-pits fisheries with WFP Food for Work assistance and promoting the further development of pond fisheries within GIP and elsewhere in the two districts. NGOs are also involved in this work, some independently but mostly in collaboration with DOF, and are assisting in the formation and organisation of groups of landless fishermen to take over fish pond and jalmohal fishing leases. These NGOs include the Bangladesh Rural Advancement Committee (BRAC), the Grameen Bank and Chinnaya Mul Unnayan.

2.4 Infrastructure

2.4.1 General

The project area contains about 8 km of sealed read running north east from Gaibandha towards the Teesta. Sealed roads also connect Gaibandha to Sadullapur and Pirgacha to Rangpur.

Elsewhere the extensive network of roads are either brick-paved roads (notably Sundarganj-Bamandanga-Pirgacha) or earth roads which can become impossible during the monsoon. There are no bridges across the Ghagot except at Gaibandha. The Local Government Engineering Department (LGED) is involved in a programme of construction of feeder roads within the project area.

The Bogra-Gaibandha-Kaunia railway line runs through the project area.

Gaibandha is a district town and provided with appropriate facilities. Sadullapur, Sundarganj, Kaunia and Pirgacha are thana headquarters and provided accordingly. Access to Sundarganj is poor, since it is not connected to a sealed road.

2.4.2 Flood Protection Infrastructure

Brahmaputra Right Embankment

The Brahmaputra Right Embankment (BRE) was constructed in 1960's to protect the agricultural land along the Brahmaputra between the confluences with the Hurasagar and Teesta (219 km) from flood with frequency of 1 in 100 years return period. The length of BRE along the GIP area is about 24 km.

The BRE has a height of 2.6 m to 5.0 m, a crest width of 3.0 m to 5.0 m, and side slope of 1:1.6 to 1:3.4 at the country side and 1:1.5 to 1:3.0 at the river side. During the monsoon season or through a year, inhabitants living in the river side area settle on and behind the BRE, excavating the body to build their houses. Also, BRE is used as traffic road. Utilization for these purposes decreases the structural strength of BRE against seepage and sliding. Besides, the embankment slope is easily eroded by rainfall, wind, wave, and animals. Erosion also deteriorates the structural strength of BRE against seepage and sliding. As a result of the mentioned activities and natural phenomenon, the side slope and crest width of BRE are presently less than the designed slopes of 1:3 at most parts.

There exist five drainage regulators, the Manos regulator draining out the flood water from the Ghagot and Manos rivers, Sarai regulator for the Matherhat, and Chandipur, Lalcharmar and Sreepur regulators for isolated basins with drainage areas of about 4 km^2. Among these drainage regulators, the Manos regulator has insufficient capacity for Ghagot and Manos rivers (catchment area of about 1,300 km^2) to drain out flood water quickly after the flood.

Teesta Right Embankment

The Teesta Right Embankment (TRE) downstream of Kaunia was constructed in 1960's as a part of the BRE. The length of TRE is about 43 km from Kaunia to the outfall but about 11 km long was breached by the floods in 1987 and 1988.

Flood embankment at breached portions at Painalghat, Sundarganj and Belka is under construction to connect it to the existing village road but its height is less than the design flood water level. BWDB provided 8 nos. impermeable groynes at Painalghat, Tarapur, Tambulpur, and Belka along the breached embankment to protect the river bank from erosion but 6 nos. of these groynes were washed away partly or totally within a few years after the completion of construction and some were reconstructed or repaired. At Belka, the TRE was breached in the post-monsoon season of 1991 along a length of about 300 m due to bank erosion.

The TRE has a height of 2.0 m to 4.4 m, a crest width of 2.5 m to 5.2 m, and side slope of 1:1.8 to 1:3.5 at the country side and 1:1.6 to 1:3.5 at the river side. Since the TRE is also utilized for housing and traffic road, and eroded by natural phenomenon in the same way as the BRE, the embankment body has rather deteriorated.

There exist 7 regulators, Mirganj and Masankura in the Masankura river, Kasiabari, Narayanpur, Bhairhat, Rajib, and Kalirhat for isolated small basins along the TRE. Among these regulators, the Masankura regulator (1 vent) is constructed for storing water for irrigation and fishing purposes.

In the upstream TRE, there also is a breach about 7 km long from downstream of the confluence with the Buri Teesta outside the GIP area. Some of the flood water and sediment of Teesta flows into the Ghagot through the breach and induces rise of flood water level and siltation of riverbed of the Ghagot.

Ghagot Left Embankment

The Ghagot Left Embankment (GLE) is constructed through two projects; one is Satdamua Katler Beel project funded by EIP and the other is Gaibandha Town Protection. The Satdamua Katler Beel project is providing flood embankment with total length of about 35 km which consists of new flood embankment 6 km long and resectioning of road embankment 29 km long on the left bank from Gaibandha to Bamandanga. The project is scheduled to be completed in 1992/1993 fiscal year. Also Gaibandha Town Protection scheme built a flood embankment with a length of 5 km from the existing road bridge to the confluence of the Manos river on the left bank along the Gaibandha town area to prevent flooding from the Ghagot and Manos.

The GLE has a height of 0.5 m to 4.6 m, a crest width of 1.0 m to 5.0 m, and side slope of 1:0.4 to 1:2.5 at the country side and 1:0.9 to 1:2.6 at the river side. But in the downstream reach from the confluence of the Manos, flood embankment is not provided. The side slope of GLE is designed and constructed at 1:2 but the existing slopes are less than designed at most parts.

There are nine regulators along the GLE. Manos regulator, discussed above in relation to the Brahmaputra Right Embankment, aims to draining out flood water of the Ghagot and Manos, South Gagoa regulator for the area of Gaibandha Town Protection, and others for an area of 6,200 ha of the Satdamua Katler Beel project which is bounded by the railway line and the Ghagot.

Sonail Embankment

The Sonail Embankment scheme is a completed project funded by EIP. The total length of flood embankment is 19.4 km on the left bank along the Alai and on the right bank along the Ghagot, of which 4 km is located along the Ghagot and is connected with the BRE. The Sonail embankment along the Ghagot has a height of 2.2 m to 3.4 m, a crest width of 3.0 m to 5.4 m, and side slope of 1:1.7 to 1:2.9 at the country side and 1:1.8 to 1:2.4 at the river side.

Most of the flood from the Ghagot flows into the Alai during peak-monsoon season since the capacity of the Manos regulator depends on the water levels of the Brahmaputra and it is difficult to drain out flood water of the Ghagot through the Manos regulator during this period. On the other hand, the flow capacity along the Alai is less than 100 m^3/s and therefore not only the project area of the Sonail Embankment scheme but also the right bank area suffers severe inundation due to drainage congestion.

2.5 Environment

Groundwater

Potential groundwater recharge is high, and both high specific yield values and high aquifer transmissivity will allow for full development with suction mode technology. Groundwater salinity forms no constraint to its use for irrigation and water supply although problems of iron toxicity can occur. A constraint to tubewell development may, however, be the occurrence of highly permeable soils, which make traditional surface irrigation inefficient. Table 2.5 gives the number of irrigation units within the project area.

Very shallow treadle pumps are used for small scale irrigation at the farm level and shallow hand pumps for domestic supply at household or village level.

Flora and Fauna

Natural vegetation has all but disappeared although there is widespread use of vegetative matter for building construction and stall-fed fodder. There is extensive use made of various naturally occurring plant species for medicinal use. The area is very poorly endowed with mammals, anything of any size has been hunted, either for food, sport or as a nuisance or has been displaced by habitat change due to the intensity of human settlement and cultivation. There are no gazetted Wildlife, National Parks or Forest Reserves in the study area.

The detailed results of the surveys into the terrestrial flora and fauna are given in Volume 15 of the Draft Final Report. Annex A summarises the main macro flora and fauna identified in the field survey and identifies their main uses. Nine common mammals, 40 bird and fowl species, 11 reptiles and two amphibians were surveyed in the GIP in the four months from February - May 1992. Floral collection recorded 36 different varieties of trees commonly grown the village groves and waysides. 52 species of herb, grass or scrub were identified, many of these being of direct economic or medicinal value. These are also predominantly managed or cultivated species in and around the village and homesteads.

Water Quality

The bacterial quality of many surface water supplies is unsatisfactory, and is a major cause of diarrhoeal disease outbreaks. Without adequate sanitation development, this situation cannot be expected to improve. The lack of appreciation of the risks of contaminated water to human health requires attention.

Water-Related Diseases

Out of the main vector-borne diseases those that can be confidently predicted to be of concern include malaria (mosquito vector), kala azar (sandfly vector), filariasis (mosquito vector), Japanese encephalitis (mosquito vector). The water-related diseases requiring particular attention in the operations of the project would include diarrhoea, dysentery, cholera, hepatitis and typhoid which are all related to polluted sources of drinking water. Further problems requiring attention include the water-washed diseases like scabies, yaws, leprosy, typhus, trachoma and conjunctivitis.

Nutrition

The problems of poor nutrition for humans and animals are widespread. The existing nutrition levels are characterised by unbalanced diets with low diversity of food intake particularly amongst lower socio-economic groups.

The public health and nutrition profile of Gaibandha District presents one of the worst pictures in the country and certainly in the North Western Region. Rates of malnutrition and prevalence of the common diseases are very high, in the riverine thanas in particular. Changes in hydrology and habitat are believed to be directly contributing to this condition.

There are permanent thana health complexes, with both out-patient and in-patient facilities in Gaibandha, Sundarganj and Shaghata. Fulchari thana has no hospital building and operates out of a small rented premise. (Shaghata and Fulchari are the thanas immediately south of the project area).

The lack of planning and administration of the flood shelters, proper sanitation and supply of safe drinking water mean that dealing with the adverse health problems of the floods always creates a problem.

Navigation

The main navigation routes of significance are the Brahmaputra, the Teesta and the Ghagot as the boundary rivers. Of these the Brahmaputra is the only river that remains navigable for larger boats throughout the year. The Ghagot is a seasonal river while navigation along the Teesta in the dry season is reduced to the smallest of boats mainly for fishing and domestic purposes.

Although Gaibandha has no strong tradition as a regional centre for country boats, nevertheless, a few centres along the Brahmaputra and Teesta provided services to the interior and to the people of charlands. Internally, the only river of importance is the Manos which is only seasonal and originates from the low lying Bamandanga beel. Some narrow drainage lines and canals flows through the project area. These are only very seasonal.

Culture and Heritage

The literature review identified no previous surveys within the GIP area. 22 sites were identified within the project area of which 4 are significant. There are a number of known sites close to the project area but outside of its boundaries. The archaeological sites that were surveyed are all new and have been logged with the Department of Archaeology.

Four types of sites have been identified - mosques, temples, Zamindar palaces, crematoria and graveyards. No buried archaeological sites were identified.

2.6 Institutions

2.6.1 Local Government

Central and local government plays a key role in the potential success or failure of future developments under the FAP. Local government provides the basic framework within which flood control developments take place. The structure of local government is at present in a state of flux but three tiers of importance to a development of the scale of the project can be distinguished:

- district level - located at Gaibandha for most of the project area (the northern part of the project lies within Rangpur district). The district administration is headed by a Deputy Commissioner, and has representatives of the major line agencies within it. Gaibandha district covers an area of 217,900 ha;

- thana level - there are parts or all of five thanas within the project area. They cover between 15 and 40, 000 ha. They are headed by an executive officer (TNO) and have more junior representatives of the line agencies attached to them. Until recently there was an elected council at thana level but this has recently been abolished;

- union level - thanas have between ten and fifteen unions, with a union council headed by an elected union chairman. Unions therefore typically cover around 2000 ha in the project area.

2.6.2 Central Government

The most important agencies under central government are:

- Bangladesh Water Development Board (BWDB), responsible for providing irrigation, drainage, flood control,erosion control, town protection and river protection throughout Bangladesh;

- Local Government Engineering Department (LGED), who provide technical and engineering expertise in support of the various tiers of local government;

- Department of Agricultural Extension (DAE), responsible for policy formulation and programme development for the national agricultural sector in order to increase food production and other crops;

- Department of Fisheries (DOF), whose functions are national fisheries management, development,extension, training, conservation,quality control,law enforcement,policy advice and information collecting for the entire fishing industry;

- Department of the Environment (DOE), a new department which is still defining its role in relation to the protection of the environment;

- Bangladesh Rural Development Board (BRDB), whose aim is to promote rural development through different types of co-operatives.

The functions, organisation and role of these agencies are defined in more detail in Volume 11 of the Draft Final Report. They are all represented at district level,and some are represented at thana level.

2.6.3 Experiences of Government Institutions

The Bangladesh Water Development Board (BWDB), the Local Government Engineering Department (LGED) and the Department of the Environment (DOE) in Gaibandha District were the subject of an institutional study by NWRS. Local attitudes to these bodies were at best neutral and at worst negative.

Communities reported that BWDB undertook projects without local consultation and because of this local people had no interest in the operation and maintenance of these structures. There was little evidence of water or sluice gate committees which the BWDB itself regards as essential to any future flood protection operation and maintenance.

Communities are not generally aware of LGED involvement in water related projects. This is perhaps hardly surprising since a number of LGED engineers thought that participation of local communities in planning projects was not necessary. Many of the engineers expressed reluctance to get involved in the long-term operation and maintenance of flood control programmes although they had implemented small-scale water projects which had been turned over to local beneficiaries.

The activities of the DoE are not known to the public. Even the thana officials were not aware of the nature of the work of this agency in their locality.

The government agency which appears to provide a satisfactory service in the northern part of Gaibandha district is the Department of Fisheries. In two beel areas, it was found that traditional fishing communities have been given preferential treatment in access to common water bodies. Neither are happy with the ever decreasing number of fish for capture but have no complaint with government fishery officials.

2.6.4 Non-Government Organisations (NGOs)

A number of prominent NGOs are working in Gaibandha district including Nijera Kori, Bangladesh Rural Advancement Committee (BRAC), Grameen Bank and CARE. There are also several smaller ones such as Gono Kallayan Kendra (GKK), Gono Unnayan Kendra.

The Grameen Bank adopts a number of strategies which are directly related to post-flood situations. The water related activities of the bank revolve around fishing groups. It will support groups which wish to lease beels or ponds when these are available. It will provide motivational training for these groups which want to start fish cultivation. At one time the bank took the leases but found this unsatisfactory since the groups did not feel they "owned" the beel and as a result did not protect the investment from illegal fishing.

CARE Bangladesh has programmes all over the northwest region and is responsible for many of the village roads in the entire area. It does both disaster management and post-flood relief and rehabilitation work. In the period during floods and immediately afterwards it provides medical help, dry food and shelter. At its centres it keeps a stock of utensils, rice and wheat and medical supplies for disaster situations such as floods. It also has a medical team with doctors who treat malnutrition and provide health advice.

Bangladesh Rural Advancement Committee (BRAC) is perhaps the largest national NGO in Bangladesh and has a regional office in Gaibandha. It does not specially get involved in flood preparedness but will provide credit to rebuild community housing and structures in the post-flood situation.

BRAC covers most aspects of development in its Income Generating Programme with assistance to farmers and to people raising poultry and livestock. It has a woman's training centre and has been very prominent in spreading the oral rehydration method to village women everywhere. It also runs special vulnerable group development projects such as chicken and duck raising for really marginalised groups.

Nijera Kori works almost exclusively with the landless and very small farmers. They train groups to lease land from larger land owners and then to cultivate the land on a group basis. It has sixty groups working with it, of which seventeen are women's groups.

Gono Kallayan Kendra (GKK) based in Sadullapur has programmes which create awareness in its group members as to the problems of floods and how to undertake rehabilitation measures afterwards. One of the issues they use to motivate people to the dangers of flooding is health and the use of medicine for the various diseases and ailments associated with excess water.

Their main development work is in health education, primary education, reforestation, some village road construction and the provision of credit to poor farmers. They do also get involved in job creation through local works at community and village level.

By far their biggest impact in terms of flooding and related problems is in the provision of Labour Contracting Societies (LCS) for earthcutting. These are provided to the World Food Programmes on the embankments of the BWDB and the Early Implementation Projects associated with water and flood control. In this way they provide employment while contributing to flood control systems in the area where the LCS people live. GKK has no fewer than 72 LCS groups working in Gaibandha district.

Gono Unnayan Kendra (GUK) works in 26 different villages in three unions of Gaibandha district. It runs disaster preparedness programmes with special emphasis on health and sanitation. It has also run post-flood rehabilitation programmes. It has given training in emergency fund creation, homestead raising above flood levels and tree planting to provide compaction for dykes and embankments. Part of the disaster preparedness programme involves environmental awareness in order to prevent soil degradation and erosion.

CHAPTER 3

FLOODING AND DRAINAGE

3.1 Hydrology

Climate

The climatic norm of the project area is more or less the same as the average climate of North West Region.

Rainfall

There are rain gauges at Sundarganj, Pirgacha and Gaibandha within the project area and several more gauges which are quite close to the project area. The average annual rainfall ranges from above 1900 mm to 2200 mm with a project area average of 2170 mm assessed on the basis of rainfall records of stations within and around the area. The rainfall of the project area is slightly higher than the regional average of 1900 mm but is well below the regional maxima which is slightly above 3000 mm in the extreme north of the region. The mean monthly and annual rainfall based on data from 1962-91 in and around Gaibandha area are given in table 3.1.

The highest one, three, five, seven and ten day rainfall at different stations are shown in Table 3.2. The maximum ten day rainfall occurred in 1987 in seven out of 12 gauges of the area.

Water Level and Flow data

Water level gauges important for the project are Gaibandha, Islampur and Jafarganj in Ghagot and Kaunia in Teesta river.Out of these only Gaibandha and Kaunia are close to the project area. Islampur and Jafarganj are west of the project area and cross to Rangpur. Water level data of these stations were checked and missing and doubtful data were filled in by correlation with other stations (Volume 10, Draft Final Report). Data is presented in Table 3.3.

Jafarganj is the only gauging station in Ghagot river for which flow data is available for the period 1964-1980. The flow is measured weekly in the monsoon and fortnightly, at times monthly during lean season. Daily mean flow is estimated from recorded mean water level with the help of rating curves. Annual maximum peak flow computed from the rating curve is 361 m3/sec in 1987 while the annual average peak flow for the period is 162 m3/sec. The station was discontinued from 1981 but restarted around 1988. Flow observation at Jafarganj was shifted to Islampur in 1990. Jafarganj flow data was used in the Gaibandha sub model.The rating obtained from the last year was used to obtain the flow of the missing discharge data. Long time discharge data is available at Kaunia. Data is presented in Table 3.4.

Table 3.1 Mean Monthly and Annual Rainfall in and around the Gaibandha Area (mm)

Station	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	YEAR
Bhawaniganj	88	310	396	424	264	268	139	12	3	4	7	21	1935
Chilmari	90	319	470	504	287	283	150	10	6	5	11	22	2158
Kaunia	106	330	504	597	346	367	136	12	3	17	8	23	2446
Kurigram	107	334	515	518	296	347	128	15	5	5	11	33	2314
Mithapukur	107	281	423	574	337	397	108	13	6	5	11	30	2293
Mahipur	102	300	461	545	352	353	122	8	6	5	13	24	2292
Pirgachha	102	286	401	511	275	304	123	17	9	4	8	23	2061
Pirganj	82	259	334	446	306	296	128	20	4	7	6	23	1911
Rangpur	90	288	451	522	322	353	134	14	5	4	10	33	2226
Sundarganj	81	315	428	466	286	295	110	6	4	3	7	21	2021
Ulipur	97	323	459	551	309	313	124	10	6	6	11	31	2240
Overall Mean	96	304	440	514	307	325	127	12	5	6	9	26	2172

Table 3.2 Maximum Rainfall for Different Duration in and around Gaibandha Area(mm)

	1 day	year	3 day	year	5 day	year	7 day	year	10day	year
Bhawaniganj	298	1983	437	1981	541	1981	568	1981	725	1987
Chilmari	306	1987	531	1987	594	1986	672	1974	775	1987
Kaunia	321	1973	479	1973	635	1987	787	1987	1118	1987
Kurigram	285	1979	533	1976	605	1976	573	1983	711	1973
Mithapukur	287	1970	518	1973	682	1973	705	1987	1029	1987
Mahipur	257	1967	613	1967	816	1967	840	1967	866	1967
Pirgachha	356	1976	859	1976	870	1976	878	1976	908	1976
Pirganj	191	1988	411	1987	555	1987	660	1988	997	1987
Rangpur	258	1979	508	1987	735	1987	763	1987	933	1987
Sundarganj	292	1973	511	1973	605	1973	705	1973	778	1973
Ulipur	305	1969	521	1973	699	1973	711	1973	711	1987
Maximum	356		859		870		878		1118	

Table 3.3 Mean Monthly water Level (PWD)

Station	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Year
Gaibandha (Ghagot)	17.68	18.05	19.42	20.72	20.65	20.38	19.41	18.20	18.17	17.56	17.39	17.08	18.73
Kaunia (Teesta)	27.97	28.40	28.99	29.35	29.25	29.18	28.61	28.01	27.76	27.58	27.53	27.65	28.36

Table 3.4 Mean Monthly Flows (Cumec)

Jafarganj (Ghagot)	0	2	11	33	26	23	16	2	1	1	1	0	10
Kaunia (Teesta)	261	561	1360	2430	2240	1920	938	380	237	175	150	166	902
Bahadurabad (Jamuna)	7520	14700	30700	46300	42700	36000	22600	10300	6590	4790	4130	4730	19300

3.2 Flood control and Drainage Options for GIP

3.2.1 Present Flooding and Drainage Problems in the GIP Area

The flooding and drainage problems were carefully identified through field investigations, public consultation with inhabitants in the GIP area, and data collection and engineering studies. The summary of the findings is given below. Places referred to are shown in Figure 5.1

3.2.2 Brahmaputra

The river channel of the Brahmaputra has been shifting westwards eroding the river banks from Horipur to Kajarhat in the project area, and therefore retirement of the flood embankment has been repeated. Especially upstream of the Manas regulator is being severely eroded in these years and predicted to be carried away in the next monsoon (FAP 21/22)

However, flood damage due to flood water intrusion of the Brahmaputra is rather small taking into account that the general ground slope of the area is from the west to the east and that flood water levels of the Brahmaputra are rather lower than those of the Ghagot and Teesta.

According to the FAP-12 study which assessed the Kamarjani reach along the BRE, the BRE has improved living conditions and minimized damage against inhabitants and their properties during the monsoon season. On the other hand, the BRE has worsened the drainage situation in the monsoon season due to the lack of drainage facilities during retirement of flood embankment. In these years, drainage congestion continues for several weeks and causes crop damage for t.aman, jute plants and jute production, and HYV boro and aus not only during the peak monsoon season but also in the pre-monsoon season.

3.2.3 Teesta

River bank erosion due to shifting of the main stream is the most serious problem along the Teesta. Presently, there is breach about 11 Km long between Painalghat and Sundarganj due to river bank erosion, and flood water enters the area through the downstream of the Burail, Kata and Masankura rivers causing crop damage to jute and paddy. Especially, along the Masankura river, Masankura regulator with 1 vent, which aims to store internal runoff and utilizing it for irrigation during dry season, is constructed and spilling water is accumulated in its reservoir area. To drain out this excessive flood water stored in the reservoir area, inhabitants cut the embankment connected with the regulator in every year. Besides, the discharged flood water from the Masankura regulator also attacks the Mirganj regulator with 5 vents in the downstream end of the Masakura river. Embankment cuts are also done by the inhabitants for drainage since the capacity of regulator is insufficient to drain out the excessive flood water.

The TRE at Belka was breached by river bank erosion with a width of 300 m in 1991. Once flood water comes through the breach into the Matherhat river, flooding water causes severe flood damage for monsoon season agricultural crops in the basin and drainage congestion in the downstream reach along the Matherhat river. The Sarai regulator is constructed on the BRE but its capacity is constrained by the water level of the Brahmaputra.

Outside the GIP area, there is a breach about 7 km long from downstream of the confluence with the Buri Teesta. Some of the flood water and sediment of Teesta flows into the Ghagot through the breach and induces rise of flood water level and siltation of riverbed of the Ghagot.

3.2.4 Ghagot

Presently, the upstream of the Ghagot is connected with the Teesta through breaches over a length about 7 km, which was formed by the flood in 1988. Therefore, flood water and large quantities of sediment conveyed by the Teesta easily enter the Ghagot. Besides, the excess flood water from the Teesta is retarded in the upstream reaches and sediment is deposited in the upstream riverbed and flood plain. Satdamua Katler Beel System funded by EIP provides a flood embankment on the left bank between Gaibandha and Bamandanga. But since the river reach upstream of Bamandanga is still unprotected by the flood embankment and there exist 11 openings such as bridge and culverts along the existing railway embankment between Kaunia and Bamandanga, flood water from the Ghagot-Alaikumari intrudes into the GIP area.

The existing flood embankment on the left bank is severely eroded on both side slopes and the stability of flood embankment is considered to be rather low against seepage and sliding considering the long duration of flood in the downstream reach.

BWDB provided the flood embankment with about 1 m height and 1 m crest width along Gaibandha to Sadullapur road on the right bank before 1987. There exist many excavated portions and severely eroded slopes in the flood embankment, and therefore it has easily allowed the intrusion of flooding water from these portions. The inhabitants claims that the flooding situation in the area became more severe than before the construction of the left embankment of the Ghagot. The inundation depth in the area is 1 m in normal year and in 1987 all the area was inundated.

There are many beel areas on the right bank surrounded by the Ghagot, National Highway, Alai Nadi, and Bangali, in which the flood water spilling from the Ghagot through the Naleya river is retained and causes drainage congestion due to insufficient capacity of drainage rivers and khals into the Karatoya/Bangali.

3.2.5 Internal Drainage

The GIP area is divided into 31 drainage basins based on topography and the existing rural road and railway embankments. These basins are inter-linked through bridges, culverts, and drainage canals identified only during monsoon season. Along the most of the drainage routes, there are many beels, which function as retention ponds regulating flood runoff during monsoon season and water storage ponds for irrigation or fishery in dry season.

Major drainage problems are:

- excessive flooding water from the Teesta and Ghagot against the capacities of existing regulators;
- insufficient discharge capacity of the existing regulators/sluices due to influx of excessive rainfall runoff into the drainage basin through interlinked canals or natural channels;
- closure of natural drainage routes by construction of rural road embankments, at about 450 locaions based on the topographic map of 1:20,000 produced by NWRS, especially along sub-drainage system, and
- localized drainage congestion along the existing embankments due to lack of drainage facilities which leads to public-cut of the flood embankment.

3.3 Impacts of Floods

3.3.1 Introduction

This section discusses the human impacts of the flooding situations described in the previous section. The information was collected by social surveys carried out by NWRS in and around the project area. The locations are shown in Figure 3.1. More details of the surveys, and those carried out in other locations, are given in Volume 11, Social Impacts, of the Draft Final Report.

3.3.2 Villages in Gaibandha

Shabaz village is a community living on the edge of Bamandanga Beel which covers an area of approximately ninety acres. More than half the beel dries out in the winter and can be used for boro rice, wheat and some jute. Villagers complained that the union chairman was using a large part of it as a private farm. To control water levels for t. aman he built a crossdam on the khal which feeds the beel from the Ghagot. In the late floods of 1991 the communities outside of the beel had to go to the upazilla chairman to get the crossdam cut as they were heavily inundated.

For the capture fishermen who were once the predominant community the crossdam meant that the beel was not being naturally restocked from the rivers nearby and that the low levels of water would not shelter larger fish. They wanted the crossdam completely removed. In the meantime, however, extension fishery was introduced to Bamandanga and some smaller surrounding beels and these areas are leased to fishing cooperatives which are quite strong in the locality. This is one of the few areas of the study where it has been found that fishing cooperatives are being given preferential access to water bodies.

In communities along the Ghagot near the beel the people claimed that siltation of the Ghagot was now causing major problems and in the last three years had seriously damaged t.aman, vegetables and their homes. They were fully cognisant that slow meandering rivers cause lots of spillage on to the land. They also stated, however, that embankments were not the answer since they would increase the levels of deposits by keeping them in the main channel. What they wanted was regular re-excavation, to be carried out by the villagers as a source of local employment.

Narayanpur village is on the right bank of the Ghagot river which runs the entire length of Gaibandha district. It is close to the Gaibandha - Sadullapur road and from 1987 onwards has been subject to heavy flooding. Since then over ninety percent of the aman had been destroyed while for late-planted aus and jute it was fifty percent. A boro crop is grown but they claimed they did not like it as it failed to give good straw and they therefore preferred local varieties; they would also like to grow wheat.

This community and others nearby are "trapped" between the road and the Satdamua - Katler Beel embankment on the left bank of the Ghagot. There is no evidence of any drainage through the road which appears unplanned in respect of the embankment system and the people claimed they were not consulted when these schemes were planned. The embankment has not been completed and the community expects the situation to worsen when that happens.

In Rasulpur village on the BRE near Gaibandha around half of the women interviewed had goitre which they blamed on a wind coming off the Brahmaputra. Many of them were also suffering from scabies, swollen gums and skin disease. The children were obviously malnourished with the symptoms of swollen stomaches and thin spindly legs. The only time they eat fish is when the men come home from spells as migrant labourers and catch them in the river or have enough money to buy them. They never eat meat.

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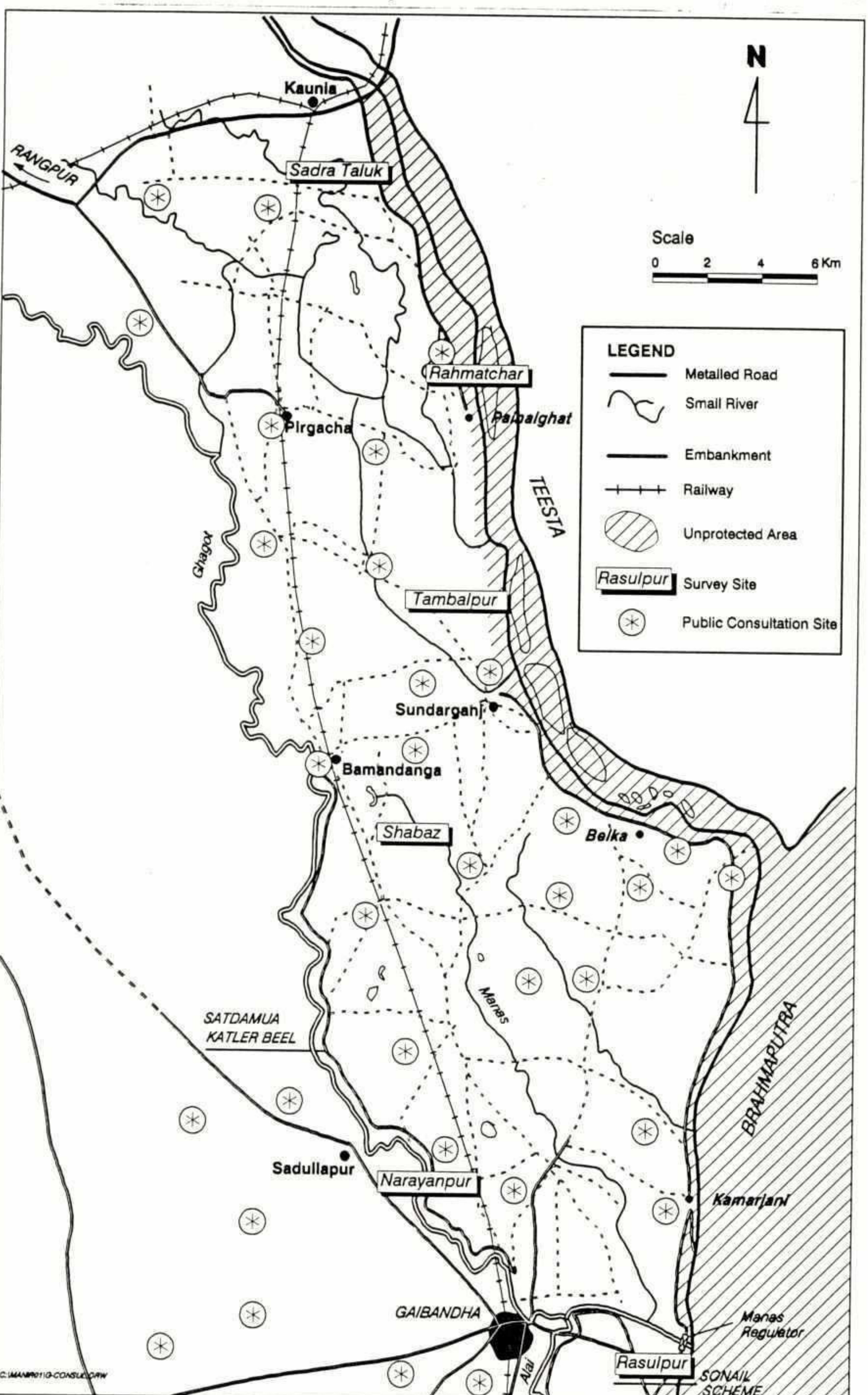
Figure 3.1
Social Survey and Public Consultation Sites



Source : NWRS

They said they only cook one meal per day for consumption in the evening and from that they try to save a little which they give to the children in the morning. This will usually be rice and occasionally pulses and chilies.

The reason why all of these women and their families are perched on the embankment is the result of floods forcing them to leave previous homesteads where in many instances they had a little land. A far greater psychological reason, which came up again and again in interviews, is that they hope that new land will emerge near where they are squatting and if they are able to cultivate it they can return to a normal family existence with their husbands and children.

Like their menfolk village women do not fear floods and stressed they could cope with them even in extremis. What is a greater concern is the lack of land and employment which might permit a decent family life and better health for them and their children.

3.3.3 Villages on the Teesta

Flood survival strategy surveys were carried out on the Teesta Right Embankment (TRE) in order to analyse comparatively different situations facing people both protected by the TRE and disadvantaged by the river's behaviour in recent severe floods.

A structured questionnaire and a participatory rural appraisal were carried out in the same areas at different times. Both the male household head and his wife were interviewed in order to avoid gender bias.

Basically the community types were:

- A community totally protected in recent years by the TRE and where everyone has access to land;
- One which is now outside the TRE but also where nearly everyone has access to land;
- Finally one where the people have had to migrate having lost everything to the river in recent years.

Sadra Taluk village is in Kaunia thana and is well protected by the TRE. The 32 households in the sample all had land which they owned. The range was from a quarter of an acre to over seven with the mean being 2.4 acres and the mode 0.66 acres. They farm all the rice varieties, aus, aman and boro and reported that wheat yields have increased in recent years. A wide range of vegetables and tobacco are grown as cash crops and the road along the top of the embankment has improved trading and access to markets.

Rahmatchar village in Pirgacha upazilla is also a settled village but the sample was chosen from farmers living outside the TRE. Out of the 28 households interviewed only one was landless with the others owning a range of land from 0.05 to 6.33 acres with the mean being 1.4 and the mode 0.7 acres. In 1991 a breach in the embankment brought large amounts of water into the area, ultimately leaving behind large amounts of sand which destroyed the agricultural potential of the land. Very little of the land is now fully productive.

Tambalpur village in Pirgacha upazilla is the refuge of around four hundred migrants who came from another community called Tambalpurchara three to four kilometres away. In their previous community nearly all of them reported to have had land. In the floods of 1991 bank erosion of the Teesta caused their village to disappear into the river. These migrants are living in the school and government buildings and now only find work as seasonal agricultural labourers and as migrant labour in the urban areas when there is no work locally. Thirty six families were interviewed.

When asked about the effects of the 1991 flash floods in the Teesta all respondents in Sadra Taluk said they has suffered no damage whatsoever. In Rahmatchar 22 said the damage was moderate to severe while nine suffered slight damage and the other three reported no damage. In Tambalpur the entire migrant community had to move inside the TRE to their present refuge when their homes in the previous location of Tambalpurchara disappeared into the river.

When asked the same question about the 1988 flood which was much more severe only five percent of the housing in Sadra Taluk was damaged. In Rahmatchar over fifty percent of the housing suffered moderate to severe damage, thirty percent reported slight damage while the rest reported no damage. In Tambalpurchara in 1988 all of the housing suffered moderate to severe damage.

Another indicator of perceptions of flood damage was elicited by questions asking for village definitions of floods. In Sadra Taluk a severe flood was defined in the context of how much damage it did to crops while in the more vulnerable locations like Rahmatchar and the ill-fated Tambalpurchara they perceived flood danger in terms of the inundation and damage to household and homestead. Ninety four percent of the residents of Sadra Taluk defined flood damage as destruction of crops while in both Rahmatchar and the now non-existent Tambalpurchara over ninety percent of all respondents said severe flooding was when their houses were submerged.

Perceptions of the role of the embankment (in this case the TRE) also reflect different flood experiences and sixty five percent of those living outside it in Rahmatchar said it was useful as a flood shelter while all of those in Sadra Taluk saw it in terms of crop protection. When this question was followed up with the direct effect of the embankment on crops all respondents in Sadra Taluk claimed enormous benefits to agriculture while in Rahmatchar only four said they felt any benefit to crops while thirteen claimed it delayed aman cultivation and ten said it was counterproductive since too much sand was deposited on good land as a result of its existence. In Sadra Taluk the farmers also said that the existence of the road on the TRE had improved their economy considerably since they had better access to markets as a result of its construction.

Another indicator of stress in floods is nutritional standards during the flooding period. Respondents in Sadra Taluk reported no difference in food intake during floods and at other times of the year. In Rahmatchar for a minority of respondents of about five percent at no time of the year were they able to afford three meals per day. In this village in the severe flood months from July to September approximately ten percent of the village only ate one meal per day, while another twenty percent were only able to obtain two meals. All of them reported that the nutritional quality of what they were able to get was much lower than in the dry season and a meal would frequently consist of rice and chilies.

The status of health in these villages was also elicited for the severe flood years of 1987, 1988 and 1991. Those who previously lived in Tambalpurchara said seventy percent of them had dysentery and diarrhoea, five percent had typhoid and the remainder a variety of fevers and skin infections. In Rahmatchar around fifty percent of them had dysentery and diarrhoea while Sadra Taluk reported little difference from other times of the year. On the more general question of family illnesses over seventy percent of Rahmatchar said illness had increased in heavy floods while in Sadra Taluk no difference had been noticed.

The major inference from this survey is that embankments do afford protection to those communities which happen to be in the right place when they are constructed. Sadra Taluk is a thriving agricultural community behind an area of the TRE which is secure and as such has improved the lot of the community. That part of Rahmatchar which is outside the TRE struggles to provide the community with a reasonable existence while Tambalpurchara no longer exists.

With this study and others done elsewhere under NWRs it is emerging that many of the problems of the region can be attenuated if the existing embankments are in good condition and maintained properly. Spillage from the internal rivers in the northwest appear to be the result of breaches in the main embankments. This increases the volume of discharge down the smaller rivers to a level that these cannot take without overspilling and brings so much sediment that the bed levels of the smaller rivers rise and severely diminish the capacity of these to hold a reasonable volume of water. The outcome for those communities on the region's major rivers with no protection from embankments is misery when flooding becomes severe.

From this survey it was clear that the communities are aware that most solutions to their flood problems must be predicated upon the good working order of the major embankments which provide the best line of defence.

3.3.4 Unprotected Areas

There are a number of different categories of unprotected area:

- those living between the embankment and the river;
- those living on chars in the river (different categories of char can also be distinguished);
- those living on the embankment (these people are mostly refugees from the riverside and are therefore a consequence of lack of protection);

There are also communities which in principle are protected but which are vulnerable to breaches in the embankment, particularly along the Teesta Right Embankment. Some households have been in all these categories at different stages: for example people living just to the south of the project area have moved three times in the last ten years between chars and embankment due to river erosion.

It is estimated that about 100 000 people live on the chars in the Brahmaputra opposite the project area (this number is based on estimates made during the FAP3.1 char study). Apart from the opportunities presented to people from the "mainland" to occupy newly-emergent char land, the rapid westward movement of the Brahmaputra and erosion by the Teesta have left many people unprotected. The general policy of embankment retirement in the face of the movement of these rivers has also left many people outside the embankment. Communities which are now living on the country-side of, but adjacent to, these embankments express themselves strongly against further retirement since they would then also fall into the unprotected zone.

Depending on precisely which unprotected areas they are in, and the frequency and depth of flooding in those areas, the cropping patterns and occupations of unprotected households vary. Household surveys and participatory appraisals conducted by the study show that, on the chars, cropping patterns are based on local varieties and crops which can survive in sandy soils, for example local aus and aman, kaon and pulses. Between the embankment and the river local aman, wheat and kaon are predominant although some boro is also grown.

Main occupations in unprotected areas are farming and agricultural labour: there are very few alternative occupations. Considerable seasonal out-migration takes place which, as in the district in general, places a significant burden on women and children who remain in the area. Those living on chars may have to migrate for up to nine months although most people are present during the flood season.

The degree of community cohesion during flooding appears to vary depending on where the settlement is. Only on the chars does one find communities claiming to face adversity as a group and to give assistance to weaker members. On the embankments there appears to be a higher degree of individualism in tackling floods while in the traditional settled communities behind the embankments families will adopt strategies with little reference to neighbours or community. These strategies perhaps can be explained in terms of degrees of adversity since it is the char dwellers who are most isolated and who face the greatest problems when severe flooding occurs.

The family on the other hand operates everywhere as a unit in flood survival strategies. Women and older children help in the construction of the macha which is a type of bamboo loft inside the house above the flood levels. Most women have an agla chula (portable stove) and have to cook in extremely unstable situations. If the floods are really severe the man will go on to the roof of the house and the women will perch with the children on a bhela raft (made of banana tree) since it is regarded as safer than the house roof. The women are responsible for making sure the children do not fall off the bhela and for paddling it to collect water from areas away from the contamination of the house. Data show that men tend not to migrate for work during the floods. The embankment dwellers, many of whom now regard their homes on the embankments as permanent, have the safest haven during severe floods and squat on the tops of the embankments until the water goes down.

3.4 Public Consultation

Public consultation is rightly seen as a key step in successful flood development. There is ample evidence that many of the failures of the past have been due to an incomplete understanding of people's needs in relation to flood protection or the inability to balance the rights of different sections of the community. The latter is particularly important in flood protection, where adverse impacts can be strongly felt outside the protected area. In such cases it is felt that a vigorous programme of public involvement will help to reduce the problems.

Such public involvement will come about in stages. The first stage is when the people concerned are consulted about their problems and needs, and the possible options and solutions that they themselves can define. As these solutions are worked up into specific development proposals, there is a need for a more active process of participation by the communities affected, first in the process of detailed design, so that the general plans are turned into specific proposals that reflect their needs, secondly in the period of implementation, so that communities can identify with the measures being built and begin to feel an "ownership" of them, and finally in operation and maintenance, so that they gain the full benefits from them and do not rely on scarce resources from government.

In the process of consultation, various levels can be identified. The most important level is clearly that of the communities and villages themselves, as it is they who directly benefit or suffer from the impacts of the development. In the case of the project, considerable efforts were made to consult a wide spectrum and extent of villages, as discussed more fully in Volume 11 of the Draft Final Report.

As a framework for village consultation,there is great value to be gained from consultations at the thana/union level. Whilst villages generally take a relatively uniform view of problems and possible solutions, thana/union discussions allow views on the impacts of possible solutions across a suitable scale of a few thousand hectares. Thus one village which wants a regulator will learn that another upstream village fears flooding from that regulator, and the thana provides a suitable framework against which this balance of interests can be discussed.

Two other groups which were specifically consulted during the project preparation phase were women's groups and NGOs.

Previous surveys which had asked questions about flood problems and solutions had experienced difficulty for two major reasons. Firstly communities were unused to being seriously consulted about their problems, far less being asked an opinion as to how to solve those problems, and were reticent about getting involved with complete strangers. Secondly there was a lack of context and questions were frequently being asked in a vacuum since the field workers had no prior knowledge of what problems the community was facing. In order to overcome these difficulties a contextual model was drawn up containing the following steps:

- Initial meetings with communities, officials and NGOs were conducted to determine their perceptions of flooding problems and their solutions to these. Where communities were concerned these meetings might be pre-arranged or take the form of transactional walks in rural areas;

- This information was analysed and compared with existing data by the study team;

- The engineers and hydrologists drew up options based on this information or alternatives to the community solutions using technical data;

- The community or official options or rejections of them were taken back to the same communities and officials and a full discussion ensued.

In the case of the Gaibandha project the public consultation process was carried out by the consultants, working in mixed teams of foreign and local staff, and of mixed disciplines. Each team, however, always had least one engineer and one sociologist/institutions specialist. A large number of villages were visited (Figure 3.1) and formal meetings held. In addition there were numerous transactional walks and informal discussions. Thana level meetings were held in the thanas of Pirgacha, Sundarganj, Sadullapur and Gaibandha. Meetings were also held with district officials in Gaibandha.

It was also decided that in order to comply with the contextual model in the Gaibandha special project area the first set of meetings would exclusively be listening experiences and only then would analysis of village and local officials' problems and solutions take place and during a third set of meetings these would be presented to the communities and officials. In briefing the teams it was therefore emphasised that they must initially listen and make no attempt to intervene or direct the dialogue. For the community meetings or transactional walks a skilled Bangladeshi sociologist would instigate the discussion and would ensure that the villagers views took precedence over all others.

As to the process itself the contextual model worked well. For the first two phases the field workers did listen very carefully to what the communities and officials were saying. The utilisation of the hydraulic model to analyse options and predict flood levels which could be explained to communities also worked well. Villagers clearly understood the relationship between a particular option and levels of water in the rivers or on their fields as predicted by the hydraulic model.

A methodological problem at prearranged meetings was getting genuine opinions from villagers and not from the mastans (touts controlled by rich and influential men in the villages). By using a skilled

Bangladeshi animateur the meetings were conducted in such a way that the widest possible opinions were sought even to the point of encouraging the most lowly villagers to contribute. The transactional walk was also a way of checking the validity of information collected at meetings. A transection would be an area where a meeting had taken place or was about to take place. These completely impromptu dialogues in fields or in randomly selected villages would confirm or refute what was heard at prearranged meetings.

Finally there is the problem of seasonal shifts. Asking questions in February and asking them during heavy flooding in September might produce different responses from both communities and officials. In the year in question the levels of water during the monsoon remained moderate. It might be necessary to conduct a longitudinal study of perceptions and attitudes to different types of flood control.

3.5 Community Perceptions

There were a number of findings concerning the project area which were supported by all the communities in the public consultation sessions. There were also a number which were determined by much more local needs. The process involved taking both sets of findings back to the office and analysing them in relation to the hydraulic model and to concepts being derived from engineering principles. The next stage which coincided with the third and fourth sets of public participation meetings was to offer options to the same communities derived from both the communities' views and those derived by hydrologists and engineers.

The findings which produced a consensus in all areas were as follows:

- Effective sealing of the Teesta Right Embankment;
- Effective sealing of the Brahmaputra Right Embankment;
- Prevention of overspilling of the Ghagot;
- Make the drainage at the Manas Regulator effective.

Findings determined by local considerations were as follows:

- Re-excavate the Ghagot;
- Dismantle the EIP embankment on the left bank of the Ghagot;
- Construct an embankment on the right bank of the Ghagot;
- Re-excavate the Alai Kumari;
- Improve drainage through the Sonail Embankment;
- Re-excavate the Alai;
- Rehabilitate khals in the Masankura and Mirganj area;
- Improve access of water and fish from Ghagot to the GIP beels.

All of these community-based options were analysed by NWRS staff and a full comparative analysis was carried out. At team meetings the options offered by the communities were explained to the study team and a debate on them ensued. This process resulted in a series of option beings drawn up by team members to take back to the communities and officials for a third and fourth series of meetings.

At village meetings these options were explained to communities and the process of arriving at them was also explained. This involved engineers acquainting villagers with the work of the hydraulic model which gave water levels for various options for the project. There was a general consensus that these options would go a long way to preventing extensive flooding of the project area and that areas adjacent to the project would also benefit from these options.

CHAPTER 4
OPTIONS FOR DEVELOPMENT

4.1 Structural Options

4.1.1 Introduction

As a result of field investigations, surveys and the rounds of public consultation a large number of options were initially conceived for the project.

The various options considered were analysed using a hydrodynamic model specially constructed for the project. This Mike 11 model was developed by the NWRS team in close co-ordination with the SWMC.

In the analysis the model was used to generate water levels along the river system and on the flood plains. For comparison purposes, the floodplain levels were converted into flood depth/duration information and also in to the standard MPO flood phases.

The initial options were screened out using a two-year simulation run, from which three refined design options were identified. The refined design options were modelled for a 10-year period, from which the preferred "with project" option was selected for a full 25-yr simulation. Public consultation continued during the period of hydraulic analysis and influenced the identification of options considerably.

Full details of the model studies is given in Volume 9, Hydraulic Studies, of the Draft Final Report.

4.1.2 Initial design options

The following options were initially conceived for the project :

Option A :	Removal of current Manas regulator
Option B :	Sealing of the TRE upstream of Kaunia
Option C :	Sealing of the TRE downstream of Kaunia
Option D :	Sealing of the TRE both upstream and downstream of Kaunia
Option E :	Extension of the Ghagot left embankment from Bamandanga to the Alai Kumari confluence. Construction of a regulator on the Ghagot immediately upstream of the Manas confluence. Embankment on the right bank of the Ghagot from Gaibandha to the Alai Nadi spill.
Option F :	Extension of the Ghagot left embankment from Bamandanga to the Alai Kumari confluence. Construction of a regulator on the Ghagot immediately upstream of the Manas confluence. Embankment on the right bank of the Ghagot from Jafarganj to the Alai Nadi spill.

Option G : Removal of current Manas regulator. Construction of regulators at the tail of the Manas and the head of the Alai Nadi. Extension of the Ghagot left embankment from Bamandanga to the Alai Kumari confluence. Embankment on the right bank of the Ghagot from Jafarganj to the Alai Nadi spill.

Option H : Option E with the TRE sealed both upstream and downstream of Kaunia.

Option I : Option F with the TRE sealed both upstream and downstream of Kaunia.

Option J : Option G with the TRE sealed both upstream and downstream of Kaunia.

Option K : Option H with the current Manas regulator removed. Construction of a new regulator at the tail of the Manas river.

Option L : Option K with an embankment on the right bank of the Ghagot from Jafarganj to the Alai Nadi spill.

Option M : Option L without the regulator on the Ghagot immediately upstream of the Manas confluence.

Option A was intended to assess the impacts if, as is widely expected, the Manas regulator is washed away. It was known that spills through the Teesta embankment were a significant cause of flooding in the project area: Options B, C and D investigated the relative importance of the various breaches. Option E and F investigated the impact of possible measures on the Ghagot right bank. Option G was used to test possible configurations at the Ghagot/Brahmaputra/Alai Nadi confluence. Options H to J repeated the analysis but including Teesta sealing. Options K to M analysed various combinations of the options that were beginning to appear appropriate, and were particularly concerned with drainage from the Manas river. Further details and discussion of the options and their impacts can be found in Volume 6, Engineering, of the Draft Final Report.

Figure 4.1 presents a schematic representation of each of these design options. Table 4.1 summarises each of the options.

Figure 4.1 (1/2)

Initial Design Options

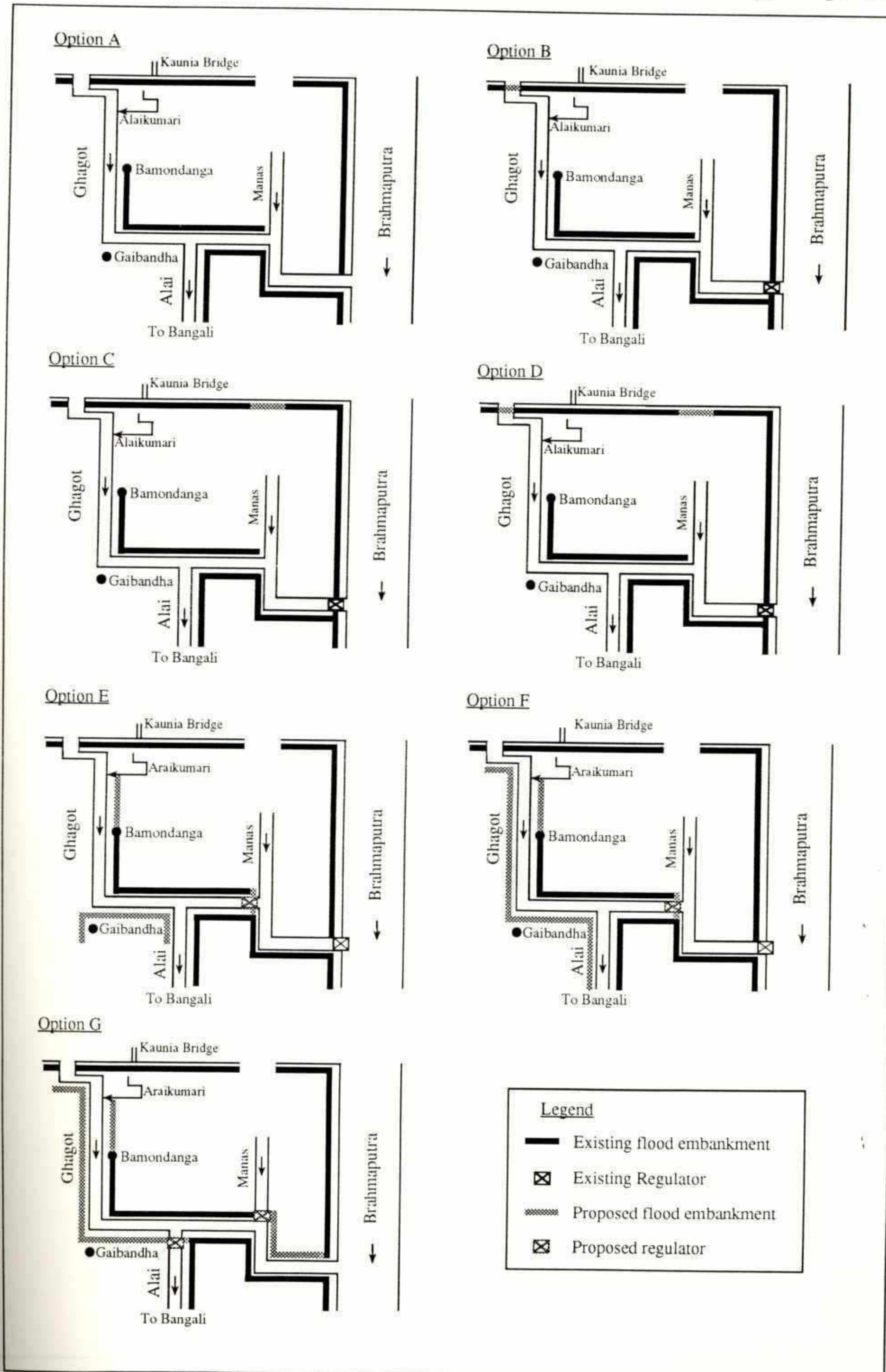


Figure 4.1 (2/2)

Initial Design Options

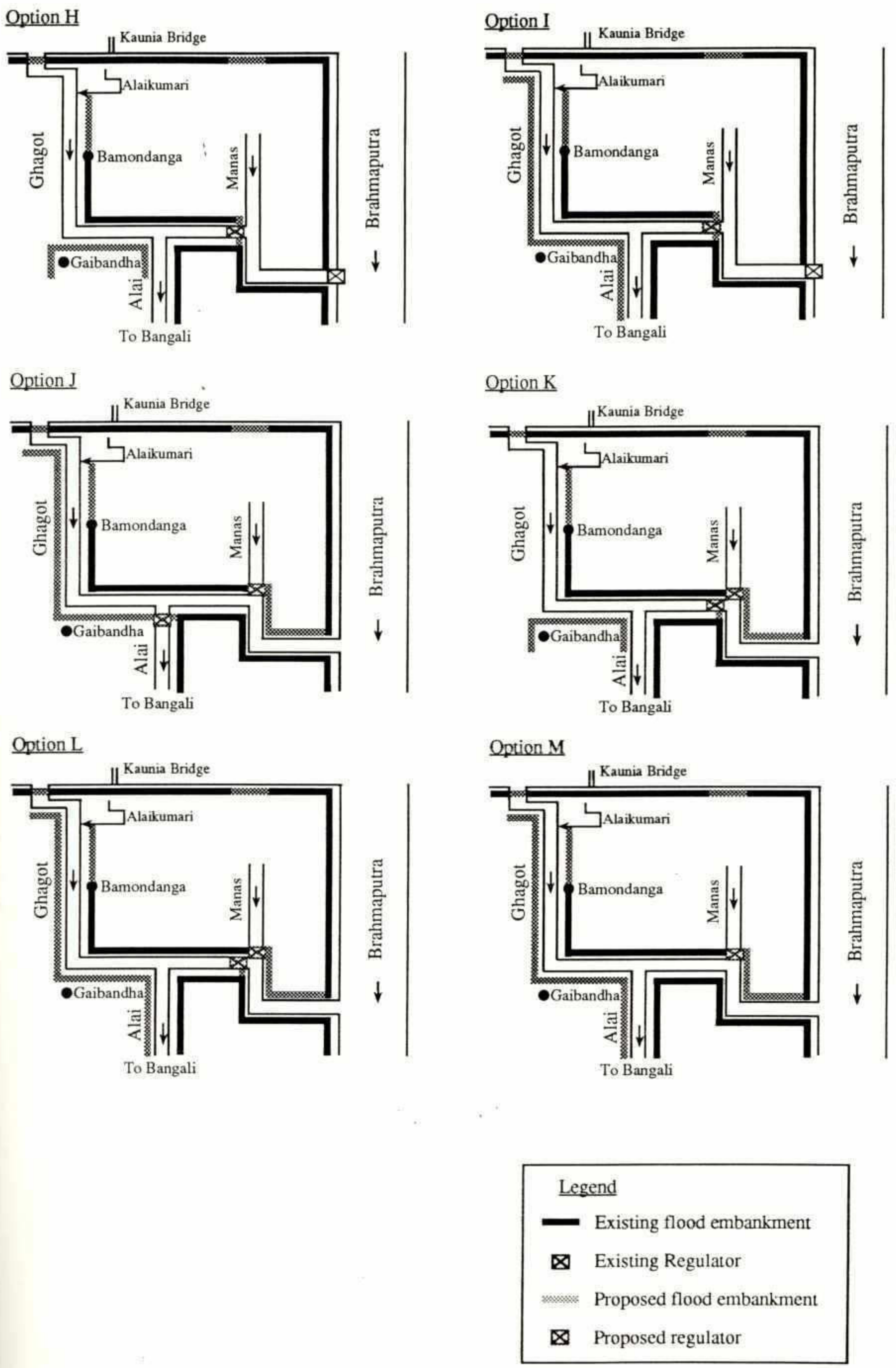


Table 4.1 Summary of Initial Gaibanda Design Options

	A	B	C	D	E	F	G	H	I	J	K	L	M
Removal of Manas regulator	X						X			X	X	X	X
Sealing TRE upstream		X		X				X	X	X	X	X	X
Sealing TRE downstream			X	X				X	X	X	X	X	X
Extension of Ghagot left embankment					X	X	X	X	X	X	X	X	X
Regulator on Ghagot upstream of Manas					X	X		X	X		X	X	
Ghagot right embankment - Gaibanda to Alai Nadi					X	X	X	X	X	X	X	X	X
Ghagot right embankment - Jafarganj to Alai Nadi						X	X		X	X		X	X
Regulator at tail of Manas							X			X	X	X	X
Regulator at head of Alai Nadi							X			X			
Backwater embankment on Ghagot right bank	X						X			X	X	X	

Based on two year simulations of the initial design options described above the following was concluded:

- sealing of the TRE upstream and downstream of Kaunia improves the internal flooding conditions in the GIP by reducing water levels in the Ghagot and also reducing inflow discharge into the GIP area.

- the reductions in water level in the Ghagot which results from sealing the TRE do not prevent spillage from the Ghagot into the GIP area; an extension of the left embankment from Bamandanga to the Alai Kumari confluence is required to achieve this.

- the proposed Ghagot right embankment reduces spillage in the right bank but increases water levels in the Ghagot which causes greater drainage congestion in the GIP area. The Ghagot right embankment has no benefits for the GIP area. Since the Manas regulator is removed a backwater embankment is required to prevent spillage on the Ghagot right bank due to high water levels in the Brahmaputra.

- a regulator at the tail of the Manas is required to prevent inflow from the Brahmaputra into the Manas basin.

- a regulator at the head of the Alai Nadi is required to prevent an unacceptable increase in discharge in this river.

4.1.3 Refined design options

Following simulations of the initial options a refined set of options was identified as follows,

Option N : Removal of current Manas regulator. Backwater embankment to prevent spillage on the Ghagot right bank when Brahmaputra levels are high. Sealing of the TRE upstream and downstream of Kaunia. Extension of the Ghagot left embankment from Bamandanga to Jafarganj. Regulator at the tail of the Manas and head of the Alai Nadi.

Option O : Option N with compartmentalisation in the GIP area. Compartmentalisation eliminates cross drainage basin water transfers.

Option P : Option N without extension of Ghagot left embankment.

Option Q : Option N with the regulator at the tail of the Manas removed.

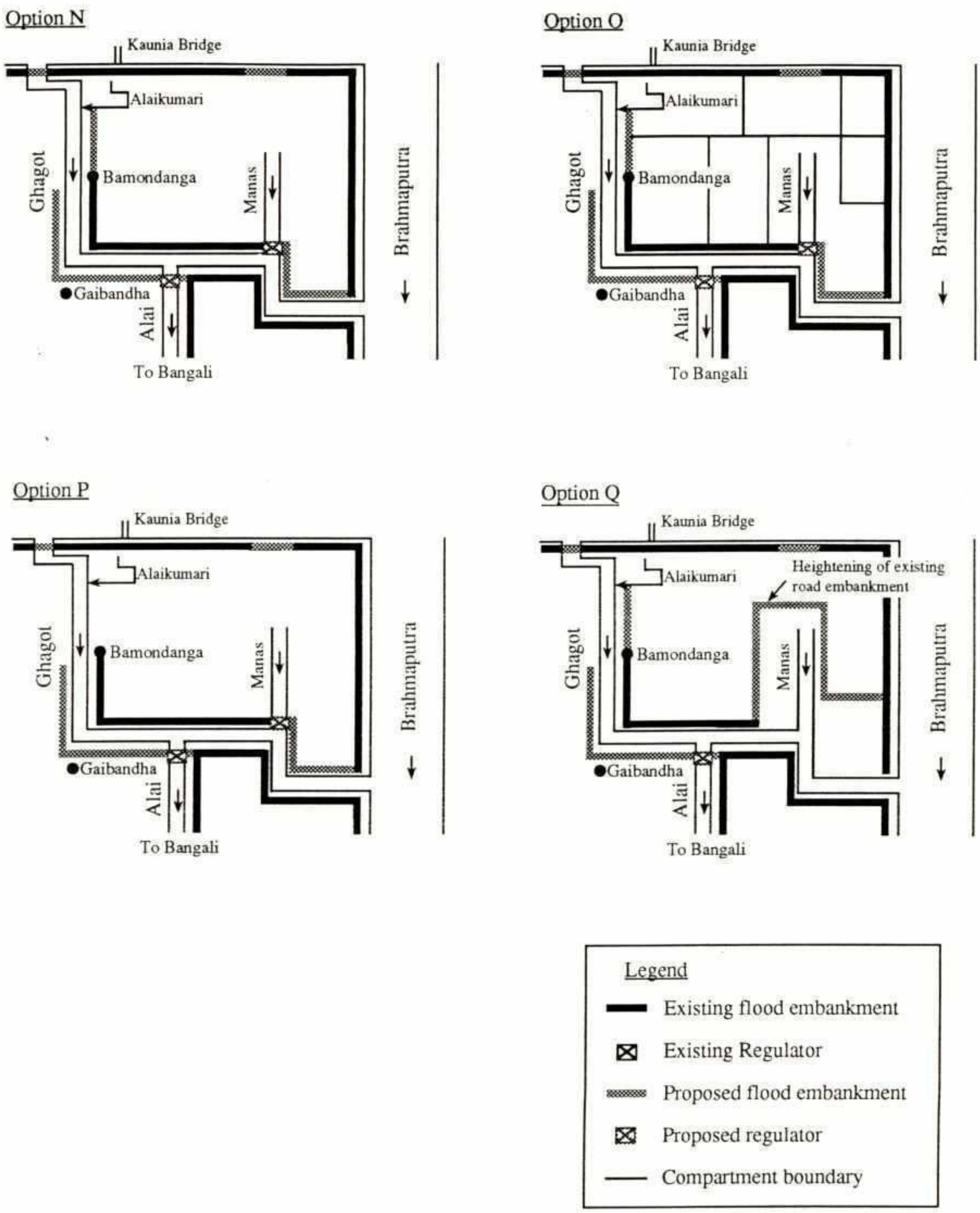
Figure 4.2 presents a schematic representation of each of these refined design options. Table 4.2 summarises each of the options.

Table 4.2 Summary of Refined Gaibanda Design Options

	Option N	Option O	Option P	Option Q
Removal of Manas regulator	X	X	X	X
Sealing of TRE upstream of Kaunia	X	X	X	X
Sealing of TRE downstream of Kaunia	X	X	X	X
Extension of Ghagot left embankment	X	X		X
Regulator at tail of Manas	X	X	X	
Regulator at head of Alai Nadi	X	X	X	X
Backwater embankment on Ghagot right bank	X	X	X	X
Compartmentalisation		X		

Figure 4.2

Refined Design Options



Model simulations were carried out for each of the refined design options for two five year blocks, 1980-84 and 1985-89. The results of each of these simulations were compared with the Without Project simulation for the same period.

The results of the ten year design options are presented by comparing the flood phases with the design option in place with those for the Without Project simulation. The flood phase results from three options (N, O and Q) for the entire GIP area are summarised in Table 4.3. Option P was undertaken as an incremental analysis to assess the cost benefits of the Ghagot left embankment extension. The model results indicated little change in flood phase with the main benefits deriving from reductions in crop damage.

Table 4.3 Flood Phases for the Entire GIP Area for Ten Year Design Option Simulations

	F0	F1	F2	F3 + F4
Without project	78 %	14 %	6 %	2 %
Option N	79 %	13 %	7 %	1 %
Option O	84 %	11 %	4 %	1 %
Option Q	85 %	10 %	4 %	1 %

Design option O and Q result in greater areas of F0 and F1 land than either the Without project conditions or design option N. In design option Q the percentage of F0 + F1 land either remains the same or is increased in each of the flood cells in the GIP area. In design option O the percentage of F0 + F1 is increased significantly in the southern parts of the area but in the areas near the outfalls of the drainage channels the percentage of F0 + F1 land is decreased. If the GIP area is considered as a whole the percentage of F0 + F1 land is the same for design options O and Q.

Design option Q involves leaving the Manas river unregulated. This creates a potential path for the Brahmaputra to enter the Manas basin; it effectively creates a breach in the BRE. This solution is felt to be unacceptable from a flood protection point of view.

4.2 The "With Project" Option

4.2.1 Selection

Design option O was selected for the With project simulation; the key features of this design option are:

- Sealing of the Teesta right embankment both upstream and downstream of Kaunia.
- Removal of the Manas regulator.
- The construction of a new regulator at the outfall of the Manas to the Ghagot.
- The construction of a backwater embankment along the Ghagot upstream of its confluence with the Brahmaputra.
- Construction of a regulator at the head of the Alai Nadi.

- An extension of the Ghagot left embankment upstream from Bamandanga as far as the Alai Kumari confluence.

- Compartmentalisation within the GIP area.

In addition to these features the capacity of regulators in the GIP was increased for the project simulation in an attempt to alleviate drainage congestion. A meander cut-off in the vicinity of Gaibanda town was also included to reduce bank erosion and flooding problems.

4.2.2 Analysis

The "with project" option was modelled using a 25-yr run. The flood phase given by the model for the without project condition is shown in Figure 4.3. It should be noted that the model shows a higher proportion of F0 land than that given by MPO data. This is because the model cannot depict the detailed micro-topography of the area and the spatial resolution within individual flood cells. Depressed areas which suffer from rainfall inundation are not therefore reflected in the model results.

Water levels

Figure 4.4 shows a long profile along the Ghagot river for a typical higher flow year, 1987. The impact of the "with project" simulation is to reduce peak water levels by over a metre throughout almost the entire reach. This impact is pre-dominantly due to the sealing of the Teesta right embankment upstream of Kaunia, thereby preventing Teesta water contributing to flows in the Ghagot. The overall hydrograph shapes in the upper and middle reaches of the Ghagot also showed a much less peaky form after the sealing of the TRE as the flows result from rainfall-runoff within the catchment area only.

Figure 4.4 also illustrates the impact on water levels in the Alai Nadi of constructing a regulator at the head of this river. The construction of this regulator has no significant impact on water levels in the Ghagot since at the point where the Alai Nadi flows from the Ghagot water levels are determined by backwater effects from the Brahmaputra. With the regulator in place, water levels are reduced by about 2m below the confluence between the Ghagot and Alai. Near the confluence with the Karatoya water levels are not changed since at this location the backwater effect from the Karatoya dominates. The Alai Nadi regulator would effectively remove problems of spillage on its right bank and allow the rainfall-runoff from the surrounding area to drain more freely down the Alai.

Discharges

The maximum discharges, simulated in the With Project run during 1987, in the main drainage channels of the GIP area are shown in Figure 4.5. Also shown in Figure 4.5 are the magnitude of the spills from the rivers. The figures in brackets represent the corresponding discharges for the Without Project situation.

The peak discharges in the Ghagot, Alai Kumari and the drainage channels which enter the north of the GIP area are significantly reduced by the sealing of the TRE. This reduction in flow is reflected throughout the Ghagot river system. The peak discharge in the Alai Nadi is also greatly reduced by the construction of the regulator at the head of this river.

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Figure 4.3

Flood Phase Analysis-Future Without

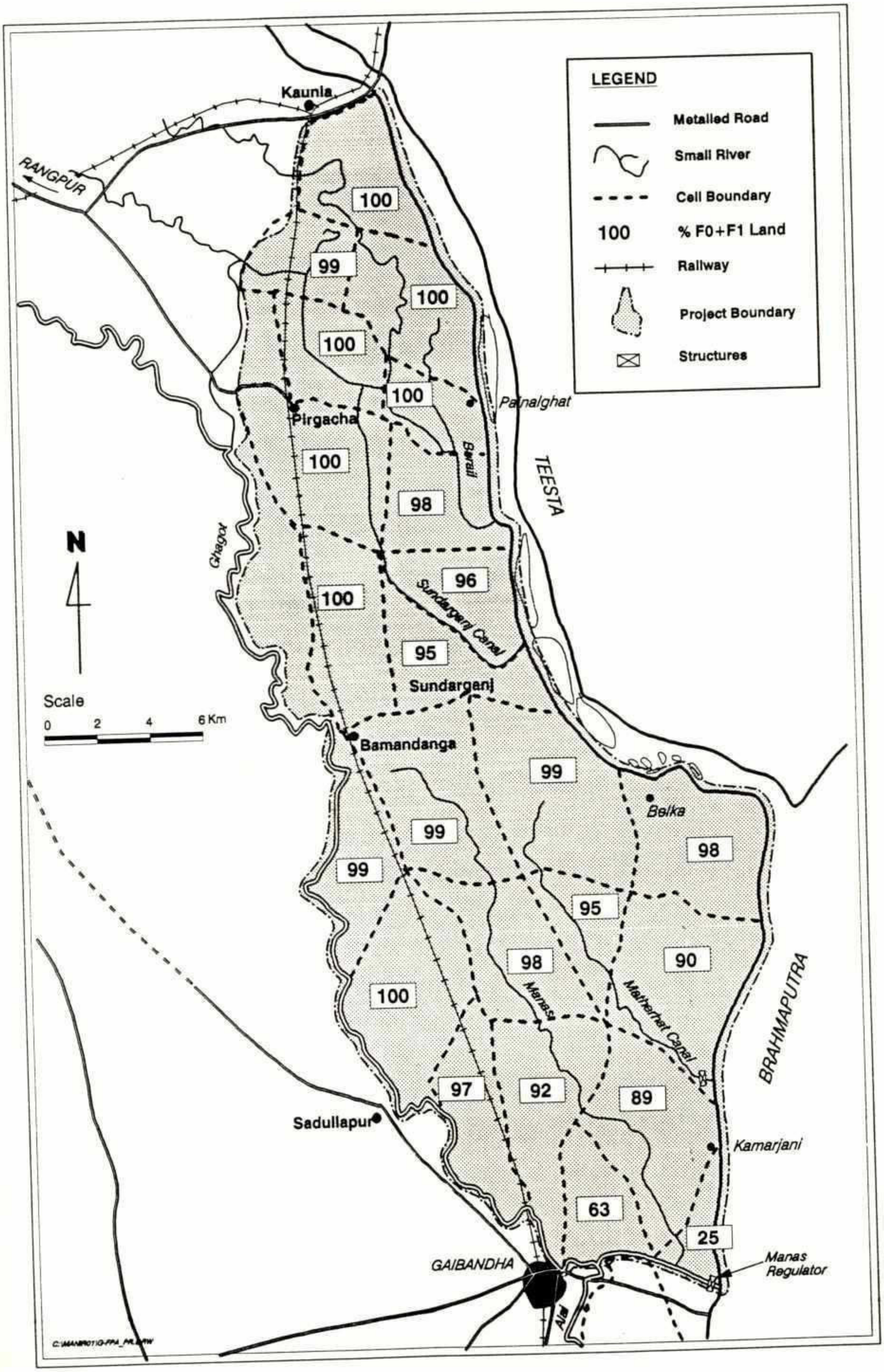
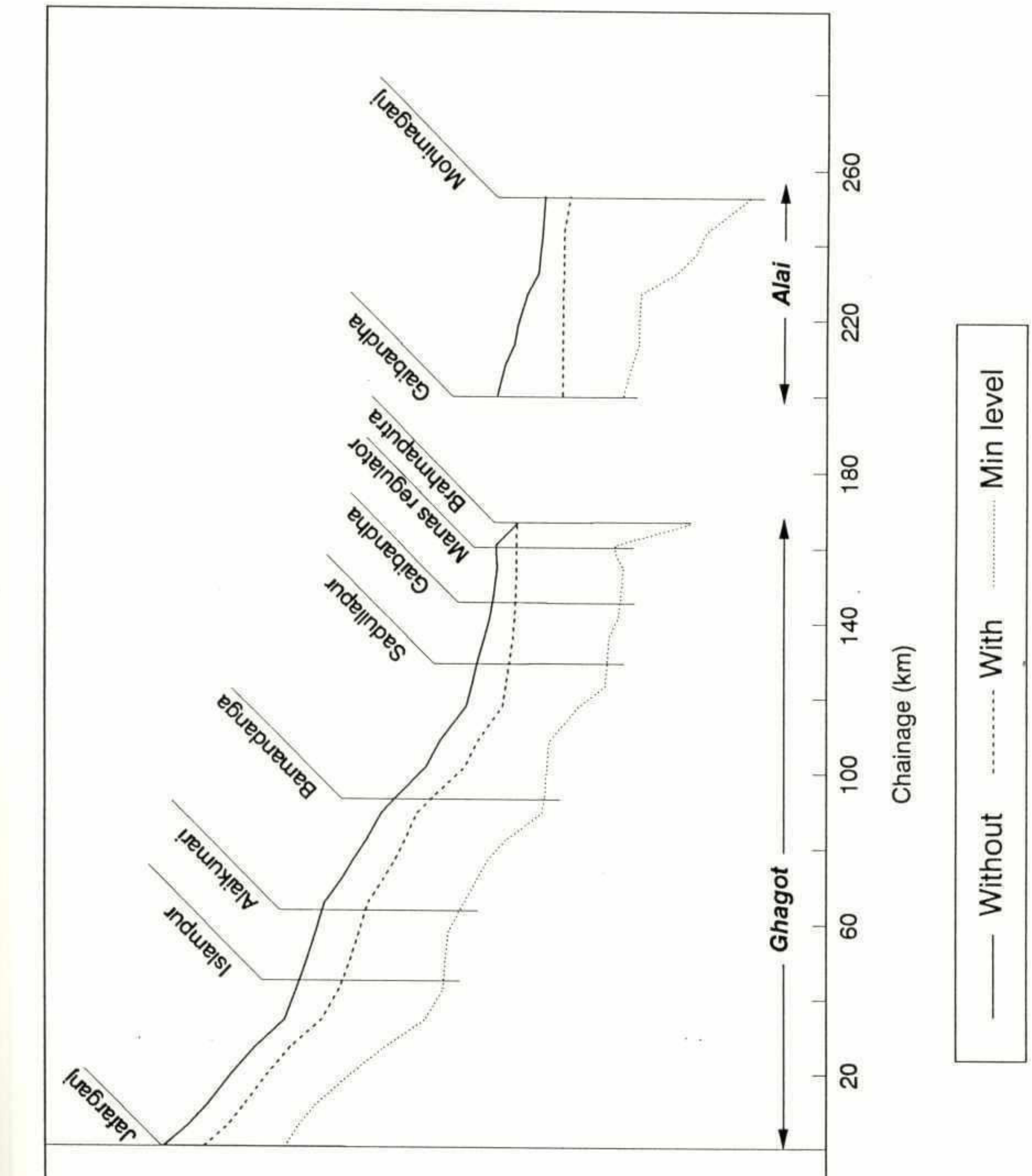


Figure 4.4
Long Profiles (1987) on Ghagot and Alai

64



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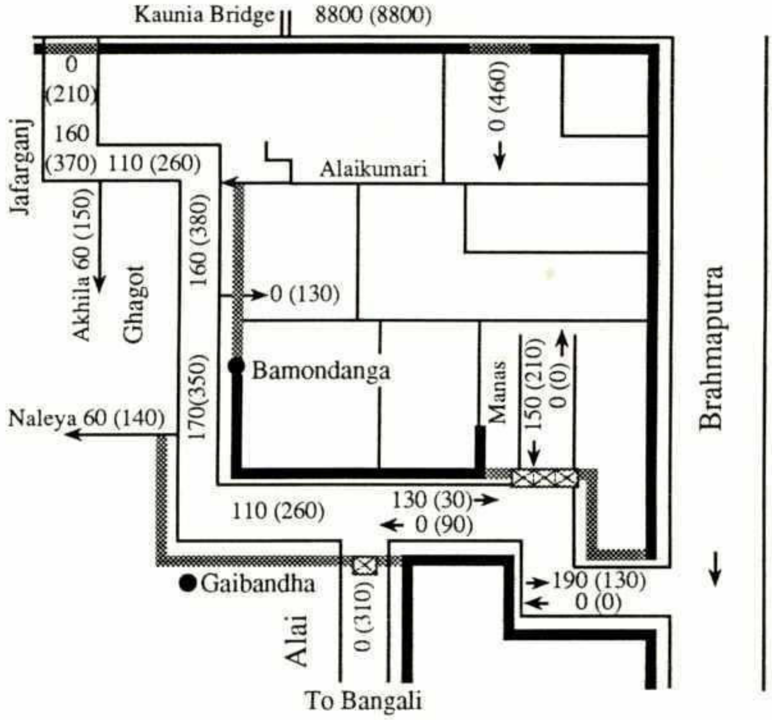
Peak Discharges

65



Legend

140 (130)	Flood peak discharges for option and under present river condition (unit : m^3/s)
▬	Existing flood embankment
⊠	Existing regulator
▒	Proposed flood embankment
⊠	Proposed regulator
—	Compartmentalisation with the improved drainage

66

The elimination of cross basin water transfers by compartmentalisation results in a decrease in flows in the internal drainage channels. These channels discharge into the Teesta and Brahmaputra; the flow can only pass to the external rivers when the water levels in these rivers is lower than in the internal drainage channels.

Flood phases

Figure 4.6 presents the areal distribution flood phases for the With Project GIP model simulations. This figure shows the percentage of F0+F1 land for each of the model cells.

The proposed developments have resulted in a significant improvement in the situation in the southern parts of the GIP area. The With project simulation shows an increase in the percentage of F0+F1 land in this area in excess of 50 %. Elsewhere in the GIP area the proposed developments have had a limited impact on the flood phases. This is to be expected since the predicted percentage of F0+F1 land in these areas was already extremely high.

The one exception to this general rule is in the eastern part of the area where the drainage channels outfall to the main rivers. Despite the sealing of the breaches in the TRE and BRE the percentage of F0+F1 land in these areas has reduced. The reason for this is that the construction of the compartmentalisation embankments have prevented flow out of these cells to the south. High water levels in the external rivers result in the impounding of water in these areas and a reduction in the percentage of F0+F1 land. The benefit of eliminating the southerly flow from these cells has been the increase in the F0+F1 land in the southern parts of the GIP area which is mentioned above. Even in the areas where the proposed developments have resulted in a slight decrease in the percentage of F0+F1 land this land still forms more than % 90 of the total land area.

4.2.3 Sensitivity analysis

The sensitivity of the results presented above to important external factors was assessed using a number of 10 year model simulations.

Sealing of TRE downstream of Kaunia

This simulation assumes that the TRE downstream of Kaunia remains open. The sealing of the TRE upstream of Kaunia is assumed to be complete.

The impact of not sealing the TRE downstream of Kaunia on flood phases is relatively minor. In the areas adjacent to the Teesta the percentage of F0+F1 land is decreased slightly but throughout the majority of the region the flooding patterns remain unaltered. An area adjacent to the TRE was also shown to have a beneficial impact. This suggests that the regulator ventage at the outfall of this cell is likely to undersized and impeded drainage is occurring due to the high external levels.

Rise in Brahmaputra water level

Developments external to the GIP area are likely to have an effect on water levels in the Brahmaputra. It was estimated that the combined impact of the proposed Brahmaputra left embankment and the Jamuna bridge will be a rise in peak water level at the Ghagot outfall by less than 10 cm. It is not felt that a rise in water level of this magnitude will have a significant impact on the conditions in the GIP area.

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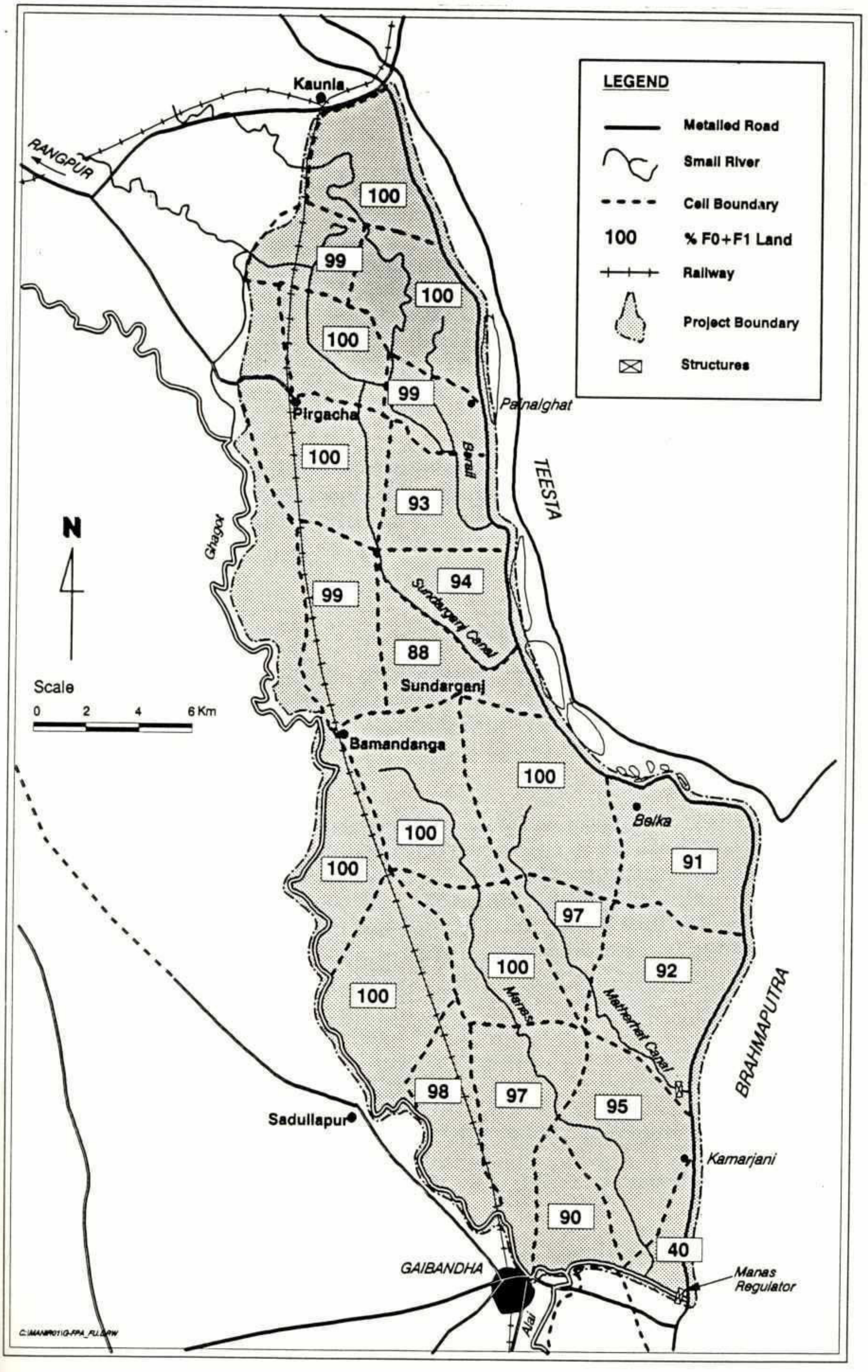
Figure 4.6

Flood Phase Analysis-Future With



A sensitivity analysis, however, was carried out to investigate the impact of a rise in peak water level of 0.5 m in the Brahmaputra in the vicinity of the GIP area; it was assumed that the low water level did not change. The analysis showed that it would result in a rise of a similar order of magnitude throughout most of the backwater-dominated zone of the Ghagot. This stretches back some 70km from the outfall location. The overall influence will extend mid-way between Sadullapur and Bamandanga.

4.3 Morphological Impact

The long-term effectiveness of sealing the TRE will depend upon the future morphological change of the Teesta river. If the right bank of the river moves to the south-west, towards the TRE, then breaches 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. For the TRE to be effective in reducing flooding down the Ghagot it is imperative that the TRE separates the Teesta from the Ghagot. It is therefore necessary to prevent any further movement westwards by the right bank of the Teesta in this area. Unfortunately this critical location coincides with one of the unstable reaches.

If spillage from the Teesta into the Ghagot is prevented by the completion and rehabilitation of the TRE then the results of the MIKE-11 simulations suggest that the dominant discharge will be reduced to approximately 50 m^3/s. The regime conditions for these revised conditions would be:

Width	22 m
Depth	2.7 m
Slope	0.00013

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

The removal of the Manas regulator is unlikely to have a major morphological impact on the Ghagot river; it will have no impact on the morphology of the Brahmaputra. It will allow some flow from the Brahmaputra to enter the Ghagot river; this flow will carry sediment with it. This flow will only penetrate a short distance up the Ghagot; any sedimentation will be in this area. Any sediment deposited in the lower Ghagot as a result of flow from the Brahmaputra is likely to be eroded by flows from the Ghagot into the Brahmaputra; this is likely to occur for at least 10 months of the year including the majority of the flood season.

4.4 Technological Options

4.4.1 Retirement or River Training

To protect the project area from intrusion by Teesta flows, two options are available:

A. to maintain the present river bank line and to prevent loss of land by providing proper and sufficient river training works;

B. to abandon the lands to erosion by the river, where it is not economic to protect them, and to repeat retirement of the flood embankment without river training works.

Option A requires significant construction and O&M costs for river training works such as groynes and revetment while option B also needs high costs for construction of new flood embankment, new regulators/sluices and land acquisition. Besides, option B might induce social problems such as;

i) increase of landless people due to land acquisition of new flood embankment;
ii) resettlement of the existing towns and villages developing along the existing flood embankment;
iii) compensation for inhabitants and farmers who are presently protected from the flood by the existing flood embankment but will be inundated due to retirement of the flood embankment; and
iv) loss of land and increase of landless people by erosion.

A preliminary study was carried out to select the optimum option applying the least cost method. In the comparative study, it is assumed that the breached embankment is repaired at 5, 10, and 15 years intervals taking set-back distance to be eroded that in the next 5, 10, 15 years for 30 years. The result of the comparative study is summarized in Table 4.4

Table 4.4 Result of Comparative Study, River Training/Bank Retirement

Items	Unit	Option A	Option B		
			5 years	10 years	15 years
Construction work					
a) New flood embankment	km	13.2	163.6	89.8	66.9
b) Resectioning/heightening of the existing embankment	km	33.4	32.6	28.6	24.0
c) Regulator	nos.	4	20	12	8
d) Sluice	nos.	5	25	15	10
e) Groyne	nos.	26	-	-	-
f) Revetment	km	4.2	-	-	-
Total construction cost	TK.m	612.7	1510.6	839.5	624.9
Construction period	year	4	2	2	2
O&M cost (percent of construction cost)	%	5	3	3	3
Land acquisition	km^2	0.94	7.89	4.42	3.10
Loss of land	km^2	0.0	54.0	54.0	54.0
Production foregone	TK.m/km^2	2.0	2.0	2.0	2.0
Total present value	TK.m	423	702	585	541

The table indicates that retirement of embankment needs a significant length of new flood embankment (70 to 164 km), and reconstruction of regulations and sluices over a period of 30 years. In the same period the total area of land lost to erosion is 54 km^2, corresponding to about 10% of the GIP area and reconstruction of regulators and sluices for 30 years.

The economic evaluation confirms that present values of construction cost for options 1 and 2 are of the same order and that option 1 is slightly cheaper than option 2 taking into account disbenefit from loss of land due to erosion. Considering the order of cost, social impact mentioned above, and the results of our public consultation, flood control works with river training work is proposed as the best option for Teesta Right Embankment for further studies.

4.4.2 Implementation Methods

Two different methods for implementing the project were analysed. These are:

- a mixture of mechanical and manual methods, in which a significant portion of the overall work would be undertaken by experienced contractors;

- manual methods, in which all appropriate work would be undertaken by labour-intensive methods, utilising Landless Contracting Societies (LCS) in particular.

There are clear advantages and disadvantages with each system. The mechanical/manual system is better from a technical view-point, because it makes possible higher standards of construction and supervision. It is also likely to be somewhat faster. On the other hand it is more expensive and does not create so much employment as the manual system. The manual system also tends to encourage local involvement in project works and should make it easier to involve local people in O&M subsequently. It should be noted that both systems would in fact include a significant portion of mechanical and manual work. There are elements of the project components which would have to be undertaken by mechanical methods, such as construction of groynes and other river training works.On the other hand the mechanical/manual system would also involve a significant proportion of the minor works being undertaken by labour-intensive methods.

Costs for the project have been calculated based on the two different systems. Differences related to construction period, costs of supervision and costs of O&M have also been incorporated. The results show that the base case with manual construction has an IRR of 10% while base case with mechanical/manual methods has an IRR of 7%.

There is a great need to improve experience and quality control in construction. This relates not only to the capabilities of local contractors but especially to the standard of compaction that is obtained on flood control works. The earthwork rate used in cost estimation has been increased significantly from the levels normally applied in BWDB contracts.This should allow for improved compaction methods and better supervision. At the same time, efforts should be made to improve compaction methods: good standards of compaction can be achieved on other types of work such as road-building in Bangladesh using locally available technology (for instance, rollers pulled by agricultural tractors). Where these methods have proved successful,they should be incorporated in manual systems which can be adopted by LCS. The experience of the WFP pilot compaction trials will be useful in this respect.

CHAPTER 5

THE PROJECT

5.1 Project Scope

Following field investigations, the rounds of public consultation, assessment of flooding problems, identification and analysis of solutions, a comprehensive development programme for Gaibandha was conceived. This has the following components:

1.	Structural Measures	-	major controlled flooding and drainage works including river training, sealing of TRE (and BRE), improvement of the Ghagot/Alai Nadi/Brahmaputra confluence.
		-	compartmentalisation and other small-scale CFD works
2.	Flood Proofing	-	on the chars and unprotected areas
		-	within the project area
3.	Associated Development	-	fisheries improvements
		-	navigation development
		-	public health

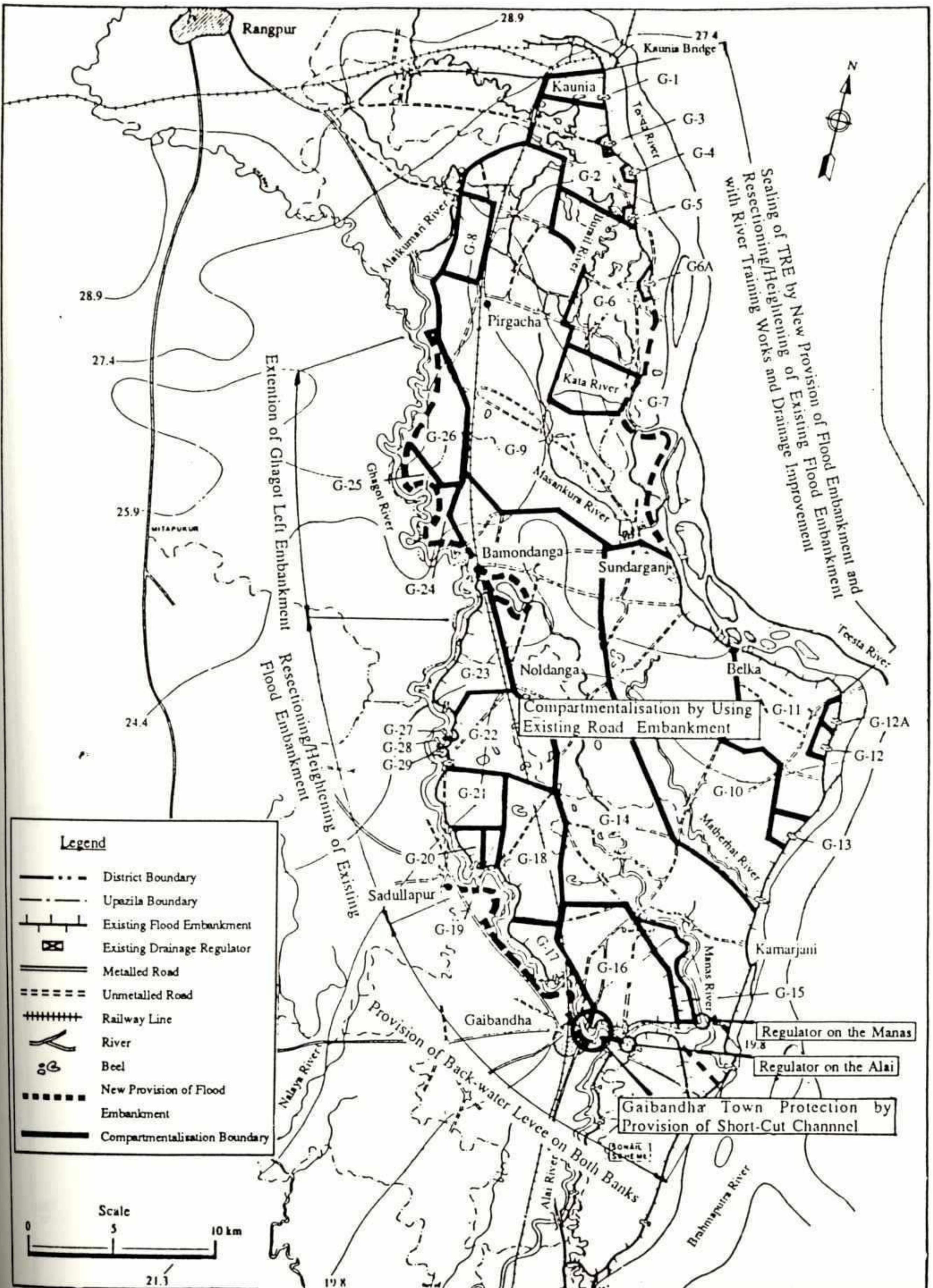
These components are discussed in the following sections.

Those carried forward for economic analysis comprise the structural measures only, with costs, benefits and dis-benefits accounted for as fully as possible. Flood proofing and associated development, many components of which have important social elements, should be considered an integrated part of the project package: however their formulation and appraisal should be considered as distinct from the project's structural measures.

5.2 Structural Measures

The project plan for the Gaibandha Improvement Project is composed of construction of flood embankments, river training works, channel excavation, construction of drainage structures for the GIP area including upstream reaches of the TRE from Kaunia to Teesta barrage and compartmentalisation of drainage areas. These components have been selected following the analysis of options described in the previous chapter to give the optimum configuration from the point of view of function, structure type and cost in order to achieve the objective of the plan. The components for the selected option are described below and illustrated in Figure 5.1

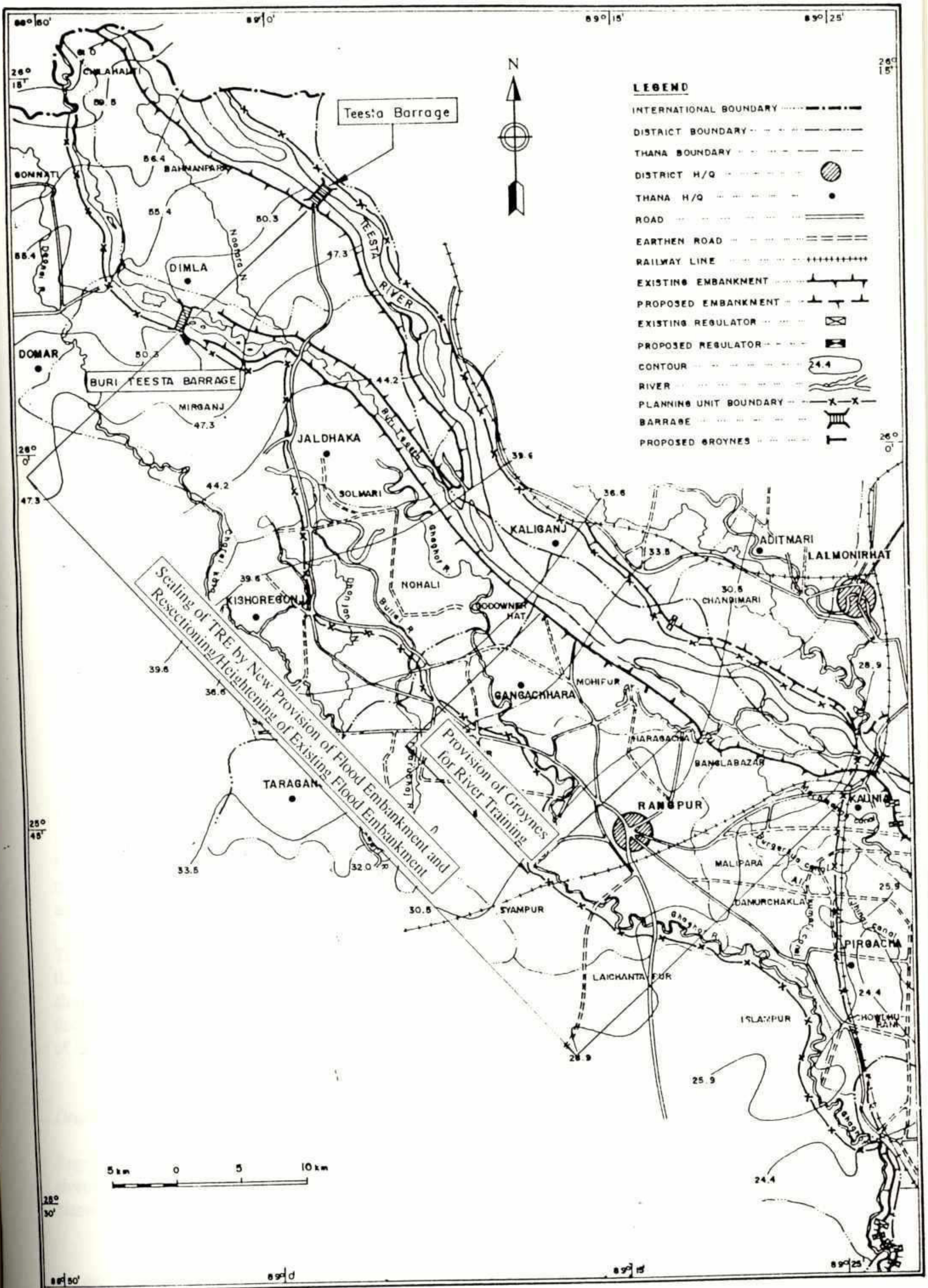
Figure 5.1
The Project Plan



Source NWRS

Figure 5.1 (2)

The Project Plan (Upstream TRE)



5.2.1 Major Works

River Training Works

Revetment and groynes are planned for river training works at the river stretches where severe bank erosion is expected. These works are planned for the Teesta river only based on a study of river conditions such as flood discharge, velocity, sedimentation, existing river training works and bank damage.

32 groynes are planned, with a total length of 5400 linear metres.

Flood Embankments

Flood embankment works are planned for the right bank of the Teesta river and the left and right banks of the Ghagot river. The total bank stretches are 105.9 km and 108.6 km for the Teesta river and the Ghagot river respectively. The stretches are divided into three work items, that is, provision of new flood embankment, resectioning/heightening of existing flood embankment and resectioning/heightening of existing road embankment. Existing flood or road embankments are fully utilized in the plan to lower the construction cost.

Of the embankments for the Ghagot, a stretch of 32.7 km on the right bank from the river mouth to Sadullapur functions as a backwater levee to cope with the backwater from the Brahmaputra river.

Project costs are also allowed for the strategic retirement of the BRE as required.

Major Drainage Structures and Channel Excavation

Major regulators are planned at the confluence of the Manas and the Ghagot, and at the offtake of the Alai as shown in Figure 5.2. The latter will have the effect of diverting the Ghagot flows to the Brahmaputra, once the existing Manas regulator has been eroded away.

New channel excavation is planned near the existing Manas regulator site and at Gaibandha town. The former is planned as an alternative channel for the existing Ghagot-Manas river to release water to the Brahmaputra, because it is foreseen that the existing Manas regulator will not only fail to function normally but constrain the outfall because of deterioration due to flood damage. The latter is planned as a shortcut channel to protect the town area of Gaibandha from flood from the Ghagot.

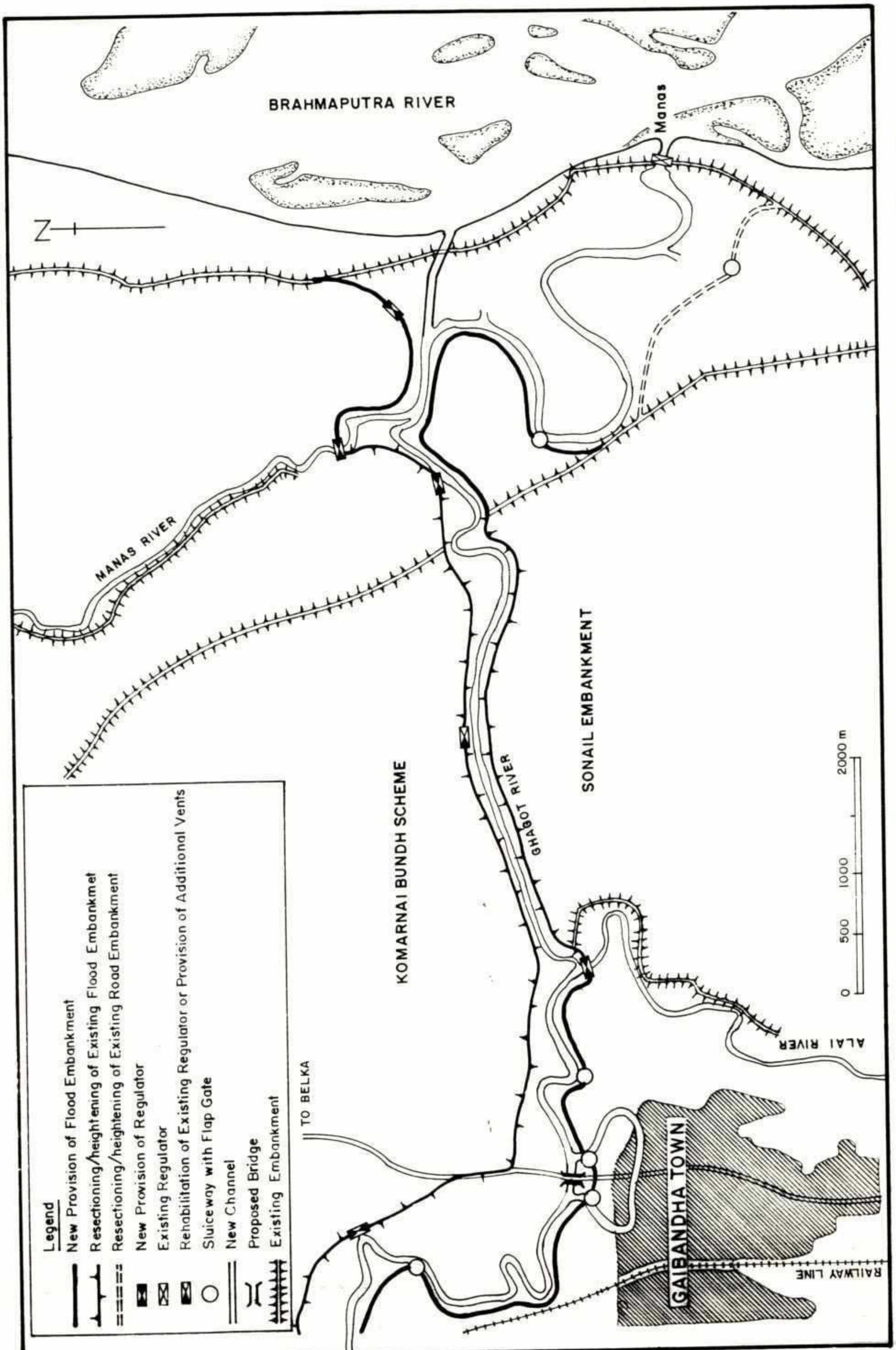
The new channel at the mouth of the Ghagot has a length of 1.2 km from downstream of the confluence the Brahmaputra. The channel is planned as a trapezoidal section with a bed width of 40 m and a side slope of 1:1. The shortcut channel at Gaibandha is planned at the site around 0.5 km distant from the north edge of town area. It has a stretch length of 0.5 km and trapezoidal section with the bed width of 30 m and the side slope of 1:1.

Drainage Structures

Regulators and sluices was are planned through flood embankments to drain out internal water to outer rivers. One regulator is planned at the most downstream portion of each sub-basin and sluice ways are planned together with side drains along embankments to drain out locally enclosed water to outer

Figure 5.2

River Layout at Ghagot Brahmaputra Confluence



rivers. Sluice ways are planned on the existing canals and also through compartment banks to secure the existing water use system. The natural drainage channels in the project area are blocked up in many places by rural road embankments. To restore the natural drainage function, drain pipes are installed at 450 points in the project area.

5.2.2 Small-Scale Works

Compartmentalization

The whole drainage area is divided into 26 sub-basins by compartment boundaries such as road embankments in order to control the concentration of rainwater and to alleviate the inundation damage in low lands. Compartmentalization is planned to fully utilize existing road banks with a significant height comparing with the design internal water level and it will be actually completed by sealing 7 existing openings such as a bridge and a culvert and providing new embankments of 6.3 km in total length. On the other hand 5 new sluice ways with control gates are provided to secure the waterway for water use during the dry season.

Other Works

Other small-scale works include the resectioning/heightering of the Ghaghot left embankment and its extension from km 43 to km 75. The proposed alignment follows existing village roads.

5.3 Flood Proofing

5.3.1 Introduction

Flood proofing conceptually includes any management measure involving no new physical structures (or only minor structural work) that will avoid or significantly reduce flood damage and adverse impacts on the productive activities of an individual household, community or private enterprise. It should, at the same time, ensure that others are not subjected to increased levels of damage by such a measure or, if so exposed, receive acceptable compensation. Thirty eight separate flood proofing measures were originally identified by FAP 23.

In the <u>unprotected areas</u>, major structural measures are not technically feasible and therefore the emphasis will be on flood proofing. Possible measures in these areas include:

- development of multi-purpose flood shelters on chars. This measure is seen as a priority and examples already exist of such shelters being built with a high degree of community involvement and support of local NGOs;

- flood proofing of public buildings, e.g. raised ground for schools and health centres;

- flood warning and evacuation systems.

- rehabilitation packages, e.g. for post-flood rehabilitation of farmers through provision of seeds, support for house reconstruction, etc.

It is necessary to concentrate flood proofing in the unprotected area, since this is the area of greatest need. There are numbers of different categories of communities in the unprotected area such as:

- those living on the river chars

- those living in between the flood embankment and the river bank (i.e. within the set-back distance of 1 km for TRE and 0.8 km for BRE)

- those living on the embankment (there are mostly refugees from the riverside and are therefore a consequence of lack of protection).

In the protected areas, structural measures undertaken by the project will reduce the impact of flooding, but flood proofing measures are needed to cope with effects of above-design events or structural failures. Such measures could include:

- flood proofing of public buildings;
- flood warning system;
- embankment surveillance;

In GIP, flood protection facilities are designed to protect project area from floods upto a specific flood event i.e., BRE 1 in 100 year river flood, TRE and Ghagot 1 in 20 year flood. For communities living inside the protected area, the flood proofing measures will be required depending on the design condition and the reliability of the protection offered. For flood protected areas inland, the requirement is to flood proof basic facilities from more extreme floods or from catastrophic failure of the protection facilities.

It should be noted that some of these measures (and others that could be identified such as post-monsoon reconstruction programmes) either already exist to some extent (e.g. rehabilitation schemes for farmers) and /or are likely to be implemented as part of national-level programmes.

5.3.2 Institutional Issues

The most significant factors to be addressed in relation to flood proofing are institutional. The quantities and costs of desirable measures can be easily calculated. Potentially very high costs and quantities are involved so that the flood proofing programme would be significant on a national scale and would need active government involvement and support. Moreover individuals benefiting from the programme must be fully involved. Mechanisms must be established which allow local and individual control over resources provided through government. Some experience has been gained in Bangladesh on such mechanisms and it seems clear that NGOs will have an important role to play.

In any case flood proofing and survival strategies as collective endeavour appears to be strongest where leadership and organisational inputs are provided by NGOs. On the chars and embankments around the confluence of the Teesta and Brahmaputra the Rangpur Dinajpur Rural Service (RDRS) have built high earthen platforms as part of their general development works. Inputs on leadership and group organisations are provided and the community builds platforms on a cash for works basis. The platform contains tubewells, a school and vegetable gardens. The group maintain the platform voluntarily as their contribution to the project. In the south around Gaibandha town there appear to be fewer NGOs involved in vulnerability reduction although one, Gono Unnayan Kendra (GOK), has done good flood relief and rehabilitation work with funds from Oxfam. On the TRE, the Bangladesh Rural Advancement Committee (BRAC) and the Grameen Bank are working. Other important NGOs like Service Civil International (SCI) and Mennonite Central Committee (MCC) were involved in a flood proofing project situated in Bhuapur Thana on a number of chars outside the Brahmaputra Left Embankment (BLE). As a part of an integrated development programme in the region SCI built a number of high elevated platforms to protect communities after the 1988 flood.

5.3.3 Flood Proofing Measures for the Gaibandha Project

Measures on the Chars and Unprotected Lands

High elevated earthen platforms with facilities for housing, drinking water, sanitation, etc. are required. It is proposed that 100 families are accommodated per shelter area (1,500 sqm) within the setback distance of BRE and TRE. Land acquisition cost will be relatively less compared to inside area, however the countryside location would be preferred for security reasons if the shelter can be constructed within the reservation width of the embankment. i.e. land already appropriated by BWDB.

- outside BRE (22 km) : 10 nos.
- outside TRE (24 km) : 12 nos.

Measures on the Main Embankments

Flood affected communities have been living on the existing main river embankments for the last few years. Improvement are required to reduce the distress suffered by these displaced populations. This can include flood proofing measure, as well as reviewing the policy of forbiding human habitation on flood control embankments and modifying the standard design section accordingly.

As ascertained through the surveys undertaken and the rounds of public participation in the GIP area, it is most important to provide the following facilities:

- installing about 100 nos tubewells for drinking water supplies along the 46 km of BRE, TRE and nearby chars (position to be selected depending on population density).

- arranging for the provision of about 500 nos sanitary latrines in the same location mentioned above, (one for three families).

This development should be designed to encourage the refugees to live a short distance away from the main embankments. Most of the people living on the BRE/TRE are landless and consequently seldom have any alternative land on which to live even when flood water recede. A offset platform will provide a possible solution, however it might attract more landless, either to the platforms or to the embankment locations vacated by those transferred to the platforms. The whole concept of providing a flood proofing assistance programme for those currently living on the BRE/TRE needs to be undertaken in close co-operation with BWDB, since major policy issues are involved.

Improved Road Communication

Heightening of existing village roads above flood level outside the GIP is require for transport of flood affected people, livestock etc. from surrounding flooded areas. For the communities within the protected area, compartment boundaries are considered adequate for basic flood proofing.

Heightening of roads (outside BRE and TRE)

- outside BRE : 5 km; average height 1.5 m
- outside TRE : 7 km; average height 1.0 m

Construction of Relief Centres

Construction of new two-storied buildings, extending existing primary school buildings or the construction of single storied food storage godown buildings will serve as emergency relief centre. These multi purpose buildings can be used for education, community development centre, medical treatment etc.

Food storage godown (in & outside GIP, 150 sqm)	:	3 nos.

The siting of the structures should be in a protected location but near an affected area. One is recommended at Bholanathhat under Sundarganj thana and others are proposed in Haripur (confluence of Teesta & Brahmaputra) and Dhariapur (southern part of GIP).

The Structural Programme

The costs and scope of a programme to serve all the flood-prone population in the Gaibandha area would be enormous. As discussed in the Regional Plan Final Report it is estimated that some 100 000 people live on the chars and unprotected area and a further 70000 along the embankment. This would require about 170 shelters on the unprotected areas and around 500 tubewells and 3000 latrines along the embankment. The cost of this alone would be of the order of Tk.75 million, without any allowance for improved road communication and relief centres.

As a pilot trial it is therefore proposed that an initial sum of Tk.10 million be allocated. This would be primarily allocated for the construction of 20 shelters on the unprotected lands (Tk. 8 millions) together with 3 relief centres within the project area but close by (Tk. 1 million) and some water and sanitation provision on the main embankments (Tk. 1 million).

Non-structural measures

The following non-structural measures are also effective for flood proofing in and outside the GIP area:

- security patrols at communities concerned with flooding;
- promotion of flood proofed buildings for public buildings such as schools, hospitals, etc. at the downstream end of internal rivers where deep inaundation water usually covers, especially the Manas, and areas outsite the TRE and BRE;
- stockpiling of foods and fuel for emergency and seed and nursery beds and other farmer recovery aids in the areas along the TRE and BRE;
- establishment of embankment surveilance groups along the Ghagot, Teesta and Brahmaputra;
- establishment of flood communication, flood forecasting, warning and evacuation sytems covering the GIP and outside areas;
- land use regulations based on flood hazard zoning and education to increase awareness of flooding risk.

The measures discussed need consultation and support at each government level from institutional, organizational and financial aspects so as to ensure their effective implementation. Therefore, the actions should be carried out on a regional or national scale.

5.4 Associated Development

5.4.1 Fisheries

The following possible measures are specific to the project. Measures appropriate to the whole region are discussed in the Fisheries Report, Volume 12 of the Draft Final Report.

Preservation and Improvement of Khas Water Bodies

It is proposed that funding should be included under the provision for mitigatory measures, for the improvement of Kachuadha, Bamandanga, Maruadha, Satrail and Hurudanga beels and a perennial section of the Matherhat Canal, all of which are located inside the GIP perimeter (Figure 5.3).

Improvement should take the form of the excavation of silted up areas around the edges of the beels, using the spoil to raise bunds within which the area and depth of permanent water can be increased, thereby expanding productivity and the numbers of fishermen who can be supported by these fisheries. The work should be jointly supervised by local BWDB and DOF officers and NGO assistance should be sought to help organise the fishermen into groups or associations. The cost of supplementary stocking, after completion of the physical works, should also be included.

Cost are estimated as follows:

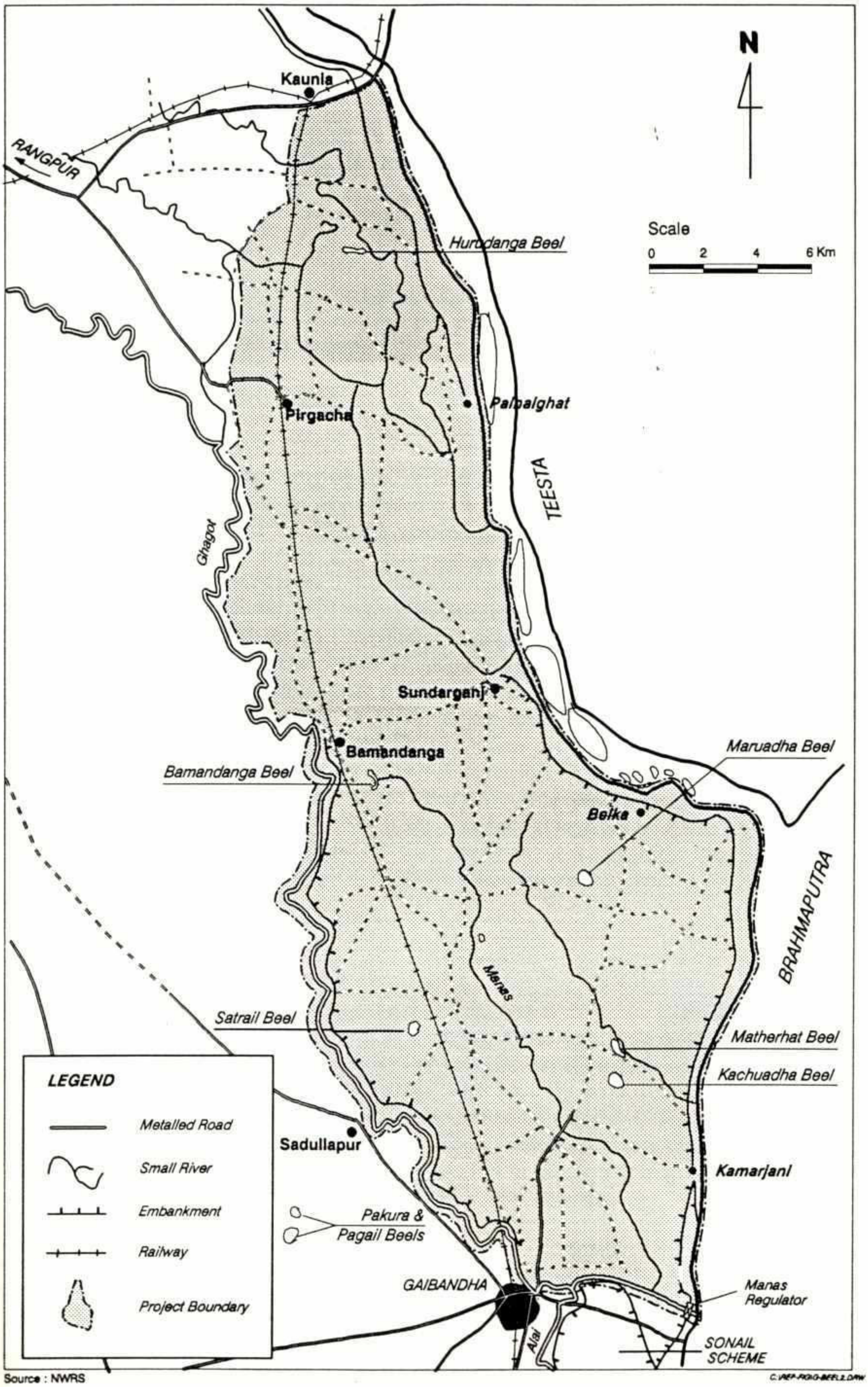
-	excavation and construction of about 25 km of low bunds around the beels, 200,000 cu.m. @ Tk. 46	Tk.	9,200,000
-	fish stocking, 65 ha x 5000/ha @ Tk. 600 per 1000 fingerlings	Tk.	200,000
-	travel, supervision & misc. @ 15%	Tk.	1,400,000
	Total:	Tk.	10,800,000

The investment would generate additional fish production from the beels totalling about 80 mt. per year, worth at least Tk. 3.2 million to the fishermen and providing employment opportunities for at least 60 additional fishermen.

Development of Borrow-pit Fisheries

In the course of constructing embankments, roads and other facilities, a very large area and number of borrow-pits have been dug with little or no though given to their possible productive use afterwards. It costs no more to plan the shape and depth of the borrow-pit and ensure compliance by the contractors, than it does to allow them to leave the area as an unusable derelict wasteland. In parts of the GIP area the ground is too porous and borrow-pits too shallow to hold water long enough to produce a fish crop, but the district fishery officer estimates there are at least 200 ha of potentially productive old borrow-pits within GIP.

Figure 5.3
Beel Improvements



Source : NWRS

It is proposed that these areas should be excavated under similar administrative arrangements as above, stocked and allocated to the use of NFMP fishermen's groups, again with appropriate NGO assistance. Initially a pilot trial of 20 ha should be undertaken.

Costs are estimated as follows:

-	excavation of 20 ha @ Tk. 5 lakhs/ha		Tk. 10,000,000
-	stocking @ 5000/ha; Tk.600/1000		Tk. 600,000
-	travel, supervision & misc. @ 15%		Tk. 1 600,000
		Total:	Tk. 12,200,000

On the assumption that these areas currently produce little or no fish, the investment could generate additional production of about 160 mt. fish per year, worth Tk. 6.4 million to the fishermen and provide work for at least 200 fishermen.

Modified FCD Structures

Designs for modifying or rebuilding sluices, regulators and other FCD structures so as to permit two way traffic by fish stocks, without jeopardising the protective function of the flood control structure, are still being studied by FAP 17. Possible modification methods might be a fish ladder with small gates as a cheaper solution, provision of additional gates and concrete works for a regulator which needs higher cost, and so on. Figure 5.4 shows a conceptual design for modification of regulators by means of provision of additional gates to migrate fish fry and mature fish, during the breeding period and monsoon season, in which option 1 provides double leaf gates for regulator to generate free surface flow but small amount of discharge, while in option 2, river and country side gates are operated as indicated in the figure; namely one is open and the other is closed with an appropriate time cycle. The required cost for modification is about Tk 1,300,000 per regulator for both options including physical contingency and engineering services, and Tk 17 million correspond to 1% of the project cost is required for modifying the existing and proposed regulators in the comparatively expensive case. Monitored pilot trials are required of perhaps several possible designs including such modifications, to determine their effectiveness. Until such trials have been completed by FAP17 it is not considered sensible to make any specific proposals for GIP. However, it is suggested that token provision be included in GIP estimates so that the position can be kept under review pending FAP 17 reaching some conclusions.

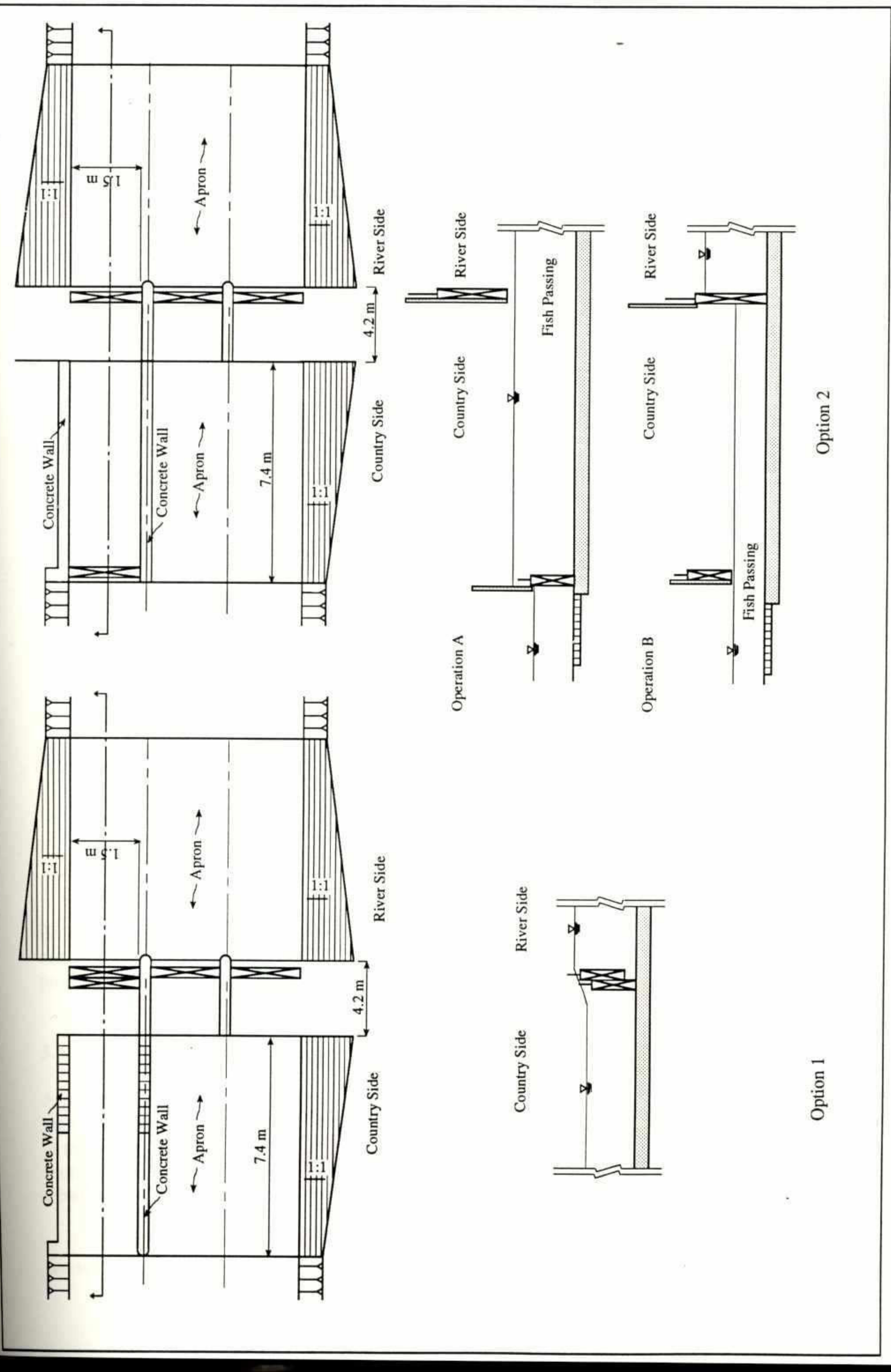
Enhancement of Capture Fish Resources

It has already been proposed that provision be included for restocking certain beels and borrow-pits. Third Fisheries Project (TFP) is likely to extend its beel restocking programme into Gaibandha District and several other beels in the area have already been partially improved with FFW assistance in readiness. Bearing in mind that GIP is likely to have external impacts as well as impacts on internal fisheries, it is proposed that GIP provision should also include funding for supplementary stocking in floodland areas in the eastern part of Sadullapur thana and in Shaghata thana, which could suffer from the effects of embanking the Ghagot right bank and the Alai regulator.

For these reasons it is proposed that Pakuria and Pagail beels in Sadullapur, and Telian Beel and Bill Basta Beel in Saghata should also be restocked. Ideally the restocking programme should include enhancement of fish stocks in the Ghagot River itself but the technology for doing this effectively has

Figure 5.4

Possible Fish Pass Structures



still to be established. This is a further matter on which FAP 17 should produce useful advice in due course, so in the meantime only token provision is proposed.

Costs are estimated as follows:

-	Restocking Pakuria, Pagail, Telian and Bill Basta Beel, 162 ha x 5000 x 600		Tk. 500,000
-	travel, supervision, etc.		Tk. 75,000
		Total :	Tk. 575,000

The project should generate an extra 32 mt. fish worth Tk. 11.3 million to the fishermen and possibly provide an additional 20 jobs for fishermen.

Fish Farming Opportunities

Increased protection from flooding, whether from river water or from rainfall congestion and thus a reduction in the risk of ponds being overtopped and fish swept away by flood water, creates the opportunity to restock any ponds that are in suitable condition, and to rehabilitate others that have fallen into disuse and become derelict. However, experience from other projects (as described in FAP 12 reports) shows that the response has often been disappointing mainly because of DOF's inability to field the necessary extension effort to give pond owners the right advice and the general lack of access to low cost rural credit to cover the costs of pond rehabilitation or new pond construction.

A further problem in GIP is high soil porosity, particularly in the southern half, and the consequent need to dig very deeply for year-round water which adds greatly to costs. Conditions are more favourable in the northern half of GIP, and it is here that efforts should concentrate in the earlier years. The project could provide some support, eg transport for extension workers and for their training as and when needed, at the new Parbatipur aquaculture centre.

Costs are estimated as follows:

-	Transport & training of field staff		Tk. 400,000
-	200 bicycles @ Tk. 5000		Tk. 100,000
		Total :	Tk. 500,000

Benefits of extension efforts are difficult to quantity but if the average yield of existing cultured ponds can be increased by 18-20% and half of the derelict ponds can be made productive again, they could produce at least 80 mt. p.a. more than now, worth Tk. 4 million to the pond owners.

5.4.2 Navigation

A preliminary study was carried out of improving inland water transport in the GIP area during the monsoon season. This would be done by building a navigation lock at each of the regulator sites located at the downstream end of the Masankura, Matherhat and Manas rivers, which are possible navigation routes. In addition, the river channels to be used for navigation purpose will have to be excavated over a bed width of 10 m at least to cope with silting problem which will also hamper the smooth navigation planned in order to secure the sectional area of channel for navigation of the boat. The channel stretches to be excavated are as follows:

-	Masankura to Pirgacha	:	15.0 km
-	Matherhat to Sundarganj	:	31.8 km
-	Manas to Bamondanga	:	37.2 km

The total of the excavated volume in these channels amounts to approximately 1.68 million m^3.

The approximate cost for the structures and dredging is Tk. 152.5 million including 25% contingencies, and engineering and supervision costs.

Preliminary calculations of the returns to such investments were described in the Volume 5 of the Draft Final Report. These suggest that further detailed study of navigation potential might be justified. The calculations were made considering only two commodities, jute and rice, although these are the most important bulk exports out of the area. However, increased trade out of the area can be expected to stimulate trade into the area, so that potential sources of cargo could be increased. In terms of the volumes of paddy and jute requiring to be shipped, it is not clear that they will be reached. The paddy volume is not large in relation to the total paddy area, but Gaibandha is not a major paddy exporter. Most jute is exported out of the area, but at present much of the jute is carried by truck.

It was concluded that the scope of any navigation improvement requires more detailed work. The works costed in the preliminary analysis may not all be necessary, and the navigation concept could be changed, e.g. transhipment points could be created at the site of the regulators so that small boats could still operate inside them. Apart from the potential for economic benefits, there are also significant potential gains in terms of local income and employment. It was therefore proposed that the scope for navigation should be explored in detail in the next phase of project preparation. For the interim, a figure of Tk 150 million was included in the associated project costs for navigation improvement.

The draft final report contains details of the results of the preliminary analysis.

5.4.3 Health

The environmental survey of the project area (Section 7. 2) identified significant water-related health problems, which would be impacted by the project works. At the present there is insufficient data to allow detailed mitigation measures to be proposed. It is therefore recommended that the associated project costs should include a notional amount for study, design and implementation of any necessary health measures.

5.5 Project Costs

The project cost for structural works within the GIP area is estimated at the feasibility study level but it is noted that the costs for sealing of upstream TRE and the proposed associated development projects are still at the preliminary study level. Therefore, further studies including investigations and surveys are needed in the next stage to establish the definitive plan for these components and for updating the cost estimated at this stage.

The project costs for structural measures estimated at September 1992 prices are summarized in Tables 5.1. These costs are based on the manual construction method for earth works. Details are given in volume 6 of the Draft Final Report.

Table 5.1 Project Cost - Structural Works (Tk. '000)

Cost Items	Foreign Currency	Local Currency	Total
1. Major Works			
Construction Cost	305,153	745,399	1,050,552
Administration Cost	0	31,516	31,516
Physical Contingency	57,373	141,081	198,454
Engineering Supervision	43,502	106,944	150,446
Land Acquisition	0	98,219	98,219
Sub-Total	406028	1,123,159	1,529,187
2. Minor Works			
Construction Cost	24,962	68,286	93,248
Administration Cost	0	2,798	2,798
Physical Contingency	3,744	10,243	13,987
Engineering Supervision	2,871	7,853	10,724
Land Acquisition	0	20,136	20,136
Sub-Total	31,577	109,316	140,893
3. Total Project Cost			
Construction Cost	33,0115	813,658	1,143,800
Administration Cost	0	34,314	34,314
Physical Contingency	6,1117	151,324	212,441
Engineering Supervision	46,373	114,797	161,170
Land Acquisition	0	118,355	118,355
Total	437,605	1,2,32,475	1,670,080

Costs for flood profing and associated development are given in Table 5.2.

Table 5.2 Project Cost - Flood Proofing and Associated Development (Tk. '000)

	Description	Project Cost
1.	Flood proofing	10 000
2.	Preservation and improvement of Khas water bodies	10 800
	Development of borrow-pit fisheries	12 200
	Modifications to structures	10 500
	Enhancement of capture fisheries	575
	Fish farming opportunities	500
	Round Total, Fisheries	35 000
3.	Navigation	150 000
	Total Associated Development	195 000

It is noted that these are preliminary estimates of costs in order to get an indication of the order of magnitude of the sums involved. Further work would be needed at the planning and detailed design stage to refine the estimates. Also the cost for non-structural flood proofing measures are not included in the above table.

5.6 Implementation Schedule

The implementation schedule for the structural works is based on phasing of the works. The first phase will include the major works required to prevent spilling from the Teesta, which will also reduce flooding risk from the Ghagot. These are the main sources of flooding and provide the greatest part of the benefits. The second phase will mitigate the drainage congestion at the lower part of the Ghagot caused by the insufficient flow capacity of the Alai and insufficient discharge capacity of the existing Manas regulator which is being eroded and expected to be washed away within a few years. This work will also provide great benefit to the lower part of the Ghagot and Manas. In regard to the second phase, it is necesssary to observe the erosion situation of the Manas regulator and to integrate the FAP2 and FAP 21/22 Proposals (FAP21/22 selected the Manas regulator site as a pilot project for bank protection works). Internal works, whilst an important part of the project, provide a smaller part of the benefits and clearly need further data accumulation and studies (especially on the hydraulic modelling with/without sealing Teesta and on social impacts through further rounds of public participation) before detailed design and implementation can take place.

Additional reasons for phasing include the intention of smoothing the annual disbursement of funds as much as possible, and aiming to ensure that parts of the works being undertaken do not worsen flooding conditions elsewhere.

The proposed programme is shown in Figure 5.5. Works in the first phase are concentrated on the sealing of the Teesta, since this will have the greatest benefits both for the project, and for the region. Phase 2 consists of construction of the backwater embankment at the downstream end of the Ghaghot. Phase 3 consists of the extension of the Ghaghot left embankment upstream and the compartmentalisation works.

It should be noted that the phasing allows a considerable period of pre-construction activities. Construction work on the Teesta is expected to begin after two years, and on compartmentalisation after eight. There is thus sufficient time available for further investigations, the formation of the Project Management Unit (see Section 8.1), the establishment of LCSs, monitoring and modelling of compartmentalisation. The design of compartmentalisation in particular must wait unit the impacts of Teesta sealing becomes known.

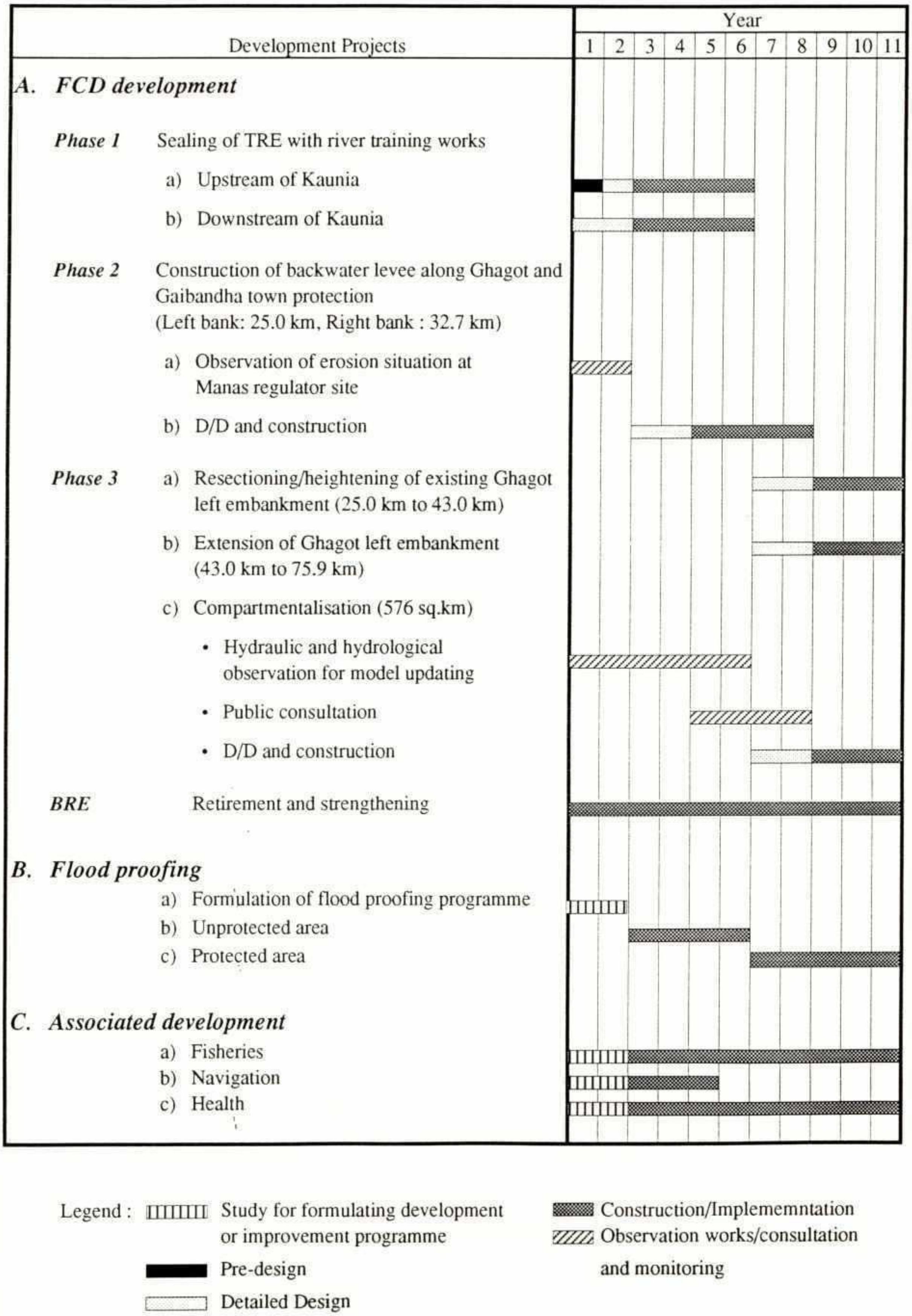
Table 5.3 shows the phasing of costs for the structural works.

Table 5.3 Project Financing Schedule - Structural Works

(Tk million)

Year	Foreign	Local	Total
1	12.06	29.61	41.67
2	12.06	42.37	54.43
3	59.85	158.27	218.13
4	115.32	284.52	399.84
5	133.83	336.33	470.16
6	56.28	174.18	230.45
7	13.99	77.35	91.34
8	5.52	30.03	35.55
9	11.88	29.81	41.69
10	18.41	41.93	60.34
11	8.37	18.12	26.49
Total	447.56	1222.52	1670.08
$mn	12.43	33.96	46.39

Figure 5.5
Implementation Schedule



Flood proofing work and associated development projects of fisheries, navigation and health are planned to be implemented in parallel with the FCD works during the project implementation period as shown in Figure 5.5. Further analyses and studies are recommended to formulate definitive development or improvement programmes before implementation. Table 5.4 shows an indicative disbursement schedule for the associated development.

Table 5.4 Project Financing Schedule - Associated Development

(Tk. million)

Year	Fisheries	Navigation	Flood Proofing	Total
1	3.2	30	0.9	34.1
2	3.2	30	0.9	34.1
3	3.2	30	0.9	34.1
4	3.2	30	0.9	34.1
5	3.2	30	0.9	34.1
6	3.2		0.9	34.1
7	3.2		0.9	34.1
8	3.2		0.9	34.1
9	3.2		0.9	34.1
10	3.2		0.9	34.1
11	3.2		0.9	34.1
Total	35	150	10	195

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CHAPTER 6

ECONOMIC ANALYSIS

Economic analysis was used both to assess the viability of the selected option and, at an earlier stage, to assist in the choice between options. Sensitivity analyses to test specific alternatives within the selected option were also carried out. Some partial analyses were conducted, for example to assess the viability of measures to assist navigation development.

This chapter reports briefly on the methodology used for analysis (which is discussed in greater detail both in the Regional Plan Main Report (Volume 1) and the Economics Annex (Volume 13) of the Draft Final Report), and then reports and discusses the main results of analysis.

6.1 Methodology

The approach to analysis has closely followed the recommendations in the FAP Guidelines for Project Assessment. The main addition to those recommendations has been the use of a scarcity premium in the economic valuation of fish output: this has been one area of analysis where it has been possible to extend the conventional cost-benefit approach to take account of long-term processes. In most other respects such an extended cost-benefit approach has not proved possible, but a multi-criteria analysis has been carried out to integrate the economic analysis and other impacts which could not be valued.

The main components which have been included in the economic analysis are:

A. Project costs
- construction and O & M costs
- economic cost of land acquisition
- costs of embankment retirement along the Brahmaputra

B. Project benefits/disbenefits
- crop intensification benefits
- benefits/disbenefits for fisheries
- benefits of reduced crop and non-crop flood damage
- benefits from avoidance of erosion losses on the Teesta River

The benefits/disbenefits have, as much as possible, been evaluated both for the impacted area as well as for the project area.

6.2 Benefit Assessment

6.2.1 Estimation of Incremental Crop Production Benefits.

Cropping Patterns

The incremental crop production benefits arise from shifts in cropping patterns due to changing flood levels induced by project developments. The extent of changes in water levels, and how these will affect the selection of cropping patterns, needs to be derived.

Two alternative approaches were undertaken in the analysis to establish the link between changes in water levels and changes in cropping patterns. These approaches are briefly described here.

The first approach (described in detail in the Volume 12, Agriculture, of the Draft Final Report) makes full use of the Gaibandha hydro-dynamic model: selection among the important crops (mostly paddy crops) is determined according to certain rules which effectively set constraints to production based on the depth and timing of floods. The model output is therefore directly utilised to predict cropping patterns in both future-without and future-with conditions.

The second approach is based more on the flood phase system developed by MPO (now WARPO) and on BBS published cropped area statistics. This approach, described in more detail in the Regional Plan Final Report and in Volumes 12 and 13 of the Draft Final Report, only utilises the model indirectly, by using it as a guide to the extent and direction of changes in flood phasing as a result of the project.

Both approaches were used in the period leading up to the Draft Final Report. They generate slightly different results in the analysis, primarily because flood phase analysis suggests a (small) switch of F1 to F0 land, allowing some replacement of local t.aman by HYV t.aman. While both approaches have merit, at present the second (MPO) approach probably gives more reliable results, and was finally used in assessing cropping pattern changes due to the project. Cropping patterns by flood phase for future without and future with are shown in Figure 6.1 and detailed in Table 6.1.

It should be noted that the benefitted area includes the area downstream of the Alai regulator, i.e. immediately south of the project area. Benefits in that area are expected to arise not only from reduced crop damage (discussed below), but also from changes in flood phasing and cropping patterns. The hydro-dynamic model and drainage analysis were used to calculate the changes in flood phasing likely to occur in the area, and cropping pattern changes were then calculated and included in the analysis. Since the southern part of this area lies on the left bank of the Upper Karatoya, care was taken in the model and drainage analysis to distinguish between changes due to upstream developments and those due to the proposed Bangali Floodway development downstream being considered under the regional plan.

Based on the flood phase analysis, the value (in economic prices) of with-project net agricultural returns is Tk. 986 mn (an increase of about Tk. 47 mn over without-project conditions) in the Gaibandha project area, and Tk. 320 mn (an increase of Tk. 41 mn) in the Alai basin. The proportionate increase is therefore larger in the Alai basin.

Input-output data for the economic analysis are unchanged from those used in the regional planning analysis. Prices, yields etc. are generally not very different from those prevailing elsewhere in the region. The main possible source of difference could be wage rates. It is known that Gaibandha is an area of high underemployment and seasonal out-migration where wages are low. The agro-economic survey conducted by NWRS indicates daily wage rates of about Tk 20-30. Nonetheless, the financial wage rate assumed in the regional plan is only Tk 30, i.e. in the upper range of observed wages in Gaibandha, and therefore the assumed financial wage rate for Gaibandha of Tk. 30 is reasonable.

Table 6.2. shows physical input-output data used in the analysis, Table 6.3. shows financial and economic prices of inputs, Table 6.4. shows financial and economic prices of outputs, and Table 6.5. shows per hectare gross and net returns by crop.

Figure 6.1

Cropping Diagrams

TABLE 6.1(a) FUTURE WITHOUT CROPPING PATTERNS BASED ON FLOOD PHASE ANALYSIS

LAND TYPE	AMOUNT(HA)
F0	15230
F1	25056
TOTAL	40287
F2	5404
F3	2948
TOTAL	8352
F4	491
GTOYAL	49130

IRRIGATION BALANCE	
HYV BORO	20143
WHEAT	0
HYV AUS	0
TOTAL	20143

DISTRIBUTION OF LAND BY IRRIGATION STATUS BY FLOOD PHASE

LAND TYPE	IRRIGATE AREA	NONIRRI AREA	TOTAL AREA	% IRRIG
F0	3415	11815	15230	22
F1	10022	15034	25056	40
TOTAL	13437	26849	40286	33
F2	4053	1351	5404	75
F3	2653	295	2948	90
TOTAL	6706	1646	8352	80
F4			491	
TOTAL	20143	28987	49130	41

CROPS ON F0+F1

RABI SEASON		AUS SEASON		AMAN SEASON		ANNUAL CROPS	
HYV BORO	13437	B. AUS	716	HYV TAMAN	19468	SUGARCAN	223
WHEAT	3009	HYV AUS	0	L.T. AMAN	21396	ORCHARDS	22
POTATO	55	JUTE	9000	VEGETABLES	100		
TOBACCO	442	OILSEEED	0	SPICES	0		
PULSES	1766	SPICES	0				
OILSEED	0	VEGETAB	232				
SPICES	0						
VEGETABLES	322						
Sub-Total	19031	Sub-Total	9948	Sub-Total	40964	Sub-Total	245
Total	70188						
CROPPING INTENSITY	174						

CROPS ON F2 LANDS	
HYV BORO	4053
DW AMAN	0
AUS	1169
WHEAT	1351
OILSEED	200
PULSES	118
JUTE	182
L.BORO	0
Total	7073
CROPPING INTENSITY	131

CROPS ON F3 LAND	
HYV BORO	2653
LOCAL BORO	0
D.W.AMAN	242
OILSEED	548
Total	3443
CROPPING INTENSITY	117

TOTAL CROPPING INTENSITY 164%

TABLE 6.1(B) FUTURE WITH CROPPING PATTERNS BASED ON FLOOD PHASE ANALYSIS

LAND TYPE	AMOUNT(HA)		IRRIGATION BALANCE	
F0	19652		HYV BORO	20143
F1	23091		WHEAT	0
TOTAL	42743		HYV AUS	0
F2	3439			
F3	2457	49130	TOTAL	20143
TOTAL	5896			
F4	491			
GTOYAL	49130			

DISTRIBUTION OF LAND BY IRRIGATION STATUS BY FLOOD PHASE

LAND TYPE	IRRIGAT AREA	NONIRRIGA AREA	TOTAL AREA	% IRRIG
F0	6116	13536	19652	31
F1	9236	13855	23091	40
TOTAL	15353	27390	42743	36
F2	2579	860	3439	75
F3	2211	246	2457	90
TOTAL	4791	1105	5896	81
F4			491	
TOTAL	20143	28987	49130	41

CROPS ON F0+F1

RABI SEASON		AUS SEASON		AMAN SEASON		ANNUAL CROPS	
HYV BORO	15353	B. AUS	1025	HYV TAMAN	23552	SUGARCANE	223
WHEAT	3991	HYV AUS	0	L.T. AMAN	19718	ORCHARDS	22
POTATO	55	JUTE	9000	VEGETABLE	100		
TOBACCO	442	OILSEEED	0	SPICES	0		
PULSES	1884	SPICES	0				
OILSEED	0	VEGETABLE	232				
SPICES	0						
VEGETABLES	322						
Sub-Total	22047	Sub-Total	10257	Sub-Total	43370	Sub-Total	245
Total	75919						
CROPPING INTENSIT	178						

HYV BORO	2579
DW AMAN	0
AUS	860
WHEAT	860
OILSEED	300
PULSES	0
JUTE	182
L.BORO	0
Total	4781
CROPPING INTENSIT	139

CROPS ON F3 LAND

HYV BORO	2211
LOCAL BORO	0
D.W.AMAN	242
OILSEED	448
Total	2901
CROPPING INTENSIT	118

TOTAL CROPPING INTENSITY 170%

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Table 6.2 Physical Input Quantities per hectare, NW Region.
Future Condition

Present Crop	Labour (man days)	Draft Animal (pair days)	Fertiliser						Production (kg/ha)		(mt/ha)
			Seed (kg)	Urea (kg)	TSP (kg)	MP (kg)	Manure (kg)	Pesticide (kg)	Main Crop		By-Product
HYV Boro	215	50	30	210	139	46	0	0.5	5.175		5.175
Local Boro	160	40	30	63	42	14	0	0	2.625		2.625
HYV Aus	205	50	30	149	103	34	0	0.5	4.3125		4.3125
Local B.Aus	160	45	80	55	0	0	1300	0	1.68		1.68
HYV T.Aman	190	50	30	149	103	34	0	0.5	4.3125		4.3125
Local T.Ama	140	44	30	49	33	11	1300	0	2.3625		2.3625
DW Aman	115	45	30	55	0	0	660	0	1.68		2.52
Wheat	120	40	140	80	26	0	0	0.25	1.785		1.785
Jute	230	48	7	64	21	16	0	0	1.785		3.57
Sugarcane I	260	65	5000	187	75	112	1400	0.75	44.1		
Sugarcane II	230	65	5000	50	20	30	1400	0	20		
Potato	190	45	1000	79	53	79	1500	0.5	10.5		
Pulse	50	30	30	31	0	0	0	0	0.84		1.05
Oilseeds	75	36	10	79	79	32	700	0.5	0.735		1.05
Onion	150	40	6.2	58	39	58	0	0	8.4		
Vegetable (Brinjal)	270	50	0.3	66	44	66	0	0	15.75		
Tobacco	260	60	0.1	0	26	26	2600	0.5	1.05		
Banana											

Sources:

(1) MPO Technical Report No.14.

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

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

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

(5) Consultants' field survey data.

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

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

Source: NWRS Estimates

Conversion factors from GPA except for revised fertiliser factor

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

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

Source: NWRS Estimates
Conversion factors from GPA

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

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

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

Source: NWRS Estimates

6.2.2 Benefits/Disbenefits for Fisheries

The analysis of fisheries impacts has also followed the approach used and described in the Regional Plan. Productivity rates for different habitat-types have been determined for future-without and future-with project conditions: these are shown in Table 6.6. Prices received by fishermen/pond owners have been used as financial prices; these have been increased in the economic analysis by 25% to account for future scarcity, particularly of capture fisheries species. The areas of floodplain fisheries are determined from the Gaibandha hydro-dynamic model and relevant productivity rates applied to these areas.

An impact analysis was undertaken to compare present condition, "future without" and "future with". The analysis is described in full in volume 12 Fisheries, of the Draft Final Report and summarised here. The results are displayed in Table 6.7 and show that doing nothing will result in a 15% loss of capture fish production from the present condition with no compensatory gain from fish farming. The project results in a 50% reduction in capture fish landings, but this is partly compensated by a 33% increase in farmed fish output. However, the net effect is that the project produces a greater overall loss (12%) compared to 8% in the "Do Nothing" case. In neither case was any allowance made for possible mitigatory action. However, a mitigation and fisheries development plan is described in Section 5.4.

Table 6.6 Fish Catch Rates (Kg/ha)

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

Source: NWRS estimates

Table - 6.7 Impact of Structural Measures on Fisheries

		Area (ha)	Yield (kg/ha)	Production (mt)
1.	Present			
		200	400	80
	Beels (Perennial)	180	180	32
	Beels (Seasonal)	1800	40	72
	Rivers & Canals	3021	70	211
	Fishable Flood Plain	380	850	323
	Ponds C&C	90	180	16
	Ponds D.	30	180	5
	Borrow-pits etc.			
			Total	739
2.	Future With			
		180	250	45
	Beels (Perennial)	--	--	--
	Beels (Seasonal)	1700	20	34
	Rivers & Canals	2188	50	109
	Fishable Flood Plain	450	1000	450
	Ponds C&C	50	50	2
	Ponds D.	50	250	12
	Borrow-pits etc.			
			Total	652
3.	Future Without			
		200	350	70
	Beels (Perennial)	180	150	27
	Beels (Seasonal)	1800	35	63
	Rivers & Canals	3021	60	181
	Fishable Flood Plain	380	850	323
	Ponds C&C	90	150	13
	Ponds D.	30	150	4
	Borrow-pits etc.			
			Total	681

6.2.3 Benefits of Reduced Crop and Non-Crop Damage

The methodology for deriving crop and non-crop damage described in the Regional Plan Final Report and Volume 13 of the Draft Final Report has basically been used for the Gaibandha analysis. In addition to the basic damage avoidance benefits within the project area, there are further damage reduction benefits in the impacted area beyond the project area. These benefits can be attributed to two measures in particular: sealing of the TRE upstream, and closing off the Alai River with a regulator. Damage reduction within the project area is assumed to apply to all damage caused by events upto the 1:20 year return period.

In the impacted area, since this area is not specifically protected against 1:20 year floods by the project, damage reductions have been worked out by comparing with- and without-project inundation areas for 1:5 year and 1:20 year water levels: some of the impacted area with-project becomes protected against 1:5 year floods but not 1:20 year floods, therefore the damage reduction has been calculated as the difference between expected annual damage from floods upto 1:20 and expected annual damage from floods upto 1:5. A smaller part of the impacted area does become protected from all floods upto 1:20.

The total expected annual damage avoided through project works is considerable. The damage estimates are shown in Table 6.8

Table 6.8 Estimated Average Annual Value of Damage in Project and Impacted Area

	(Tk. mm) 1991-1992 Financial Prices	
	Crop Damage	Non-Crop Damage
TRE Planning Unit	9.69	10.17
TRE Impacted Area	2.75	2.89
Ghagot Right Bank	3.9	4.1
Alai Right Bank	8.92	9.38
Sonail Embankment	0.79	0.83
Gaibandha Project Area	16.3	17.12
Gaibandha Town	-	0.5
Total:	42.35	44.99

Source: Consultant's Estimates

6.2.4 Erosion Losses

Benefits from avoidance of erosion losses on the Teesta River are highly significant in terms of the project concept and its justification. The Teesta River is moving south-west into the project area at a rate causing estimated erosion losses of 180 hectares per year in downstream reaches, and 60 hectares per year in upstream reaches. If this erosion continued, large amounts of agricultural land would be lost, infrastructure and property would be washed away, Sundarganj thana headquarters would be likely to be washed away, and considerable dislocation of hundreds or thousands of households would occur.

The technological choice between river training and embankment retirement was analysed and discussed in Section 4.4. The justification for river training is largely to avoid the losses listed above, as well as to reduce the possibility of long-term morphological change. Conversely, if embankment retirement is carried out, it would imply accepting the high erosion losses that presently exist.

The benefits in this category have, therefore, been considered in three locations:

- erosion losses in the Teesta upstream reaches, 60 ha. per year
- erosion losses in the Teesta downstream reaches, 180 ha. per year
- loss of property and infrastructure at Sundarganj.

The valuation of lost land is in terms of production foregone (net returns per hectare based on without-project cropping patterns are taken as the basis for the analysis.). The valuation of loss of property and infrastructure at Sundarganj is based largely on costs developed by the FAP 1 study which examined similar dangers at six locations on the BRE. These costs are shown in Table 6.9.

Table 6.9 Assumed Erosion Losses at Sundarganj

	No	Financial Unit Cost (Tk.mm)	Total Cost (Tk.mm)	Conversion Factor	Total Economic Cost (Tk.mm)
A. Property Losses					
Pucca Public buildings	10	2	20	0.85	17
Semi Pucca Public Buildings	20	0.2	4	0.80	3.2
Pucca House and Shops	10	0.25	2.5	0.85	2.13
Semi Pucca House and Shops	950	0.01	9.5	0.80	7.6
Katcha Houses and Shops	950	0.003	2.9	0.67	1.95
Village Houses	5000	0.001	5	0.67	3.55
B. Infrastructure Losses					
Roads: - Semi Pucca	3	1	3	0.85	2.55
- Katcha	9	3.2	3.2	0.66	2.11
- Bridges/Culverts	5	0.2	1	0.89	0.89

				Total	40.78

Source : Consultant's Estimates
Unit rates adapted from FAP1 Second Interim Report, December, 1991.

6.3 Cost Assessment

The basis of project costing is detailed in Volume 6, Engineering, of the Draft Final Report. A summary of project costs and phasing of expenditure are given in Tables 5.1 and 5.3 of this report.

Construction Costs

The method for deriving economic capital costs follows that used and described in the Regional Plan Final Report with different allowances being made for the more detailed level of study. Two alternative methods of construction were considered: results of the comparison of these alternatives are discussed in Section 4.4. For the basic analysis, it was assumed that the manual construction method would be used. The latter is 30% cheaper than the method using more mechanised means and provides significant employment in an area of considerable underemployment and poverty.

The phasing of economic capital costs follows the implementation schedule.

O&M Costs

The method for deriving economic O & M costs again follows that used for the Regional Plan. Annual O & M costs are calculated as 5% of capital costs in the case of earthworks, and 3% in the case of structures. Sensitivity analyses have also been conducted assuming higher O & M costs, of

10%, for bank protection works on the Teesta Rivers. Results of these (and other) sensitivity analyses are discussed in section 6.4.2.

Economic Costs of Land Acquisition

The economic cost of land acquisition is calculated as the net value (in economic prices) of production foregone from the acquired land, using the without-project cropping pattern to derive net value. These land acquisition costs enter the cash flow according to the implementation schedule as land is acquired for different components of the overall work.

Costs of Embankment Retirement on the Brahmaputra River

Measures along the BRE fall within the plan being prepared by FAP1. The Brahmaputra is relatively stable along the Gaibandha reach and there are therefore no plans to undertake major bank protection works. There will, however, be a need for some embankment retirement.

The cost of embankment retirement is included as a project cost : it is assumed to take place on an annual basis over the whole project period along a 25 km stretch, i.e. an average length of about 0.83 km per year.

The associated loss of land left outside the retired stretch is not counted as a project disbenefit, however, since it would be lost under both with and without conditions.

6.4 Results of Economic Analysis

6.4.1 Base Analysis

Each of the components of the project described in Section 5.1 have impacts which, as far as possible, have been measured and valued.

The main areas of benefit/disbenefit are:

- General reduction in water levels primarily due to upstream sealing of the Teesta.
- Further reduction in water levels and prevention of damage due to extension of embankments on the Ghagot River.
- Reduction of flows down the Alai River causing a reduction in water levels and damage downstream of Gaibandha.
- Prevention of losses due to erosion by the Teesta River, particularly in the downstream reaches around Sundarganj.
- Alterations in drainage patterns to reduce the amount of water draining across the whole area.
- Reductions in water levels and damages in the impacted area.

Most of the measures result in some reduction in water levels. This reduction has some impact in terms of increasing crop production, but the impact is not very great since most of the area is already planted to t. aman and in the areas of deepest flooding the backwater influence of the Brahmaputra prevents any major change in flood depths. Significant reductions in damage should however be achieved as a result of the project. This is important since Gaibandha is the worst affected district in the Greater Rangpur District in terms of crop damage, and by association also suffers considerable damage to infrastructure and property.

One of the greatest positive impacts of the project will be in terms of reducing erosion losses. Current rates of erosion by the Teesta River on its right bank vary, but it has been assumed that in the upstream area 60 hectares of land would be lost every year, and in the downstream reaches 180 hectares. In the downstream reaches the Sundarganj thana headquarters is also threatened by erosion. Not only will river training prevent these losses, but it should also aim to make the river more stable and reduce the morphological risks associated with the current processes.

The reduction in water levels will have a negative impact on capture fisheries, but the overall impact appears to be rather small. This is partly a reflection of the relatively small area of effective floodplain, and also of the gradual reclamation of what were previously quite widespread beel areas. Specific mitigation and development measures are proposed for the fisheries sector in Chapter 5.

Construction costs are high, but this is unavoidable given the need for river training works. The high cost measures on the Teesta River nevertheless have a wide impact, particularly the upstream sealing. Although this work lies outside the project area, it has a major impact on the area and was therefore included in the project. Since upstream sealing also affects a wider area, the impact felt in this area in terms of reduced crop and non-crop damage was also included in the benefits.

The IRR for the base case is 10%. The cash flow analysis is shown in Table 6.10. The IRR implies that the project is marginal from an economic viewpoint, although it will have considerable employment benefits and greatly reduce flood risks over a large area. The main reasons for the low IRR are the high costs of river training works and the relatively small cropping changes that are predicted to take place.

6.4.2 Sensitivity Analyses

A number of sensitivity analyses were carried out on the base case. Results are reported and discussed here.

Import Parity Pricing for Rice

The economic price assumed for paddy crops in the basic analyses has been based on the mean of the import and export parity price, i.e. it implies a position of approximate self-sufficiency in rice output. While this appears to be the position at present, it is not yet clear whether the output increases of the past can be maintained. If Bangladesh again reverted to a position where import parity pricing was appropriate, the economic price assumed for paddy would increase.

TABLE 6.10 GAIBANDHA IMPROVEMENT PROJECT, ECONOMIC ANALYSIS: BASE CASE PATTERNS

(Tk mn, 1991-92 prices)

Year	Cap. Cost	O&M Cost	Total Cost	Net Ag. Returns w/o Pro	Net Prod. Lost	Crop Loss Avoid.	Sund-ergonj Loss Avoid.	Net Ag. Returns w.Pro.	Red. Crop Damage	Ag. Benefits w.Pro.	Net Fish Return w/oPro	Net Fish Return w.Pro	Fish Bene-fits w.Pro	Red.Non-Crop Dam.	Total Net Benefit	Net Cash Flow	Disc. Factor (12%)	Present Value of Benefits	Total Public Cost	PV of Public Costs
0																				
1	51.88	0.00	51.88	1217.87	0.08	0.00	0.00	1217.87	0.00	-0.08	25.15	25.15	0.00	0.00	-0.08	-51.96	0.89	-46.40	327.91	292.82
2	51.88	0.00	51.88	1217.87	1.50	0.00	0.00	1217.87	0.00	-1.50	25.15	25.15	0.00	0.00	-1.50	-53.38	0.80	-42.54	497.51	396.52
3	164.19	0.00	164.19	1217.87	3.59	0.00	0.00	1217.87	0.00	-3.59	25.15	25.15	0.00	0.00	-3.59	-167.78	0.71	-119.46	998.94	711.25
4	297.76	0.00	297.76	1217.87	6.40	0.00	4.10	1217.87	0.00	-2.30	25.15	25.15	0.00	0.00	-2.30	-300.06	0.64	-190.84	1263.37	803.50
5	346.78	31.34	378.12	1217.87	8.91	5.04	4.10	1231.94	25.85	40.15	25.15	25.39	0.24	27.34	67.73	-310.39	0.57	-175.99	1400.62	794.15
6	179.82	31.34	211.16	1217.87	10.07	10.08	4.10	1246.01	25.85	58.10	25.15	25.39	0.24	28.16	86.50	-124.66	0.51	-63.20	1066.17	540.55
7	74.69	39.10	113.79	1217.87	10.87	15.12	4.10	1260.08	34.39	84.95	25.15	25.39	0.24	37.89	123.08	9.29	0.45	4.20	718.30	324.67
8	31.59	45.64	77.23	1217.87	11.37	20.16	4.10	1274.15	34.39	103.56	25.15	25.39	0.24	39.02	142.82	65.59	0.40	26.50	604.83	244.35
9	18.25	45.64	63.89	1217.87	12.20	25.20	4.10	1288.22	34.39	121.84	25.15	25.39	0.24	40.19	162.27	98.38	0.36	35.52	606.42	218.92
10	25.42	47.24	72.66	1217.87	13.02	30.24	4.10	1288.22	34.39	126.06	25.15	25.39	0.24	41.40	167.70	95.04	0.32	30.60	687.97	221.53
11	14.31	47.24	61.55	1217.87	13.31	35.28	4.10	1294.08	37.26	139.54	25.15	25.39	0.24	45.62	185.40	123.85	0.29	35.54	417.33	119.77
12	4.66	47.24	51.90	1217.87	13.39	40.32	4.10	1299.94	37.26	150.36	25.15	25.39	0.24	46.99	197.59	145.69	0.26	37.44	46.91	12.06
13	4.66	47.24	51.90	1217.87	13.47	45.36	4.10	1305.81	37.26	161.19	25.15	25.39	0.24	48.40	209.83	157.93	0.23	36.17	46.91	10.74
14	4.66	47.24	51.90	1217.87	13.55	50.40	0.00	1305.81	37.26	162.05	25.15	25.39	0.24	49.85	212.14	160.24	0.21	32.85	46.91	9.62
15	4.66	47.24	51.90	1217.87	13.63	55.44	0.00	1305.81	37.26	167.01	25.15	25.39	0.24	51.35	218.60	166.70	0.18	30.51	46.91	8.58
16	4.66	47.24	51.90	1217.87	13.71	60.48	0.00	1305.81	37.26	171.97	25.15	25.39	0.24	52.89	225.10	173.20	0.16	28.23	46.91	7.65
17	4.66	47.24	51.90	1217.87	13.79	65.52	0.00	1305.81	37.26	176.93	25.15	25.39	0.24	54.47	231.64	179.74	0.15	26.24	46.91	6.85
18	4.66	47.24	51.90	1217.87	13.87	70.56	0.00	1305.81	37.26	181.89	25.15	25.39	0.24	56.11	238.24	186.34	0.13	24.22	46.91	6.10
19	4.66	47.24	51.90	1217.87	13.95	75.60	0.00	1305.81	37.26	186.85	25.15	25.39	0.24	57.79	244.88	192.98	0.12	22.39	46.91	5.44
20	4.66	47.24	51.90	1217.87	14.03	80.64	0.00	1305.81	37.26	191.81	25.15	25.39	0.24	59.52	251.57	199.67	0.10	20.77	46.91	4.88
21	4.66	47.24	51.90	1217.87	14.11	85.68	0.00	1305.81	37.26	196.77	25.15	25.39	0.24	61.31	258.32	206.42	0.09	19.20	46.91	4.36
22	4.66	47.24	51.90	1217.87	14.19	90.72	0.00	1305.81	37.26	201.73	25.15	25.39	0.24	63.15	265.12	213.22	0.08	17.70	46.91	3.89
23	4.66	47.24	51.90	1217.87	14.27	95.76	0.00	1305.81	37.26	206.69	25.15	25.39	0.24	65.04	271.97	220.07	0.07	16.29	46.91	3.47
24	4.66	47.24	51.90	1217.87	14.35	100.80	0.00	1305.81	37.26	211.65	25.15	25.39	0.24	66.99	278.88	226.98	0.07	14.98	46.91	3.10
25	4.66	47.24	51.90	1217.87	14.43	105.84	0.00	1305.81	37.26	216.61	25.15	25.39	0.24	69.00	285.85	233.95	0.06	13.80	46.91	2.77
26	4.66	47.24	51.90	1217.87	14.51	110.88	0.00	1305.81	37.26	221.57	25.15	25.39	0.24	71.07	292.88	240.98	0.05	12.77	46.91	2.49
27	4.66	47.24	51.90	1217.87	14.59	115.92	0.00	1305.81	37.26	226.53	25.15	25.39	0.24	73.21	299.98	248.08	0.05	11.66	46.91	2.20
28	4.66	47.24	51.90	1217.87	14.67	120.96	0.00	1305.81	37.26	231.49	25.15	25.39	0.24	75.40	307.13	255.23	0.04	10.72	46.91	1.97
29	4.66	47.24	51.90	1217.87	14.75	126.00	0.00	1305.81	37.26	236.45	25.15	25.39	0.24	77.66	314.35	262.45	0.04	9.71	46.91	1.74
30	4.66	47.24	51.90	1217.87	14.83	131.04	0.00	1305.81	37.26	241.41	25.15	25.39	0.24	79.99	321.64	269.74	0.03	8.90	46.91	1.55
TOTAL																	NPV=	-111.54		4767.48
																	IRR=	0.10		
																	NPVR=	-0.02		

The FAP Guidelines for Project Assessment calculate a conversion factor of 1.02 for paddy for import parity pricing. This study estimates the appropriate conversion factor to be 1.19 (see discussion in Volume 13, Economics, of the Draft Final Report). Sensitivity analyses have been done for both conversion factors:

	Conversion Factor	Conversion Factor
	1.19	1.02
IRR	12.7%	11.3%

The analysis with a conversion factor of 1.19 increases the IRR to just above 12%.

10% Increase in With-project Agricultural Net Returns

A 10% increase in the value of with-project agricultural net returns increases the IRR to about 17%. This indicates the relative sensitivity of this project, and others analysed for the Regional Plan, to changes in agricultural returns.

20% Increase in Construction and O&M Costs

This increase in costs causes the IRR to fall to about 8%. Since the cost estimates are based on rates well above existing rates, and the implementation period is long, there are no particular reasons for such cost overruns to occur.

O&M Rate of 10% for River Training Works

Since the cost of river training works is estimated at almost Tk. 600 mn, an increase in the O&M allowance for such works has a significant impact: an increase to 10% reduces the IRR to 6%.

Lower Rate for Labour

The cost estimates have been based on Tk 55 per day for unskilled labour. These estimates conventionally include a percentage for contractors' profit. Contractors normally pay labour at most at the current market wage rate, taking the difference as profit. However, since the market wage rate in Gaibandha is very low (Tk 20-30), and since, if LCS groups are employed, the contractors' profit would be reduced, actual cost savings could be made. If the costs were based on a rate for unskilled labour of Tk 40 instead of Tk 55, the IRR would increase to 11%.

Hazard Analysis

This sensitivity run explores a hypothetical extreme event causing embankment failure. It assumes failure shortly after completion of all parts of the project. Resulting damages are assumed roughly equivalent to actual damages during the 1988 flood, and are followed by a need for reconstruction (assumed at 50% of original construction costs), and a period of 4 years during which recovery back to full development takes place. The IRR under this scenario drops to 3.3%. Although the analysis is speculative, it serves to demonstrate the risks associated with failure of the structural elements of the project. The damages in such an extreme event would be similar without the proposed developments.

Analysis of Individual Project Components

Further analyses were conducted to attempt to identify the benefits generated by individual components of the project. The analysis is not precise since it is not always possible to separate out the benefits: however the analysis is broadly indicative of the significance of each component.

The base case, including all components, has an IRR of 10%. This includes provision for backwater embankments on the Ghagot river and a new regulator on the Manas river, to provide protection in the likely event of the current Manas regulator being washed away.

However, since these works will essentially fulfil the same function as the existing regulator, they produce no benefits over the present situation with the Manas regulator still in place. It could in fact be argued that the future-without condition should exclude the Manas regulator. Although the latter analysis has not been conducted, an analysis has been carried out of the base case excluding these replacement costs. The IRR increases to 12% in this case.

Other analyses were conducted of individual project components: these analyses included the replacement cost of the Manas regulator.

The sealing of the Teesta Right Embankment and construction of a regulator on the Alai river were analysed together, since it is difficult to desegregate agricultural benefits in the Alai basin. The IRR in this case is 11% (If Manas regulator replacement costs are excluded from this analysis, the IRR increases to 13%).

It is reasonable to conclude from the above analysis that sealing the Teesta Right embankment, probably in conjunction with regulation of the Alai river, is the priority work and is on the margin of economic viability. This justifies the proposed phasing of the overall project, since more study will be required to establish the precise design of compartmentalisation which in a preliminary analysis does not render significant additional economic benefits.

CHAPTER 7

IMPACT ASSESSMENT

7.1 Environmental Impacts

7.1.1 Component Impacts

Sealing the BRE and TRE

The significant reduction in flood damage due to breaches will be offset to some extent by disbenefits in the loss of fish and wetland benefits. Many of these effects had already occurred in the initial construction period. Some of the losses are thus not directly attributable to this phase of investment. The GIP strategy will rectify some of these earlier losses through the planned removal of the Manas Regulator (see c. below).

Removal of the Existing Manas Regulator

All the rounds of public participation and the hydraulic modelling indicate that the removal of this structure will alleviate the disbenefits of impeded drainage it currently causes. In practise, erosion is likely to remove it anyway. There were no grounds established where its future role could be justified. As the structure could pose a physical hazard it would be advisable to plan for its organised demolition and removal.

Its removal will revitalise the system again. The benefits will include - the unrestricted passage of fish migration; the unrestricted flushing of pollutants away from Gaibandha town which either originate there or from Rangpur; unrestricted seasonal navigation to and from the Jamuna and Ghagot systems which will benefit inter-regional, intra-regional and local commercial, marketing and domestic boating networks.

Minimising External Impacts

A fundamental principle applied throughout the NWRS is the avoidance of schemes that make people worse off downstream or in adjacent areas. The confinement of the Ghagot on the left bank, the need to rationalise the flood protection levels in the backwater areas of the Jamuna (once the existing Manas regulator has been removed), and the need to avoid river capture of the Jamuna down the Alai, all require that a regulating structure be sited at the head of the Alai. This effectively is an in-built mitigation component, as well as part of a regional strategy to alleviate flooding in the Alai floodplain by diverting some drainage flows to the Jamuna through the Ghagot.

Options to embank the right bank of the Ghagot were examined to avoid spillage to the right bank floodplains and beels. The model results showed that once the TRE has been effectively sealed the effects of the GIP schemes on the Ghagot river levels are minimal and would not require any mitigation by embanking the right bank. Flood protection measures required for the Ghagot right bank areas thus remain a study in their own right.

Construction of a New Regulator at the Confluence of the Manas and Ghagot and Completion of the BRE

This component showed no positive hydraulic or economic effects during the early analysis within events less than the design criteria laid down under FAP for an agricultural area (1:20 year flood protection). The analysis showed that, in most years, the location of this regulator would actually impede drainage in the same way that the existing Manas regulator does. As a physical obstruction it will also have many basic disbenefits affecting both biological, water quality and navigation systems into the Manas basin. On pure technical and economic grounds there was no justification for this additional investment cost.

It has been argued that some local people within the GIP area might be unhappy to see the existing Manas Regulator removed and then the GIP system left totally open to the potential of flooding from the Brahmaputra. However, the risks of flooding from the Jamuna into the GIP area appear infrequent and not catastrophic (unless the BRE is breached). There has been no public consultations to elicit the community's actual response to this proposal.

The regulator might also be necessary to rationalise the boundary disparities in flood protection in the backwater area influence of the major rivers that have 1:100 year flood protection along their main river frontage. The flood heights associated with the 1:100 year flood event near to the design criteria of the BRE would flood areas within the Manas basin. The degree of damage that this flooding would result in is probably far less than the damage from a similar event in the Teesta. Breaches in, or overtopping of the TRE, would create considerable damage to parts of the GIP. In this event the Manas regulator may again be an impediment, rather than an aid to flood relief.

The issue of the degree of protection to be given along the extension of the BRE on both sides of the confluence of the Ghagot and Jamuna is a policy decision based on the switch in boundary conditions required by opening the Jamuna to the Ghagot and its 1:100 year protection level and that of 1:20 year protection for the GIP on its southern side.

Extending the Ghagot Left Embankment (GLE)

The inclusion of this component has been justified partially on the grounds that it logically forms a part of a complete package of engineering structures to control water that is consistent with traditional FCD interventions. Basic flood protection to the area behind this embankment primarily is achieved through the sealing of the TRE. The beneficial effects of the GLE would be to provide flood protection to a part of the GIP area. It again has hidden sunk costs as it will mainly rehabilitate existing roads. The inclusion of these sunk costs would reduce the basic economic benefits in any similar component that had to start from scratch. The construction works, nonetheless, are cheap and will create local employment. The connection of the spills to the important major water body of Bamandanga beel has been built into this embankment alignment. However, this remaining alignment may still leave other beels and floodplain areas isolated.

Compartmentalisation

The results of the modelling and economic analysis show significant hydraulic benefits accruing to the sub-division of the area into drainage compartments. The context must be understood. First, the strategy is based on using existing roads which become sunk costs in the analysis. Second, the scale at which each compartment is being modelled has reached the boundary limits for proper analysis.

Thus, the actual conditions and distribution of water within compartments cannot be well understood or modelled. This is because of the local variation in micro-topography and the degree of landscape alteration already undertaken by local communities. Thus, cumulative impacts of many small areas, where impeded drainage or more drought prone areas may occur, is currently undefinable. The benefits or disbenefits of this, according to the social structure and socio-economic and political organisation within each compartment, are also unclear.

7.1.2 Impacts in the Pre-Construction Phase

The current study has introduced the first level of impacts into the area, particularly through its association with a major national project FAP that is already a subject of public debate in the media. The levels of public participation have also made the potential future investments well-known to the local communities. Their effects of this cannot be ascertained at the current time, but may include impacts on land values and local tactics to dispose of or acquire land in a speculative fashion in advance of these works actually beginning.

7.1.3 Impacts in the Construction Phase

By far the most important benefit to be derived from construction will be the potential for generating local employment and Food-for-Work options. This programme can bring temporary relief to the condition of many economically and resource poor people.

The most significant adverse effect will be the need for land and the displacement of people. The socio-economic profiles show intense deprivation already existing. Dispossession can transform access to survival strategy and future opportunities. The resettlement options are negligible. The scheme will have to rely on a sympathetic and well-managed compensation programme. The land acquisition problems of FAP have been the responsibility of FAP 15. They concluded that major changes are needed to ensure speedier and more equitable settlement of claims. Without this they are likely to be a major constraint to the implementation of project requiring land acquisition under the FAP. Their conclusions and recommendations must be made integral to the TOR, staffing and work capabilities of the detailed design stage. The phasing of these studies must also be carefully matched to the time by when the land acquisition process must be completed to allow actual construction to begin.

The drain on non-renewable and scarce resources of the construction phase of GIP has not been carried out in detail for each major item. As an indicator of scale the number of bricks required has been estimated. This will be a drain on national energy resources in the form of fuelwood, coal or gas. The results indicate a consumption of 900 cu.m.of bricks for all works. This would require in the order of 250 tonnes of fuelwood. Disposal of spoil is not regarded as a major issue for further compensation payments.

A number of important sites of cultural and historic significance lie very close site of construction works. Further survey and assessment of the specific mitigation will be required in the detailed design phase.

7.1.4 Impacts in the Post-Construction Phase

Physical Impacts

The critical impact of the physical and dynamic effects of river morphology and erosion as a basic risk must be emphasised. These are effects that will express themselves in the short to medium term future. Internally the processes affecting siltation of drainage channels and soil quality will not be significant. A major benefit will be the prevention of poor quality soil covering farmers' fields when washed through major breaches.

If major river training works proposed prove deficient to impede the movement of the Teesta or the Brahmaputra there will be a need for ongoing retirement of the embankments.

Biological Impacts

Internationally, nationally or regionally the GIP area is not significant for the habitats or species diversity it supports. No requirements for protected areas is necessary.

The key problems noted for the area include the role of medicinal plants, the encouragement of food diversity and community based programmes to ensure that habitats suitable for the spread of malaria are minimised.

The bacterial quality of many surface water supplies is unsatisfactory, and is a major cause of diarrhoeal disease outbreaks. Without adequate sanitation development, this situation cannot be expected to improve. No significant levels of any common toxins were detected in the study surveys, but they are reported to be locally significant near industrial units in Gaibandha and Rangpur. The chemical standards set for drinking water are in some cases irrelevant and would preclude every tubewell source tested, despite their being generally the best quality water available in the Region. The proposed interventions are unlikely to have any significant effect on surface water oxygenation, since reducing flows permits the development of phytoplankton, which form an alternative source of supply for aquatic organisms.

High soil water levels in the highlands may inhibit the ability of many trees to absorb nutrients, a process promoted by the fungae-tree association. Interventions which reduce the water table in highland areas, therefore, have the potential to improve the nutrition of trees, which provide the most important ranges of natural resources for rural people. Flood interventions potentially affect soil biology by altering the balance between processes which alternate through the annual inundation cycle. The present semi-natural system relies considerably on aquatic components. Interventions, which cause an increase in the length of time that the soils remain unsaturated each year, will certainly cause a reduction in nitrogen fixation. This nitrogen is another of the "free goods" of the floodplain, which will need to be replaced by traded goods if the natural cycle is disturbed.

The proposed interventions may potentially encourage the preservation of the floral and animal diversity in the highlands by reducing a high watertable in the flood season. This will enhance the growth of the trees which form the dominant group in the highland habitats, and so improve the resource availability of those species which rely on them.

The embankments serve as important linear habitats and are major dispersal corridors for many species, some of which may be reservoirs of infectious diseases which affect humans. They are also important as dispersal routes for the agents of some contagious human and animal diseases. They provide shelter - often the only shelter - amongst the open and generally treeless fields of the floodland for the wild birds which feed on insects which may at times become crop pests.

The importance of the beels does not lie in their conventional role as wetland reserves for wildfowl, but as dry-season refuges for the floodland fish. The preservation of the fish stocks, which should be a matter of international concern, demands that the present network of beels and river channels should be maintained and the fish sheltering in them protected by sound and effective management policies, to ensure that their access to their essential energy source, the floodland, is continued. This means that compartmentalisation centred on the major beel complexes, but allowing some access to the river channels as well, is the correct approach to the management of the fish stocks in the area.

7.1.5 Cumulative Impacts

There are a range of cumulative impacts which may affect the basic integrity of the project. These relate to risks and hazards of extreme events that would exceed the design criteria of the scheme. The GIP would be at risk because of its location at the confluence of two large rivers.

Cumulative impacts associated with the trends in current farming systems will result in the longer term in the complete loss of sound environmental management. Remedial strategies based on integrated pest management (IPM) and integrated resource management are recommended.

7.1.6 Residual Impacts

Increased Damage and Disruption

The most significant residual impacts will include the higher risks of damage and disruption of failure to maintain the integrity of the sealing of the BRE and TRE. As each year goes with the embankments complete the attitude to risk inside the GIP will change, affecting land and other values in the society and the natural resource base concerned. Growth of small villages into towns and small towns into cities would accompany the growth in population and greater levels of infrastructure and commercial investment in other sectors if this were commercially attractive. Any failure after many years of no breach would lead to increasing levels of damage and disruption. This appraisal stresses the need for a properly integrated flood proofing and disaster preparedness programme to be totally integrated into the detailed design phase.

Impeded Drainage

The cutting of even small local drainage lines will create varying degrees of recurring impeded drainage across the compartments. These areas will require special attention and management to ensure that problems of poor water quality and development of sites for insect vector breeding do not develop. These aspects can probably be mitigated to some extent during the detailed design phase and by monitoring of the system after construction to identify appropriate levels of response in the agricultural, fisheries and public health sectors.

Reduced Floodplain Processes

The upstream potential sources of pollutants from outside the project into the GIP area come mainly from Rangpur. The diversion of flows into the Ghagot and off the GIP floodplain will be of marginal benefit to GIP and will tend to raise the pollutant load of the Ghagot.The most significant feature here will be the lack of flushing and dilution after sealing the TRE. The capacity of floodplain wetlands to take up nutrients and pollutants would be reduced by disconnecting them from the Ghagot and heavier reliance would be put on the capacity of the river Ghagot bio-system to undertake this role. This residual impact would require monitoring and, if necessary, lead to controls and processing of potential pollutants and sewage from sources which currently primarily emanate from Rangpur.

The loss of connections to many floodplain depressions and beels will affect the characteristics of the habitat and species composition of wetland dependant species. However, the results of compartmentalisation indicate that some wetland areas may be advantaged, while other may be disadvantaged. The basic change in the system is that recharge will come more from local rainfall catchments and not from spillage out of connections to the Teesta waters and its aquatic life forms that are transmitted in the current system. Given that the current degradation of the ecology from its natural state is so extensive, this issue can no longer be of primary concern.

Losses to floodplain fisheries are forecast with the project in its current format. This will significantly change the current system of exploitation and survival strategies that utilise this natural resource base. These impacts are most likely to affect those who are already the most disadvantaged including the poor, landless, women and children. The effects would need to be monitored and responded to in other forms of relief efforts. The key areas for monitoring will be access to income-generating activities and deteriorating health status, often associated with nutrition-related disorders.

7.2 Social and Economic Impacts

The sealing of the TRE would have a positive impact on nearly all the communities in the GIP as evinced by the findings of all the fieldwork carried out. The main negative impact would be if sufficient care were not taken to allow fish migration from the river into the beels and khals of the northern part of the project area. Rural appraisals in the northern part of the project area revealed that communities want the embankment sealed properly but they also want gates in the main embankment from which they can let water into and out of the area as required by flood, agricultural or fishing considerations. These gates would allow fish migration but require human management which opens and closes them at the appropriate times.

Likewise effective sealing of the BRE will have positive impacts on most of the GIP area providing water which gathers inside the embankment can be released into the Brahmaputra. The major contemporary problem is the Manas regulator which is slowly being destroyed by Brahmaputra bank erosion. It is generally the opinion of most communities in the GIP area, and indeed many to the south of it, that it never achieved its potential in relieving flooding inside the project area. These complaints come from nearly every thana in the GIP area apart from a few communities living close to it.

The removal of the Manas regulator has the positive impact of allowing free migration of fish to and from the Brahmaputra and an improvement to the deteriorating river transport system that has been a feature of the area over the last decade. In the public participation sessions which were held in the area this option of opening of the internal drainage system to the Brahmaputra was warmly welcomed in nearly all of the thanas where meetings were held.

The option for the Ghagot and Manas also allows for a regulator where the Ghagot enters the Alai. This aspect of the GIP option will have positive social impacts outside the GIP area. It will mean that flood water which previously flowed down the Alai can be directed into the Brahmaputra by closing the gate on the Alai. Those communities on its right bank which have continuously cut the Sonail Embankment will be given a better degree of protection than at any time since the Sonail project was conceived. With this gate and developments to the south of the Sonail Embankment it is highly probable the cuts made by the public in the embankment will be avoided.

Another area which is not in the GIP but which will have positive impacts as a result of the above options comprises the communities on the right bank of the Ghagot and to the east of the main Gaibandha to Sadullapur road. These communities presently suffer from heavy siltation in the Ghagot, much of which they claim comes from the Teesta. They also suffer because the embankment on the left bank of the Ghagot acts as a drainage barrier when they are inundated by a combination of heavy rain and spillage from the Ghagot. The project works should help to reduce these problems.

A significant social impact will be the increased employment generated from both construction works, raised agricultural production and the more equitable distribution of the flood waters that will remain after the reductions attained through sealing the main river embankments.

Social tension may arise through conflicts over water, particularly between fishermen and farmers. This stresses the need for a full mitigation programme for fisheries and for the development an operational framework where paddy-fish culture is promoted amongst predominately farming communities. Resource tenure and the degree of community participation in organising the details of local water management systems will be the key to reducing these conflicts and enhancing the benefits which could come through the potential complementary features of multi-purpose farming systems.

The public health and nutrition status in the area is particularly poor. The resurgence of malaria internationally, the risks associated with the development of the irrigation canal schemes along the Teesta, and the likely problems of impeded drainage that will result at the micro-level within the scheme all indicate that the highest priority be put on mitigating these potential problems. Properly staffed and adequately resourced specialist teams should be sent to the area to carry out in-depth surveys to assess the current situation and potential for risks based on the project plans as developed to date. These same specialists should also be directly attached to the detailed design phase to issue the minimum criteria for the engineering and operational designs.

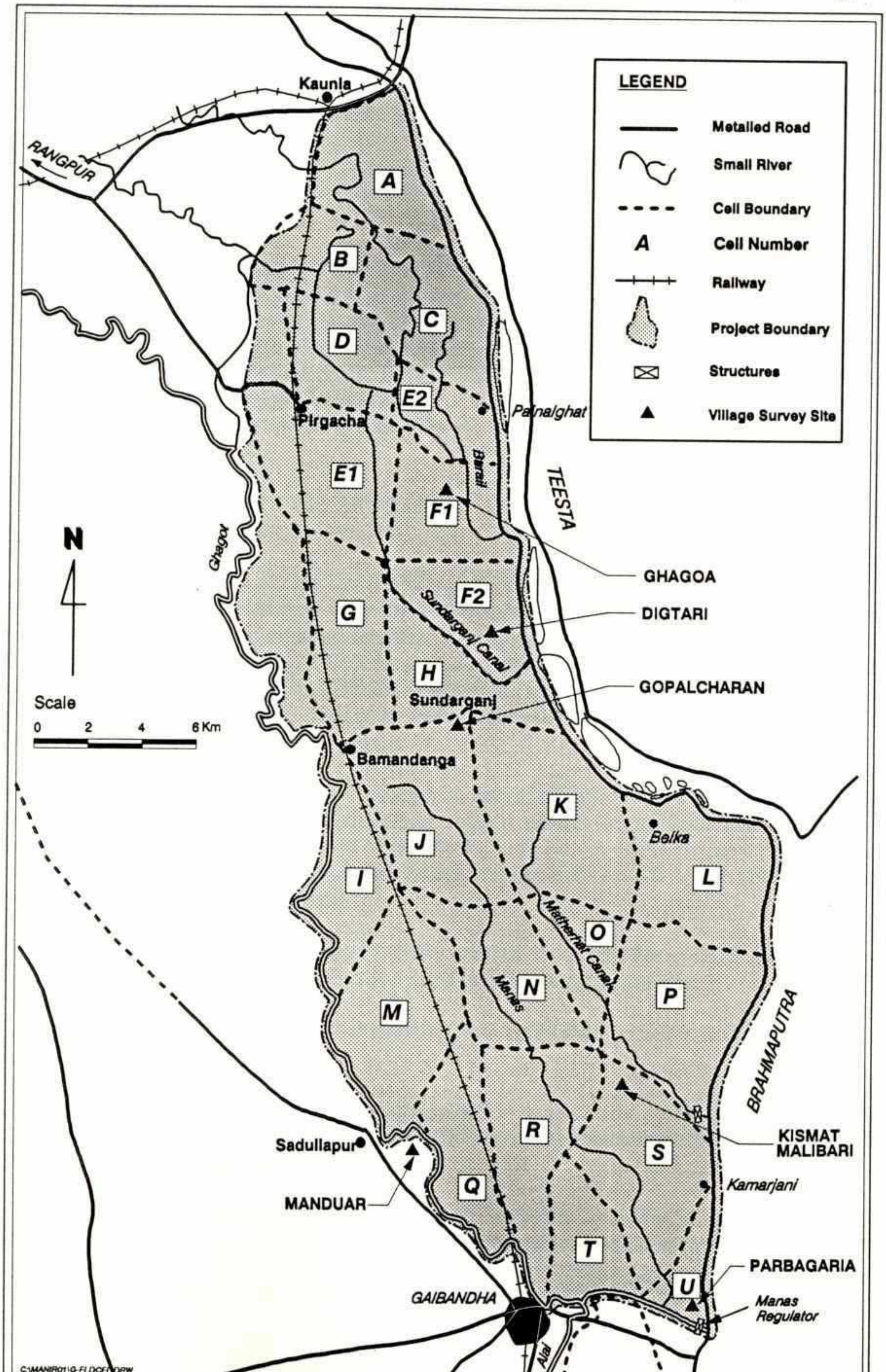
A number of important local sites of cultural and historic interest lie close to sites of construction. Local and specialist advice must be gained, preferably before the detailed planning phase begins, on how these sites should be treated.

7.3 Farm-Level Changes in Cropping and Income Distribution.

An agro-economic survey was conducted in the project area, comprising six villages and 210 farm households. The villages were chosen to represent different conditions in relation to present-condition flooding and potential impact of the project (Figure 7.1).

A complete household census was taken in each village, and households were then stratified according to land ownership. A total sample size of 35 households was selected from each village, and households were sampled from each farm-size group approximately proportional to their total number in the village. However, at least 5 pure tenant households and 5 large farmer households were also selected in each village.

Figure 7.1
Location of Agro-Economic Survey Villages



The survey results for the six villages have been analysed to determine changes in cropping patterns and income as a result of project interventions. The results are discussed on a village basis below, but first the basic methodology is explained.

The methodology for analysing farm-level cropping changes follows the approach used to analyse aggregate cropping changes for the economic analysis, as described in section 6.2.1. Present-condition cropping patterns were derived directly from the farm survey on a farm-size basis. Farmers were asked to classify their land in terms of high, medium-high, medium-low and low land (corresponding with F0, F1, F2 and F3 land) and the crops as reported in the survey were then allocated to particular land levels.

Future-without cropping patterns were then derived on the basis of the projected growth of irrigation in the project area. The assumption used in the economic analysis was that irrigation would grow from 29% coverage to 48% based on analysis of irrigation equipment statistics and groundwater availability (see volume 10 of the Draft Final Report). In some of the villages even this upper limit is already exceeded, and therefore a similar proportionate rate of growth was assumed from the base as revealed in the survey. An upper limit of 80% was imposed however (the only exception being on sharecropped land, since many sharecroppers grow HYV boro as the main crop and therefore must have access to irrigation).

The change in irrigation coverage was the only change assumed between present and future-without conditions.

Future-with cropping patterns are the result of the project interventions. As described in the Draft Final Report (Volume 9), the analysis of changes in flood levels is currently carried out at a rather aggregated level and it is not possible to accurately forecast changes at village level. Nonetheless, the hydro-dynamic model developed by NWRS for the Gaibandha project area is sub-divided into 23 sub-units (i.e. on average about 2,500 ha. per cell), for each of which a with- and without-project flood phase distribution has been derived. This is the best guide available to give an indicative analysis of the extent and direction of change.

Therefore, in deriving future-with project flood phase distributions for each village, the distribution given by the model for the sub-unit containing the specific village was used, at least as a guide. It could not be used exactly because the flood phase distribution reported by the sample farmers in some cases differed markedly from the sub-unit distribution, but the direction and approximate magnitude of change were derived from the model.

It is clear, too, that the approach as described above could be carried further in detailed design work, with agricultural and other surveys more closely tied in to a disaggregated model.

Once the future-with project flood phase distribution was established, changes in cropping patterns could be forecast.

The output of this analysis is, therefore, cropping patterns by farm size group and flood phase for present, future-without and future-with conditions. These cropping patterns are then the basis for the forecast of changes in net income due to the project.

The data on yields, prices and input use derived from the survey were used to calculate gross and net incomes on a per acre and per household basis. Some differences exist between farm size groups in input intensity, yields, and proportions of supplied to purchased inputs, and therefore the input-output data used to derive incomes were specific to the farm size group. Only prices were the same for all farmers.

The resulting analysis gives gross and net incomes by farm size group for present, future-without and future-with project conditions in each village. These data sets were initially derived for representative farm households, and then the village-level income distribution was derived simply by multiplying household incomes by the number of farmers of that group in the village.

Tables showing changes in flood phase distribution and resultant impact on farm incomes for each village are given in Appendix I and the results are described below.

A. Digtari.

Digtari is a village in Pirgacha thana in the north of the project area with a high proportion of low-lying land. It falls in an area where the effect of compartmentalisation may actually be to increase water levels compared with present conditions. The with-project conditions in this village are therefore forecast to stay the same or even to get marginally worse.

The flood phase distribution for the village is shown in Table I.1. This shows a small increase in flooding conditions. Table I.2 shows the impact on farm incomes. Incomes are unchanged between future-without and future-with conditions for all groups except tenants, who experience a decline in net income of 11%. The reason for this outcome is basically that a small shift in cropping has a larger proportionate impact on tenants' incomes than on other groups. In addition, tenants start off with a greater proportion of higher land and have a cropping pattern less adjusted to flooding conditions, whereas the other farmer groups all grow some deepwater aman.

Table I.2. also shows that the distribution of village income remains unchanged. Large farmers, who comprise 7% of farming households, receive 26% of net farm income, while tenants, who make up 12% of households, receive 1% of net farm income. These are the extremes however: small and medium farmers make up 81% of farm households and receive 74% of net farm income, so that overall income distribution is not too highly skewed. These, however, are 'first-round' effects without taking into account income to the leasers of land, sellers of water, providers of credit and draught power etc., who are generally the larger farmers.

Examining household-level net incomes under present conditions, incomes of large farmers exceed those of tenants by fifty times! Even small farmer incomes are more than six times greater than those earned by tenants.

B. Ghagoa.

Ghagoa is also in Pirgacha thana, further north from Digtari. It has a similar flood phase distribution to Digtari, and is similarly affected by the project. Table I.3 shows the flood phase distribution, and Table I.4 shows income changes. There is again a small shift to higher flood depths, and this time all farm size groups are adversely affected, although again tenants experience the greatest proprtionate decline in net income, for similar reasons as above. Tenants grow only HYV t.aman, whereas the other farm size groups grow equal amounts of HYV and local t.aman: tenants are therefore forced to make greater proportionate shifts in their cropping pattern than the other groups.

Village-level income distribution is again similar to Digtari. It is notable that small and medium farmers comprise 79% of farm households and receive 79% of net farm income.

C. Gopalcharan.

This village is south of Digtari, in Sunderganj thana, and has predominantly F1 and F2 land, as shown in Table I.5. Project interventions bring about a fall in water levels and an increase in farm incomes of all groups, as shown in Table I.6. In this case the proportionate increase in net incomes of 5% is the same for all groups, and the main change in cropping is an increase in HYV t.aman.

Small farmers predominate in this village, comprising 72% of all farm households, and receiving 45% of net farm income.

D. Kismat Malibari.

This village is in Gaibandha thana to the north east of the Manas river. It has high proportions of F1 and F2 land, and smaller amounts of F3 land. Project interventions bring about a substantial reduction in water levels and an increase in farm net incomes. The changes in flood phase distribution are shown in Table I.7 and changes in income shown in Table I.8. The proportionate income change is less for large farmers than for other groups, but in absolute terms their incomes increase substantially. (Present condition cropping patterns show that large farmers grow a far higher proportion of local t.aman to HYV t.aman than other farm size groups, and it is assumed that in future this situation will still hold to some extent). The main cause of increased incomes is more cultivation of HYV t.aman.

E. Manduar.

Manduar is in Sadullapur thana on the right bank of the Ghagot river. It has high proportions of F1 and F2 land, and fairly similar amounts of F0 and F3 land. It is subject to spills over the right bank of the Ghagot.

Table I.9 shows the flood phase distribution, and Table I.10 the income changes as a result of the project. Incomes increase for all groups, and particularly for tenants. The latter finding differs from the estimate in the Draft Final report and is probably more appropriate, in view of the fact that all other incomes increase. The size of increase for tenants is possibly overstated, since future-without incomes are predicted to be less than present incomes, a situation which may not in fact occur.

Even with an increase in incomes, tenants' incomes remain far below those of all other farm size groups. Small farmers' incomes are ten times those of tenants in all periods.

F. Parbagaria.

Parbagaria is in Gaibandha thana just to the north of the Manas regulator, has a high proportion of low-lying land and suffers from drainage congestion. As a result the proportion of t.aman grown is lower than in the other villages: conversely, the proportion of HYV boro is higher, and oilseeds are also a significant crop.

Table I.11 shows the flood phase distribution, and Table I.12 the income changes. The project is not able to remove the drainage congestion problem fully, but it does bring about some reduction in flooding depths which is reflected in increases in farm incomes. The main change is some increase in local and HYV t.aman, partially offset by a reduction in oilseeds. Again the proportionate change of large farmers is less than for other groups.

Conclusions.

The analysis described above should be regarded as indicative rather than precise, since it is difficult to predict with accuracy what changes in flood levels are going to occur, especially at village level. Predictions of cropping pattern changes are also only approximations.

Nonetheless, the analysis tends to show that the direction of income change in a specific location tends to be the same for all farm size groups, although the proportionate and absolute changes may differ. The project interventions have relatively little impact on income distribution at village level, although absolute income increases at household level tend to be larger as farm sizes increase, a predictable result. Tenants' incomes remain far below those of any other group.

A further point not yet made is that the income change between present and future-without conditions is generally larger than that between future-without and future-with conditions. The former change essentially reflects the assumed impact of irrigation growth, while the latter reflects the assumed impact of flood control.

7.4 Impact Matrix

Table 7.1 summarises the assessment of impacts for the project. The table compares the future situation with and without the project, both inside the project area and outside it, for option N (which has all project components but without compartmentalisation) and Option O, which is the base option. It can be seen that changes due to the project are often relatively small.

The impact analysis shows that Gaibandha development without compartmentalisation is likely to be the more benign strategy. All the negative impacts of this option are reproduced for the compartmentalisation option but are magnified in a number of important areas, including :

- the potential for public cutting
- the greater likely potential for the spread of water-related disease

This conclusion has to be weighed against the major improvement in the equity of spread of flood water in the system overall which can only be achieved through the strategy of compartmentalisation. Herein also lie the major economic benefits of investment which cannot be achieved to the same extent if development without compartmentalisation were selected.

As the economic and equity potential of compartmentalisation is significantly greater, it has been taken through as the most likely preferable option for future implementation. However, great priority must be placed upon being able to resolve the likelihood of differential water levels between drainage cells before this option should be decided on as the actual option for investment. Similarly, whichever option is finally selected, a proper survey tied to design and detailed mitigation planning must be carried out on the risks and management of water-related diseases.

The study therefore concludes that sufficient flexibility must be maintained during design and implementation to allow future changes in design and selection of tactics. This must be adequately represented in the TOR. Also, the future phasing of surveys, studies and design must be carried out in such a fashion as to ensure that the correct information is available and phased to allow proper design and decision making to occur.

Table 7.1 Assessment of Impacts for GIP

Resource Issue/Important Environmental Component	Option N				Option O			
PHYSICAL RESPONSES	INSIDE		OUTSIDE		INSIDE		OUTSIDE	
	FWO	FW	FWO	FW	FWO	FW	FWO	FW
WATER								
- Surface Water								
Peak levels	0	+1	0	+3	0	+4	0	+3
Flood frequency and duration	0	+1	0	+3	0	+4	0	+3
Drainage conditions	0	+1	0	+3	0	+4	0	+3
Morphological change	0	-1	-5	-5	0	0	-5	-5
Quality	0	-3	0	0	0	-4	0	0
- Groundwater, Wetlands and Waterbodies								
Recharge in highland	0	-1	0	-1	0	-1	0	-1
Wetland extent and recharge	0	0	0	-4	0	-2	0	-4
Seasonal availability	0	-1	0	-1	0	-1	0	-1
Quality	0	-1	0	-1	0	-1	0	-1
LAND								
Fertility	0	-2	0	-2	0	-2	0	-2
Physical status	0	-2	0	-2	0	-2	0	-2
Moisture status	0	-2	0	-2	0	-2	0	-2
Erosion or sedimentation	0	+2	0	+2	0	+2	0	+2
Disposal of construction spoil	0	0	0	0	0	0	0	0
BIOLOGICAL RESPONSES								
TERRESTRIAL ECOSYSTEM								
Habitat diversity	0	0	0	0	0	0	0	0
Wildlife habitats	-3	-4	-3	-4	-3	-4	-3	-4
Faunal species diversity	-3	-4	-3	-4	-3	-4	-3	-4
Floral species diversity	-3	-4	-3	-4	-3	-4	-3	-4
Pests and diseases	-3	-4	-3	-4	-3	-4	-3	-4
AQUATIC ECOSYSTEM								
Habitat diversity	-1	-2	-1	-3	-1	-2	-1	-3
Habitats for threatened species	-1	-2	-2	-2	-1	-2	-2	-3
Faunal species diversity	-2	-3	-2	-3	-2	-3	-2	-3
Floral species diversity	-1	-2	-1	-3	-1	-2	-1	-3
Pests and diseases	-2	-3	-2	-3	-2	-3	-2	-3
Wetland functions and productivity	-2	-3	-2	-3	-2	-3	-2	-3

Impact Issue/Important Environmental Component	Option N				Option O			
HUMAN RESPONSES	INSIDE		OUTSIDE		INSIDE		OUTSIDE	
	FWO	FW	FWO	FW	FWO	FW	FWO	FW
HAZARD LOSSES								
Normal flood damage	0	+4	0	+4	0	+4	0	+4
Extreme flood damage	-5	-5	-5	-5	-5	-5	-5	-5
Drought losses	0	-1	0	-1	0	-1	0	-1
Liquefaction	-4	-4	-4	-4	-4	-4	-4	-4
SUSTAINABLE RESOURCE USE								
Cropping	-3	-4	-3	-4	-3	-4	-3	-4
Fuel and energy	-4	-4	-4	-4	-4	-4	-4	-4
Common property	-3	-3	-3	-3	-3	-3	-3	-3
Capture fisheries	-2	-4	-2	-4	-2	-4	-2	-4
Culture fisheries	0	+3	0	+3	0	+3	0	+4
Livestock	-2	+1	-2	+2	-2	+1	-2	+2
Traditional medicines	-2	-2	-2	-2	-2	-2	-2	-2
INCOMES AND EMPLOYMENT								
Construction work	0	+2	0	0	0	+3	0	0
Agriculture	0	+4	0	+4	0	+4	0	+4
Fisheries	0	-3	0	-3	0	-3	0	-3
Navigation	0	-1	0	-2	0	-1	0	-2
Landless	0	+2	0	+1	0	+4	0	+2
Equity	0	-1	0	-1	0	-1	0	-1
SOCIAL								
Community and family cohesion	0	+3	0	+3	0	-3	0	+3
Impacts on women	0	+3	0	+3	0	+3	0	+3
Impacts on children	0	+2	0	+2	0	+2	0	+2
Minority groups	0	0	0	0	0	0	0	0
Access to flood survival strategies	-2	+1	-2	-2	-2	+1	-2	+2
Attitudes to flood risks	-3	+4	-3	+4	-3	+4	-3	+4
Land acquisition displacement	0	-2	0	-3	0	-3	0	-3
Settlement patterns	0	0	0	0	0	0	0	0
INSTITUTIONAL								
Public participation	0	+4	0	+4	0	?	0	0
Institutional complexity	0	0	0	0	0	-4	0	0

Impact Issue/Important Environmental Component	Option N				Option O			
HUMAN RESPONSES	INSIDE		OUTSIDE		INSIDE		OUTSIDE	
	FWO	FW	FWO	FW	FWO	FW	FWO	FW
NUTRITION AND HEALTH								
Entitlements	-2	-3	-2	-3	-2	-3	-2	-3
Food diversity	-2	-3	-2	-3	-2	-3	-2	-3
Nutritional disorders	-2	-3	-2	-3	-2	-3	-2	-3
Waterborne disease incidence	0	-2	0	-5	0	-5	0	-0
Sewage and sanitary systems	0	-2	0	-2	0	-4	0	-4
CULTURAL								
Cultural diversity	-2	-3	-2	-3	-2	-3	-2	-3
Cultural activities	0	-2	0	-3	0	-2	0	-3
Archaeological, cultural and religious sites	-2	-4	0	0	-2	-4	0	0
INFRASTRUCTURE								
Road network	0	+1	0	0	0	+2	0	0
Navigation Network	0	-1	0	-2	0	-2	0	-2

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

OPTION 1 = Full FCD without Drainage Cells
OPTION 2 = Full FCD with Drainage Cells

CHAPTER 8

SUSTAINABILITY

8.1 Institutional Issues

As far as possible the aim should be to implement and manage the project through existing institutions and to develop and strengthen them as needed. Thus it is expected that government agencies such as BWDB, LGED, DAE, DOF as well as the local government structure will be involved as they are at present on flood prevention work. In addition there will be a need to include into the management structure NGOs and others who can play a leading role in establishing and supporting public participation. A possible institutional arrangement is given in Figure 8.1, which shows the involvement of the various agencies in the different components of the project.

Traditionally great emphasis has been put on project committees to obtain the necessary interaction between different departments and institutions. There is a need for such committees but there is also a danger that they are so big that they are not effective.By the time the Gaibandha project comes to be implemented, useful experience will be available from FAP20 on institutional arrangements for projects of this type. In the meanwhile, it is suggested that these should be a pilot experiment with a much smaller form of committee, composed of the BWDB Executive Engineer, the LGED Executive Engineers and a well-respected member of the NGO community. The committee should be chaired by the District Commissioner, who would be responsible for ensuring that there was the necessary co-ordination, particularly will other agencies and with the local government structure. He would also be able to ensure that the project initiatives complemented other developments in the district.

In making decisions on institutional issues and implementation it should be noted that Gaibandha, in common with the rest of the North West region is a dynamic landscape. Works which relate closely to the project concept are already in hand by others (for instance the study being undertaken by SRP on a scheme in the south of the project area near Gaibandha town, Kumarnai Bundh). There may also be an urgent need to make long-term decisions concerning the Ghaghot/Brahmaputra confluence during 1993, if the existing Manas Regulator is washed away. Therefore there should be the intention to try to mesh the proposed institutional set-up with that already existing, so that there is an integrated approach to the problems of Gaibandha, and duplication of effort is avoided.

It is envisaged that support will be necessary to the project committee.This should be provided through a Project Management Unit (PMU), directly funded as part of the project. The PMU would be a consultancy team who could have a variety of functions such as:

- ensuring good standards of project management and quality control;
- initiating and supervising necessary monitoring and technical investigations, such as modelling;
- ensuring that methods of construction and maintenance are developed which maximise benefits to poor groups;
- ensuring a smooth transition to operation and maintenance as the works are constructed;

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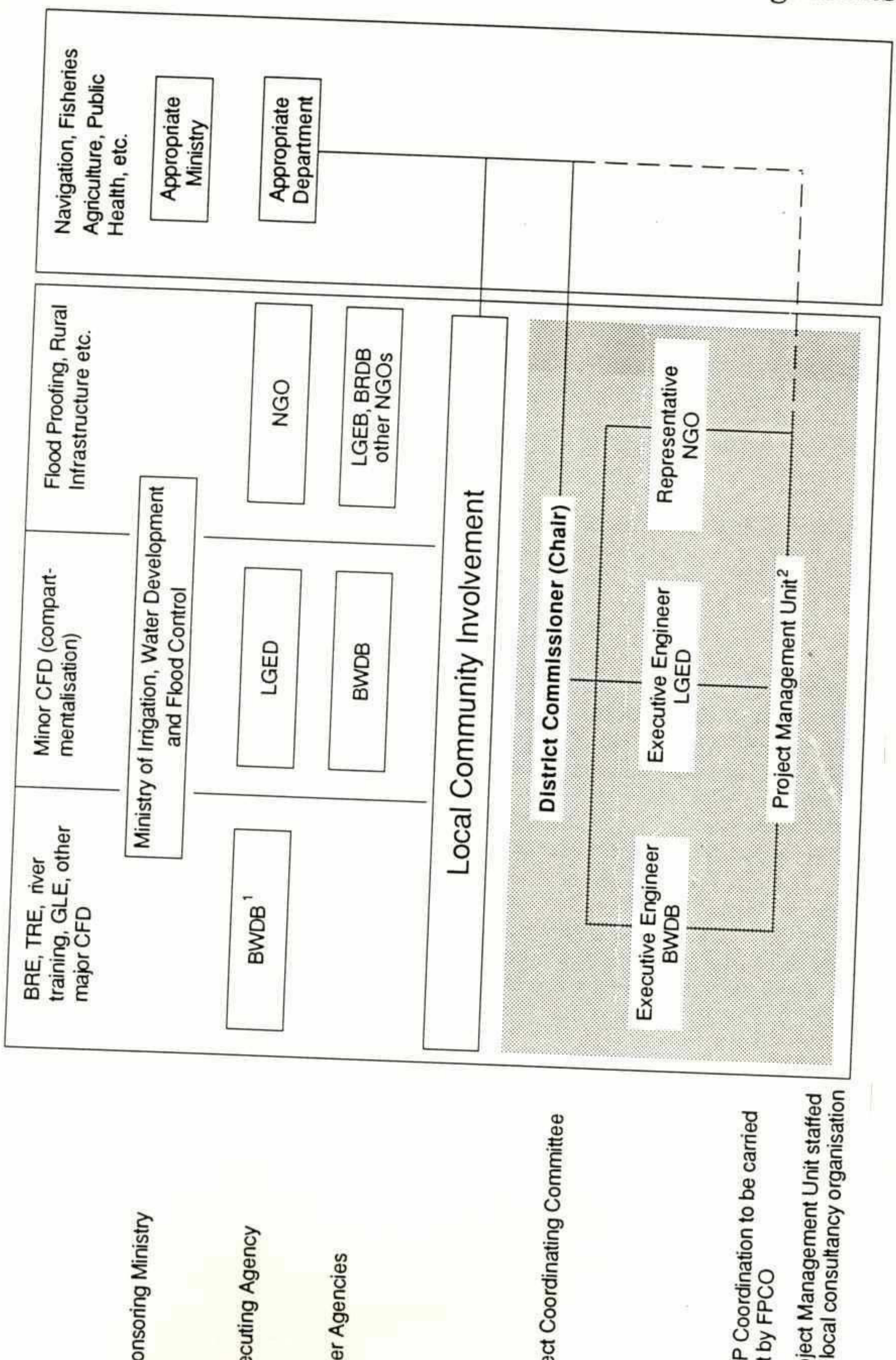
Figure 8.1
Project Institutional Arrangements



1. FAP Coordination to be carried out by FPCO
2. Project Management Unit staffed by local consultancy organisation

- transferring skills, for instance in planning and construction.
- ensuring consultation with the public; and
- coordinating associated development activities.

Again the experience of FAP20 will be important in determining the exact structure of the PMU. It is expected that most of the necessary skills could be available through local consultancy organisations,with involvement of other local organisations such as NGOs. Some foreign expertise might be useful, to provide cross-fertilisation of ideas from other countries.

Some training will be necessary for the staff involved in implementing and managing the project. This should be directed towards the goal of managing sustainable development within the Gaibandha area, and would have three main aspects:

1) management skills to ensure that the project is efficiently and effectively managed;

2) institutional development, to ensure a successful partnership between government agencies, NGOs and local people.

3) the sustainable use of natural resources, relating particularly to water, land, agriculture and fisheries.

8.2 Public Participation

At an immediate and practical level, there is a need to stimulate an on-going and vigorous involvement of local people in the development of the project. Detailed discussions and participation are required for the next stage of detailed design, to ensure that, as far as possible, the designs meet the needs and aspirations of the people. A good start on this has been made with the consultation carried out by the NWRS study team but there is now a need to put in place a mechanism which would allow a continuous dialogue to take place. NGOs have an obvious role to play in this process but it will be necessary first to establish positive working relationships between them and the government agencies responsible for the detailed designs, in particular BWDB.

Beyond that, mechanisms must be drawn up to allow local people to become involved in implementation, both to realise the immediate benefits of construction employment and also so that they develop a sense of ownership of the facilities. Various models have been developed for this and there are already NGOs within the project area, such as GKK (Section 2.6), who have experience of forming and supporting LCS to undertake project works.

When implementation is completed, there will then be an on-going need for local participation in O&M. This is discussed more fully in section 8.4.

Whilst there are many problems to be faced, the Gaibandha project has the advantage that many of its major measures, such as sealing the Teesta embankment, improving the drainage at the Ghagot outfall, and reducing flooding down the Alai, meet with very widespread approval. There should not therefore be difficult conflicts to resolve during the process. The next stage, after the major measures have been put in hand, is more difficult since it involves areal development and the balance of conflicting interests, between farmer and farmer, farmer and fisherman, fisherman and boatman and so on. The PMU's importance is likely to increase at that time.

8.3 Benefits to Poor Groups

Although a significant proportion of project benefits will of necessity go to those who own land, it is essential to also target benefits to poor groups as far as possible. Gaibandha district is one of the poorest districts in the NW region, which is one reason why a significant investment in the district should have high priority. A larger proportion of the male labour force has to migrate each year, leaving women to look after children on very limited incomes. In addition, a substantial population now lives on charlands and the main river embankments.

Increases in agricultural production will generate more work for agricultural labourers, but the increases foreseen are not enough to tackle the poverty problem. While an effective anti-poverty strategy will require involvement of many agencies and other projects and programmes, much can be done within the scope of the Gaibandha project. The proposed PMU will have responsibility to promote much of the poverty-focused work.

The first aim should be to maximise construction employment and income going to poor groups. Often the former is easier than the latter, as members of project committees or contractors sometimes fail to pay proper wages. The system of Labour Contracting Societies (LCS), if properly organised and supervised, can ensure both fair payment to labourers and good quality work. This system should be adopted as widely as is feasible. Womens' groups can also be involved in this work.

The use of LCS groups need not be limited to earthworks. There will be a need for large quantities of cement blocks for river bank protection, pipe sluices for compartmentalisation, and C.I rings for sanitary latrines under the flood proofing programme. All of these items could in principle be fabricated by poor groups given some training (the experience of LGED's RESP programme in Kurigram and Faridpur Districts is generally encouraging in relation to pipe culvert fabrication).

A further aim of the project should be to promote natural resource development which spreads benefits widely. The proposals for fisheries development (see section 5.4.1) are particularly important, given both the relative poverty of the fishing community and the nutritional importance of having fish more widely available in the market.

Broader income-generation activities need to be identified, and developed. While there are many government and NGO programme already operating, they clearly do not satisfy the need for work. This need should be focused on women as a priority, in view of the high rates of male seasonal out-migration already mentioned.

Since some of the poorest women live on the main river embankments, there should be specific focus on the productive use of those embankments for example to grow pulses or some vegetables (although technical and legal obstacles would first have to be cleared). Work done by MPO [FCDI Projects and the Productive Use of Resources, Centre for Development Research 1985] explores this potential in detail.

Clearly, in addition to the above, the overall demand for work needs to be tackled through specific poverty-focused programmes with provision for credit and training.

Although employment and income (productive needs) are priorities (as expressed by poor people themselves), the project can also contribute in the area of reproductive needs - health and security from the impact of floods being two major areas. The former should be addressed in the next stage of detailed project design, where the health implications of project proposals must be scrutinised.

In addition, however, the overall health and nutrition status, particularly of embankment dwellers, is poor, and this needs to be addressed, not just through medical-related campaigns, but through the fisheries developments and vegetable cultivation projects already discussed.

The issue of security from flooding is addressed by the flood proofing programme, which should be seen in the broadest sense, not just to provide immediate shelter, but also to provide rehabilitation to restore people's economic position.

8.4 Operation and Maintenance

Effective operation and maintenance has been correctly identified as a major problem in achieving the expected benefits from flood control investments. The problems and recent developments have been fully documented in the FAP13 study, and are summarised in the Regional Plan Final Report.

There are two major problems related to the O&M of a project such as the Gaibandha Improvement Project. The first relates to the operation of the project, and particularly its structures.The second relates primarily to the maintenance of the major works , which are the main river embankments. These two problems are underlain by a third problem, relating to institutional issues - which agency or institution is to be responsible for O&M, and how will O&M be funded.

At the present stage it is not possible to be definite about how these problems will be tackled, but various approaches can be investigated and developed during the implementation phase.This should be in co-ordination with other programmes working on O&M, such as SSFCDI, EIP, SRP and others. It is also possible that the Gaibandha project could form a pilot project for the second phase of FAP13, the O&M study. As with planning, one important aspect of work at Gaibandha will be to integrate the work of others: this particularly relates to SRP's development of Kumarnai Bundh, and the recently-completed Satdamua-Katler-Beel embankment of EIP.

Consideration has been given to designs that reduce O&M requirements: for example, embankment design makes allowance for embankment dwellers to live on a berm inside the embankment rather than on the embankment where they may cut it. Automatic structures have been considered as an alternative to manually-operated structures to regulate drainage flows. However it is considered that these structures would be vulnerable to non-operation during an emergency, and might also be more costly than manual structures.

In relation to structure operation, the proposed project committee and PMU have an important role in fostering local involvement so that the balance of interest and trade-offs between different groups are known and understood by all before structures are built. It will then be necessary to persevere with the concept of gate committees, even though experience to date with them has not been very encouraging, utilizing the same groups for operation that were involved in the planning, detailed design and construction. More intensive attention to issues of how to resolve conflicts on water availability and drainage at local level will be necessary at all stages of project development.

Concerning maintenance, the major problem relates to the main river embankments.One aspect of this is the deterioration of the section due to human habitation and interference; attempts to improve this situation include the provision of a wide berm on the landward side of the embankment for habitation and cultivation. A more serious problem relates to continued erosion by the rivers. In this respect the work of FAP1 and FAP21/22 is important in determining the most economic methods of providing permanent solutions to the problems of erosion.

Institutional issues related to O&M are difficult to resolve and experience from other programmes will be very important in this respect. An important objective of the work of the project committee and the PMU will be to develop, during the period of implementation, local forms of involvement and awareness so that institutions are established which can take over the O&M of the facilities as they are constructed. This will itself go some way to resolve the problems of resources for O&M; if local people are involved and see the benefit, they will be ready to contribute part of the requirement through their own labour. However, this will not provide all the resources needed for O&M. For the foreseeable future it seems unlikely that this can be raised directly from the beneficiaries: experience from most Asian countries is that cost recovery is very poor, even for schemes providing the direct benefit of irrigation water. O&M resources will therefore have to be provided from central funds, as at present, but greater efforts will be needed to channel them directly to the facilities themselves, rather than to the staff establishment, as at present.

Training of different personnel involved in O&M will be an important component. Proposals on the nature of training required should be developed consistent with the adopted organisational structure.

CHAPTER 9

CONCLUSIONS

9.1 Multi-Criteria Analysis

The multi-criteria analysis for the project is summarised in Table 9.1 (These criteria are the same as those used for regional planning and are discussed in Chapter 8 of the Regional Plan Final Report.

Table 9.1 Gaibandha Improvement Project Multi-Criteria Analysis

Net Cultivated Area (ha)	49130
(including d/s benefitted area)	197780
Total Cost	Tk 1670 million
IRR	10 %
Rice Output	335,000 tonnes (+8 %)
Total Fish Output	675 (-3 %) tonnes
Construction Employment	9.76 million days
Annual Agricultural Employment	20 million days (+6 %)
Land Acquisition (ha)	425
Net impacts on biophysical environment	Zero
Net impacts on social conflict	+1
Institutional Complexity	Zero
Susceptibility to Hazard	Zero
External Impacts	+2

The rate of return puts the project in the marginal category in basic economic terms, but it is nonetheless recommended for implementation. There are a number of reasons for recommending that the project be taken up:

- The benefit assessment may be understating the full benefits to be gained in the wider impact area particularly from sealing the Teesta upstream. The analysis at this stage did not allow an assessment of potential changes in cropping patterns in the impact area (except for the Alai area).

- The risks of not undertaking the most costly works, i.e. river training work on the Teesta, could be considerable. If the Teesta was not sealed downstream, for example, and the compartmentalisation works were used instead to give flood protection, the risks of erosion would be great. If, instead of river training, the embankment was retired, this option would again result in considerable erosion losses.

- The option of bank protection is strongly supported by all people living in the area; conversely, continued retirement and land acquisition increase landlessness and poverty.

- The costs of the project include work on the BRE at the outfall of the Ghagot which has no direct agricultural benefit but is required to maintain the integrity of the BRE.

- The construction work creates almost 10 million man-days of employment, in an area of chronic under-employment and poverty. This work would make a significant contribution to development of what is a generally depressed area. It is further recommended that as much of this work as possible should be carried out through LCS groups, including women's groups, to maximise the income actually received by labourers, and to ensure good quality work.

- The increased agricultural output due to the project will result in approximately 1 million additional man-days of agricultural labour per year. While a significant percentage of this increase will be taken up by farm families themselves, it will still result in a substantial increase in employment for agricultural labourers.

- Other benefits from associated natural resource development can be targetted so that benefits to poor households are maximised (see section 8.3).

When reviewing the scores of the project against other criteria, it must be remembered that these are being used to rank it against other possible projects in the North West Region. Generally its impacts on the biophysical environment will be relatively neutral particularly if associated fisheries improvement measures are undertaken. It scores well in reducing social conflict and in beneficial impacts downstream, for instance reduction in flows down the Alai will increase productivity in the Sonail scheme and reduce the conflicts which regularly lead to public cuts of the embankment. In general, planning for the Gaibandha project has tried to reduce disbenefits and causes for conflict to the extent possible.

The project as formulated has no major negative impacts which would be sufficient to cause its rejection.

9.2 Future Action

It is recommended that GOB should proceed with implementation of the Gaibandha project immediately, and should seek to secure the necessary level of funding for it. This should be done in the knowledge that a long implementation period is expected,and that considerable further work will be required before the exact physical configuration can be determined for some of the works.

The works required for sealing of the Teesta are well defined and do not have complex relationships with other parts of the project. These can proceed to modelling and detailed design immediately. There will also be a need to take early decisions on how to incorporate the on-going work of others (particularly SRP at Kumarnai Bundh) in the Gaibandha Improvement Project, and actions to be taken in the likely event that the Manas Regulator will be washed away in 1993.

There is a need to put in hand immediately the necessary institutional structure for managing the implementation of the project.This includes setting-up the project committee and the project management unit, as a first step to taking more far-reaching decisions about institutional structures for the project.

Further investigations and studies that are needed include:

- hydraulic and hydrological observation for updating the model and improving it for the design of the compartmentalisation of the project;
- further rounds of public consultation, particularly related to compartmentalisation;
- formulation of a flood proofing programme;
- analysis of fisheries, navigation and health aspects for incorporation into the areal development plan.

APPENDIX I

AGRO-ECONOMIC SURVEY TABLES

TABLE I.1 CHANGES IN FLOOD PHASE DISTRIBUTION BY FARM SIZE GROUP
VILLAGE: DIGTARI

FARM SIZE	PRESENT/FUTURE-WITHOUT (%)			
GROUP	F0	F1	F2	F3/F4
TENANT S/C LAND	0	20	80	0
TENANT OWN LAND	0	15	85	0
SMALL FARMER S/C LAND	10	0	0	90
SMALL FARMER OWN LAND	2	20	57	21
MEDIUM FARMER OWN LAND	0	5	57	38
LARGE FARMER OWN LAND	0	0	54	46

	FUTURE (%)			
	F0	F1	F2	F3/F4
TENANT S/C LAND	0	0	0	0
TENANT OWN LAND	0	0	85	15
SMALL FARMER S/C LAND	0	10	0	90
SMALL FARMER OWN LAND	0	18	57	25
MEDIUM FARMER OWN LAND	0	2	57	41
LARGE FARMER OWN LAND	0	0	50	50

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TABLE I.2 FARM-LEVEL INCOME CHANGES
VILLAGE: DIGTARI

COSTS AND INCOME PER HH.

FARM SIZE GROUP		GROSS RETURN	CASH COST OF INPUTS	FULL COST OF INPUTS	NET RETURN CASH COST BASIS	NET RETURN FULL COST BASIS	NET INCOME	NO. OF HHS IN VILLAGE IN FARM SIZE GROUP	NET INCOME AT VILLAGE LEVEL	% FARM HHS	% AGRIC. NET INCOME
TENANT	PRESENT	2338	1062	1803	1277	536	1175	15	17620		
	FUT. W/O	2364	1072	1809	1292	555	1197	15	17955		1
	FUT. W.	2158	1004	1669	1154	489	1065	15	15975	12	1
	% CHANGE W/O TO W.	-9	-6	-8	-11	-12	-11		-11		
SMALL FARMER	PRESENT	11650	3201	5069	8449	6581	7767	70	543690		
	FUT. W/O	13828	4106	6218	9722	7610	8942	70	625940		30
	FUT. W.	13828	4106	6218	9722	7610	8942	70	625940	54	30
	% CHANGE W/O TO W.	0	0	0	0	0	0		0		
MEDIUM FARMER	PRESENT	35057	8559	13264	26499	21794	23602	35	826070		
	FUT. W/O	41323	11510	16922	29814	24401	26419	35	924665		44
	FUT. W.	41323	11510	16922	29814	24401	26419	35	924665	27	44
	% CHANGE W/O TO W.	0	0	0	0	0	0		0		
LARGE FARMER	PRESENT	82358	24565	35947	57793	46411	49088	9	441792		
	FUT. W/O	103422	32569	46757	70853	56665	59818	9	538362		26
	FUT. W.	103422	32569	46757	70853	56665	59818	9	538362	7	26
	% CHANGE W/O TO W.	0	0	0	0	0	0		0		
									2106922		
								129	2104942		

Note: Returns and income for tenants and small farmers comprise final receipts from own and sharecropped land where relevant, i.e. receipts from sharecropped land after deduction of 50% share for landlord.

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TABLE I.3 CHANGES IN FLOOD PHASE DISTRIBUTION BY FARM SIZE GROUP
VILLAGE: GHAGOA

FARM SIZE	PRESENT/FUTURE-WITHOUT (%)			
	F0	F1	F2	F3/F4
GROUP				
TENANT S/C LAND	0	50	34	16
TENANT OWN LAND	0	0	0	0
SMALL FARMER S/C LAND	0	30	16	54
SMALL FARMER OWN LAND	0	47	20	33
MEDIUM FARMER OWN LAND	3	29	33	35
LARGE FARMER OWN LAND	0	16	31	53
	FUTURE (%)			
	F0	F1	F2	F3/F4
TENANT S/C LAND	0	41	41	18
TENANT OWN LAND	0	0	0	0
SMALL FARMER S/C LAND	0	24	19	57
SMALL FARMER OWN LAND	0	43	23	34
MEDIUM FARMER OWN LAND	0	25	37	38
LARGE FARMER OWN LAND	0	14	32	54

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TABLE I.4 FARM-LEVEL INCOME CHANGES
VILLAGE: GHAGOA

COSTS AND INCOME PER HH.

FARM SIZE GROUP		GROSS RETURN	CASH COST OF INPUTS	FULL COST OF INPUTS	NET RETURN CASH COST BASIS	NET RETURN FULL COST BASIS	NET INCOME	NO. OF HHS IN VILLAGE IN FARM SIZE GROUP	NET INCOME AT VILLAGE LEVEL	% FARM HHS	% AGRIC. NET INCOME
TENANT	PRESENT	3950	1952	2933	1676	1017	1894	32	60608		
	FUT. W/O	4292	2375	3426	1917	865	1794	32	57408		2
	FUT. W.	4129	2324	3346	1805	783	1685	32	53920	17	2
	% CHANGE W/O TO W.	-4	-2	-2	-6	-9	-6		-6		
SMALL FARMER	PRESENT	18870	5114	7898	13757	10972	12643	127	1605661		
	FUT. W/O	19611	5515	8417	14097	11194	12933	127	1642491		56
	FUT. W.	19387	5482	8353	13905	11034	12757	127	1620139	68	56
	% CHANGE W/O TO W.	-1	-1	-1	-1	-1	-1		-1		
MEDIUM FARMER	PRESENT	45755	12185	18046	33570	27709	29939	21	628719		
	FUT. W/O	51243	14584	21000	36659	30243	32576	21	684096		23
	FUT. W.	50459	14370	20723	36090	29736	32051	21	673071	11	23
	% CHANGE W/O TO W.	-2	-1	-1	-2	-2	-2		-2		
LARGE FARMER	PRESENT	95687	28777	41309	66910	54378	56979	8	455832		
	FUT. W/O	124537	39668	56014	84869	68523	71704	8	573632		19
	FUT. W.	124073	39588	55910	84485	68163	71327	8	570616	4	20
	% CHANGE W/O TO W.	-0	-0	-0	-0	-1	-1		-1		
									2957627		
								188	2917746		

Note: Returns and income for tenants and small farmers comprise final receipts from own and sharecropped land where relevant, i.e. receipts from sharecropped land after deduction of 50% share for landlord.

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TABLE I.5 CHANGES IN FLOOD PHASE DISTRIBUTION BY FARM SIZE GROUP VILLAGE: GOPALCHARAN

FARM SIZE GROUP	PRESENT/FUTURE-WITHOUT (%)			
	F0	F1	F2	F3/F4
TENANT S/C LAND	0	12	76	12
TENANT OWN LAND	8	12	80	0
SMALL FARMER S/C LAND	0	35	48	17
SMALL FARMER OWN LAND	0	45	44	11
MEDIUM FARMER S/C LAND	0	74	26	0
MEDIUM FARMER OWN LAND	3	43	53	1
LARGE FARMER OWN LAND	2	35	39	24
	FUTURE (%)			
	F0	F1	F2	F3/F4
TENANT S/C LAND	4	18	69	9
TENANT OWN LAND	16	16	68	0
SMALL FARMER S/C LAND	3	42	41	14
SMALL FARMER OWN LAND	3	51	39	7
MEDIUM FARMER S/C LAND	5	79	16	0
MEDIUM FARMER OWN LAND	6	49	44	1
LARGE FARMER OWN LAND	5	40	35	20

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TABLE I.6 FARM-LEVEL INCOME CHANGES
VILLAGE: GOPALCHARAN

COSTS AND INCOME PER HH.

FARM SIZE GROUP		GROSS RETURN	CASH COST OF INPUTS	FULL COST OF INPUTS	NET RETURN CASH COST BASIS	NET RETURN FULL COST BASIS	NET INCOME	NO. OF HHS IN VILLAGE IN FARM SIZE GROUP	NET INCOME AT VILLAGE LEVEL	% FARM HHS	% AGRIC. NET INCOME
TENANT	PRESENT	7255	3712	5464	3542	1790	3302	15	49530		
	FUT. W/O	7402	3789	5510	3612	1892	3379	15	50685		1
	FUT. W.	7609	3836	5575	3774	2034	3546	15	53190	7	1
	% CHANGE W/O TO W.	3	1	1	4	8	5		5		
SMALL FARMER	PRESENT	16094	4608	7206	11487	8888	10430	160	1668800		
	FUT. W/O	19419	5812	8794	13607	10625	12402	160	1984320		45
	FUT. W.	20155	5912	8991	14244	11165	12991	160	2078560	72	45
	% CHANGE W/O TO W.	4	2	2	5	5	5		5		
MEDIUM FARMER	PRESENT	63538	16881	24680	46657	38858	41732	35	1460620		
	FUT. W/O	71839	20306	28986	51533	42853	45953	35	1608355		36
	FUT. W.	74801	20890	29835	53911	44966	48061	35	1682135	16	36
	% CHANGE W/O TO W.	4	3	3	5	5	5		5		
LARGE FARMER	PRESENT	93477	27229	39448	66248	54029	56834	12	682008		
	FUT. W/O	114501	35325	50307	79176	64194	67346	12	808152		18
	FUT. W.	118852	36099	51562	82753	67290	70551	12	846612	5	18
	% CHANGE W/O TO W.	4	2	2	5	5	5		5		
									4451512		
								222	4660497		

Note: Returns and income for tenants and small farmers comprise final receipts from own and sharecropped land where relevant, i.e. receipts from sharecropped land after deduction of 50% share for landlord.

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TABLE I.7 CHANGES IN FLOOD PHASE DISTRIBUTION BY FARM SIZE GROUP
KISMAT MALIBARI VILLAGE

	PRESENT/FUTURE-WITHOUT (%)			
FARM SIZE	F0	F1	F2	F3/F4
GROUP				
TENANT S/C LAND	0	14	27	59
TENANT OWN LAND	0	50	50	0
SMALL FARMER S/C LAND	22	52	12	14
SMALL FARMER OWN LAND	5	37	43	15
MEDIUM FARMER OWN LAND	1	34	42	23
LARGE FARMER OWN LAND	1	32	43	24
	FUTURE (%)			
	F0	F1	F2	F3/F4
TENANT S/C LAND	21	20	21	38
TENANT OWN LAND	25	50	25	0
SMALL FARMER S/C LAND	41	46	6	7
SMALL FARMER OWN LAND	22	37	31	10
MEDIUM FARMER OWN LAND	20	34	31	15
LARGE FARMER OWN LAND	20	32	32	16

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TABLE I.8 FARM-LEVEL INCOME CHANGES
VILLAGE: KISMAT MALIBARI

COSTS AND INCOME PER HH.

FARM SIZE GROUP		GROSS RETURN	CASH COST OF INPUTS	FULL COST OF INPUTS	NET RETURN CASH COST BASIS	NET RETURN FULL COST BASIS	NET INCOME	NO. OF HHS IN VILLAGE IN FARM SIZE GROUP	NET INCOME AT VILLAGE LEVEL	% FARM HHS	% AGRIC. NET INCOME
TENANT	PRESENT	7147	3717	5299	3430	1848	3166	8	25328		
	FUT. W/O	7928	4475	6223	3452	1705	3162	8	25296		2
	FUT. W.	8513	4661	6517	3852	1996	3552	8	28416	12	2
	% CHANGE W/O TO W.	7	4	5	12	17	12		12		
SMALL FARMER	PRESENT	14963	4792	7445	10171	7518	9119	35	319165		
	FUT. W/O	17778	5839	8784	11938	8994	10767	35	376845		24
	FUT. W.	19163	6019	9133	13144	10030	11880	35	415800	54	24
	% CHANGE W/O TO W.	8	3	4	10	12	10		10		
MEDIUM FARMER	PRESENT	52785	14651	21296	38133	31489	34539	14	483546		
	FUT. W/O	62859	18372	26279	44487	36580	39395	14	551530		35
	FUT. W.	68448	19378	27842	49070	40606	43588	14	610232	22	36
	% CHANGE W/O TO W.	9	5	6	10	11	11		11		
LARGE FARMER	PRESENT	123246	36545	52918	86702	70328	73642	8	589136		
	FUT. W/O	133695	40619	58357	93076	75338	78861	8	630888		40
	FUT. W.	138805	41526	59813	97279	78992	82646	8	661168	12	39
	% CHANGE W/O TO W.	4	2	2	5	5	5		5		
									1584559		
								65	1715616		

Note: Returns and income for tenants and small farmers comprise final receipts from own and sharecropped land where relevant. i.e. receipts from sharecropped land after deduction of 50% share for landlord.

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TABLE I.9 CHANGES IN FLOOD PHASE DISTRIBUTION BY FARM SIZE GROUP
VILLAGE: MANDUAR

FARM SIZE	PRESENT/FUTURE-WITHOUT (%)			
	F0	F1	F2	F3/F4
GROUP				
TENANT S/C LAND	21	31	21	27
TENANT OWN LAND	0	0	0	0
SMALL FARMER S/C LAND	0	47	53	0
SMALL FARMER OWN LAND	15	32	45	8
MEDIUM FARMER OWN LAND	6	31	47	16
LARGE FARMER OWN LAND	20	55	19	6
	FUTURE (%)			
	F0	F1	F2	F3/F4
TENANT S/C LAND	28	30	20	22
TENANT OWN LAND	0	0	0	0
SMALL FARMER S/C LAND	0	47	53	0
SMALL FARMER OWN LAND	20	32	42	6
MEDIUM FARMER OWN LAND	8	31	47	14
LARGE FARMER OWN LAND	27	51	18	4

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TABLE I.8 FARM-LEVEL INCOME CHANGES
VILLAGE: MANDUAR

COSTS AND INCOME PER HH.

FARM SIZE GROUP		GROSS RETURN	CASH COST OF INPUTS	FULL COST OF INPUTS	NET RETURN CASH COST BASIS	NET RETURN FULL COST BASIS	NET INCOME	NO. OF HHS IN VILLAGE IN FARM SIZE GROUP	NET INCOME AT VILLAGE LEVEL	% FARM HHS	% AGRIC. NET INCOME
TENANT	PRESENT	4543	3103	4397	1440	147	1204	25	30100		
	FUT. W/O	4515	3180	4427	1335	88	1103	25	27575		1
	FUT. W.	4823	3286	4503	1537	320	1340	25	33500	17	1
	% CHANGE W/O TO W.	7	3	2	15	264	21		21		
SMALL FARMER	PRESENT	21224	6243	9427	14981	11797	13704	83	1137432		
	FUT. W/O	22340	6894	10035	15446	12306	14164	83	1175612		50
	FUT. W.	22970	6737	10001	16233	12969	14883	83	1235289	56	51
	% CHANGE W/O TO W.	3	-2	-0	5	5	5		5		
MEDIUM FARMER	PRESENT	37079	8750	13671	28329	23408	25310	34	860540		
	FUT. W/O	42405	10981	16576	31424	25829	27978	34	951252		41
	FUT. W.	43500	11150	16858	32350	26642	28822	34	979948	23	40
	% CHANGE W/O TO W.	3	2	2	3	3	3		3		
LARGE FARMER	PRESENT	57560	15904	23991	41657	33569	35262	5	176310		
	FUT. W/O	63521	19073	27763	44448	35759	37483	5	187415		8
	FUT. W.	64433	19230	27968	45203	36466	38224	5	191120	3	8
	% CHANGE W/O TO W.	1	1	1	2	2	2		2		
									2341854		
								147	2439857		

Note: Returns and income for tenants and small farmers comprise final receipts from own and sharecropped land where relevant, i.e. receipts from sharecropped land after deduction of 50% share for landlord.

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TABLE I.11 CHANGES IN FLOOD PHASE DISTRIBUTION BY FARM SIZE GROUP
VILLAGE: PARBAGARIA

FARM SIZE	PRESENT/FUTURE-WITHOUT (%)			
	F0	F1	F2	F3/F4
GROUP				
TENANT S/C LAND	0	0	28	72
TENANT OWN LAND	0	0	0	0
SMALL FARMER S/C LAND	0	0	56	44
SMALL FARMER OWN LAND	0	9	47	44
MEDIUM FARMER OWN LAND	0	4	52	44
LARGE FARMER OWN LAND	0	8	22	70
	FUTURE (%)			
	F0	F1	F2	F3/F4
TENANT S/C LAND	0	21	25	54
TENANT OWN LAND	0	0	0	0
SMALL FARMER S/C LAND	0	16	50	34
SMALL FARMER OWN LAND	0	24	42	34
MEDIUM FARMER OWN LAND	0	20	47	33
LARGE FARMER OWN LAND	0	25	22	53

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TABLE I.12 FARM-LEVEL INCOME CHANGES
VILLAGE: PARBAGARIA

COSTS AND INCOME PER HH.

FARM SIZE GROUP		GROSS RETURN	CASH COST OF INPUTS	FULL COST OF INPUTS	NET RETURN CASH COST BASIS	NET RETURN FULL COST BASIS	NET INCOME	NO. OF HHS IN VILLAGE IN FARM SIZE GROUP	NET INCOME AT VILLAGE LEVEL	% FARM HHS	% AGRIC. NET INCOME
TENANT	PRESENT	6293	3366	4497	2927	1796	2780	10	27800		
	FUT. W/O	6293	3366	4497	2927	1796	2780	10	27800		3
	FUT. W.	6641	3456	4666	3185	1975	3024	10	30240	14	3
	% CHANGE										
	W/O TO W.	6	3	4	9	10	9		9		
SMALL FARMER	PRESENT	16298	5503	7668	10796	8630	10107	53	535671		
	FUT. W/O	16442	5608	7816	10835	8626	9964	53	528092		61
	FUT. W.	17243	5672	7980	11570	9263	10646	53	564238	74	61
	% CHANGE										
	W/O TO W.	5	1	2	7	7	7		7		
MEDIUM FARMER	PRESENT	41923	12925	18376	28998	23547	25617	5	128085		
	FUT. W/O	52590	16861	23655	35730	28935	31468	5	157340		18
	FUT. W.	56190	17275	24452	38916	31738	34376	5	171880	7	19
	% CHANGE										
	W/O TO W.	7	2	3	9	10	9		9		
LARGE FARMER	PRESENT	57560	15904	23991	41657	33569	35262	4	141048		
	FUT. W/O	63521	19073	27763	44448	35759	37483	4	149932		17
	FUT. W.	64433	19230	27968	45203	36466	38224	4	152896	6	17
	% CHANGE										
	W/O TO W.	1	1	1	2	2	2		2		
									863164		
								72	919254		

Note: Returns and income for tenants and small farmers comprise final receipts from own and sharecropped land where relevant, i.e. receipts from sharecropped land after deduction of 50% share for landlord.

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