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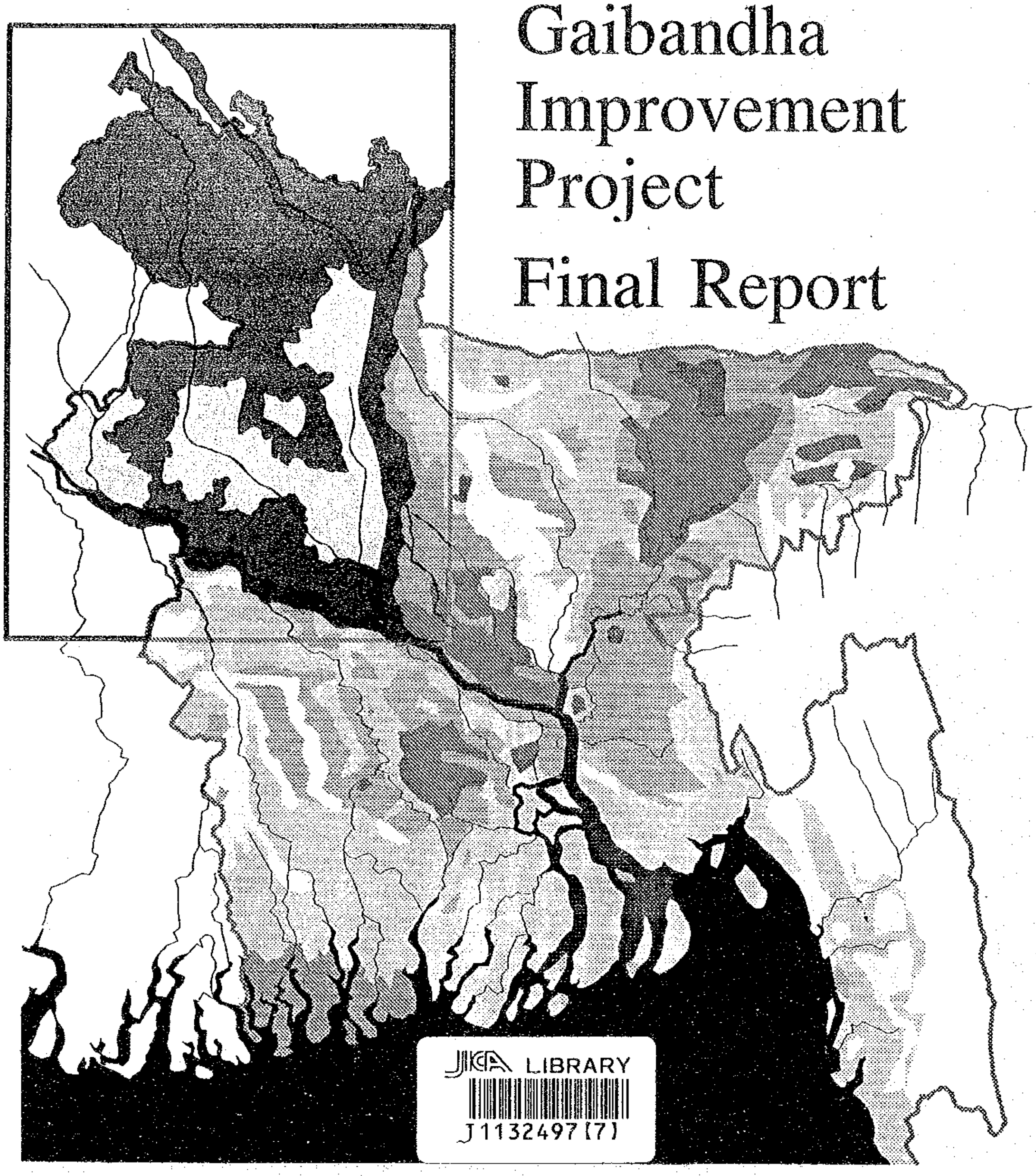
North West Regional Study (FAP2)

Gaibandha Improvement Project Final Report



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

January 1993

North West Regional Study (FAP2) Gaibandha Improvement Project Final

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.
under assignment to
OVERSEAS DEVELOPMENT ADMINISTRATION

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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.

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.

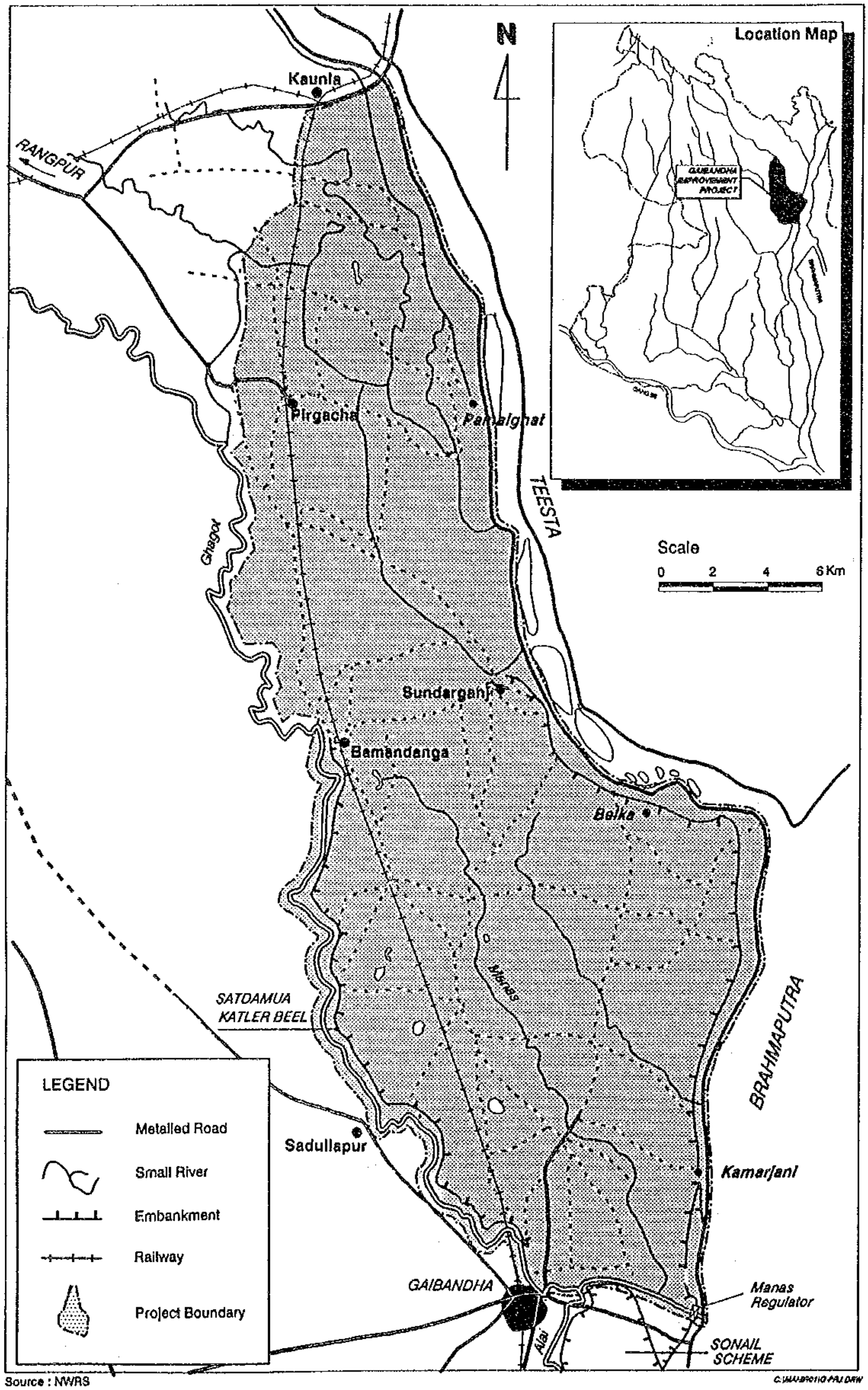
With the exception of the limited number of beels within the area, there are no large areas of persistent deep flooding. The land is intensively farmed and the biophysical environment has been modified as a result of this. Groundwater supplies are adequate and there are no serious problems of water quality. 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



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

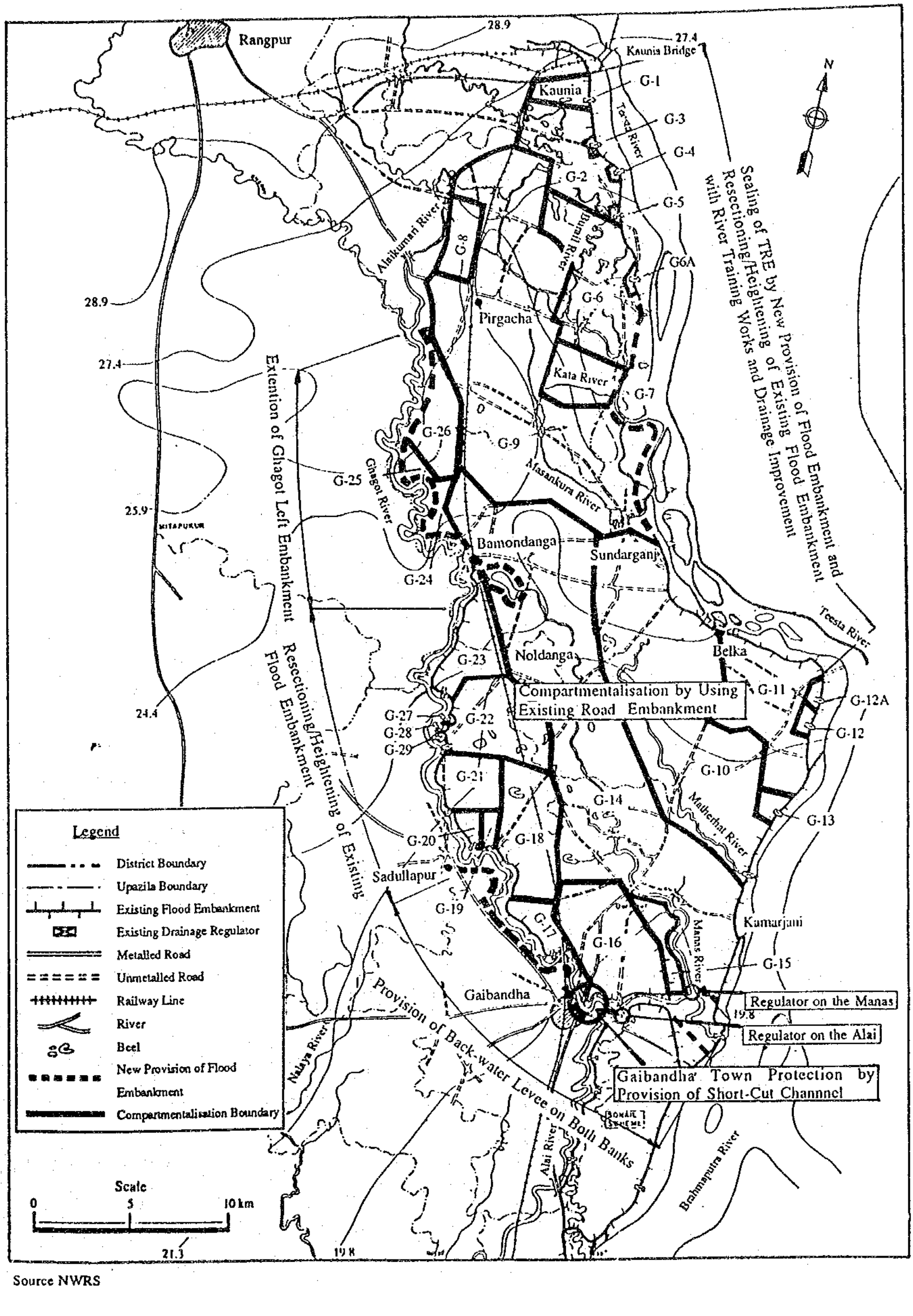
A number of important associated developments should be undertaken at the same time as the main project. These relate to flood proofing, fisheries, navigation, and health.

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.

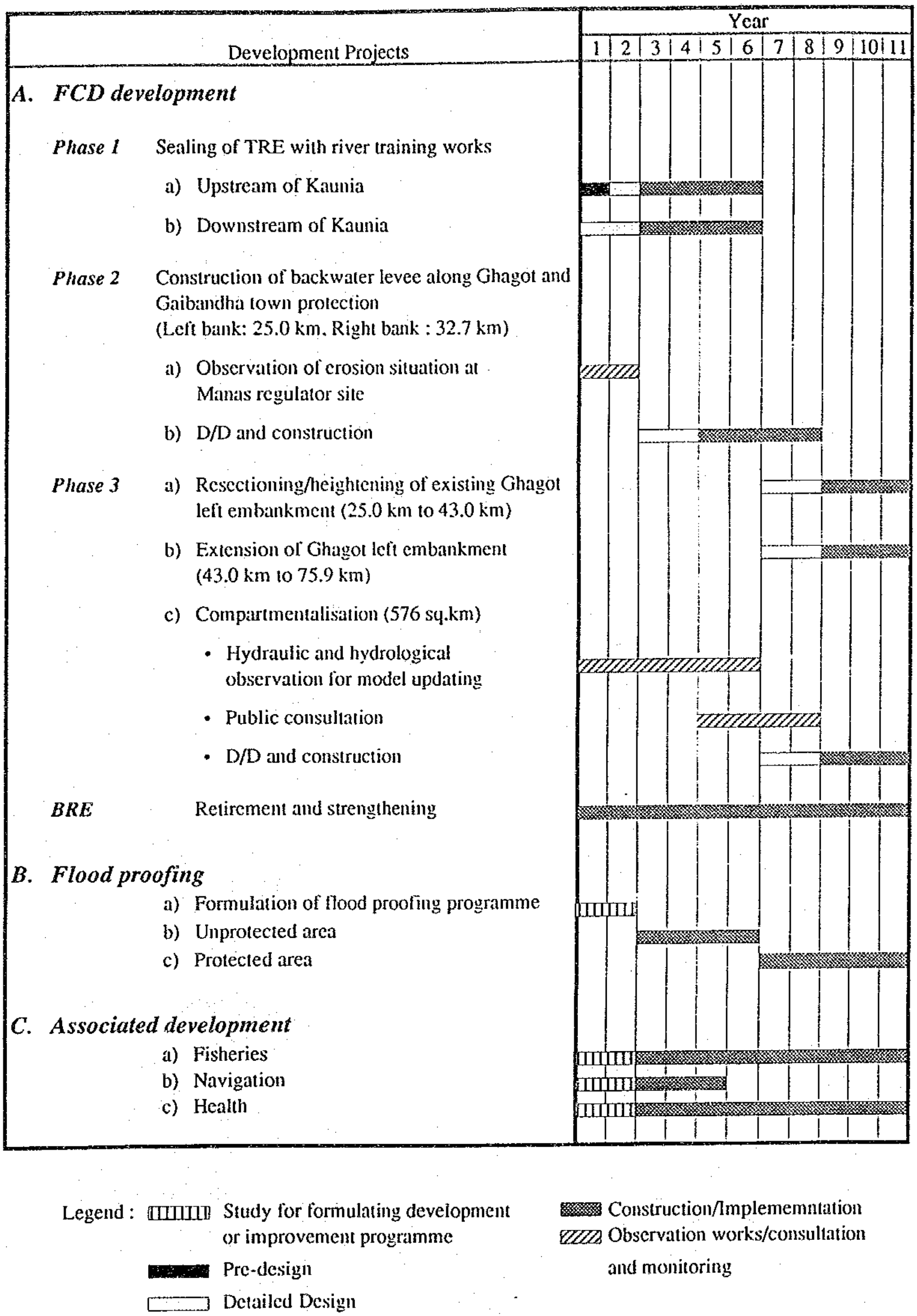
The estimated cost for flood proofing, fisheries and navigation is of the order of Tk 200 million. Health costs are not included, since they are not sufficiently defined at this stage.

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

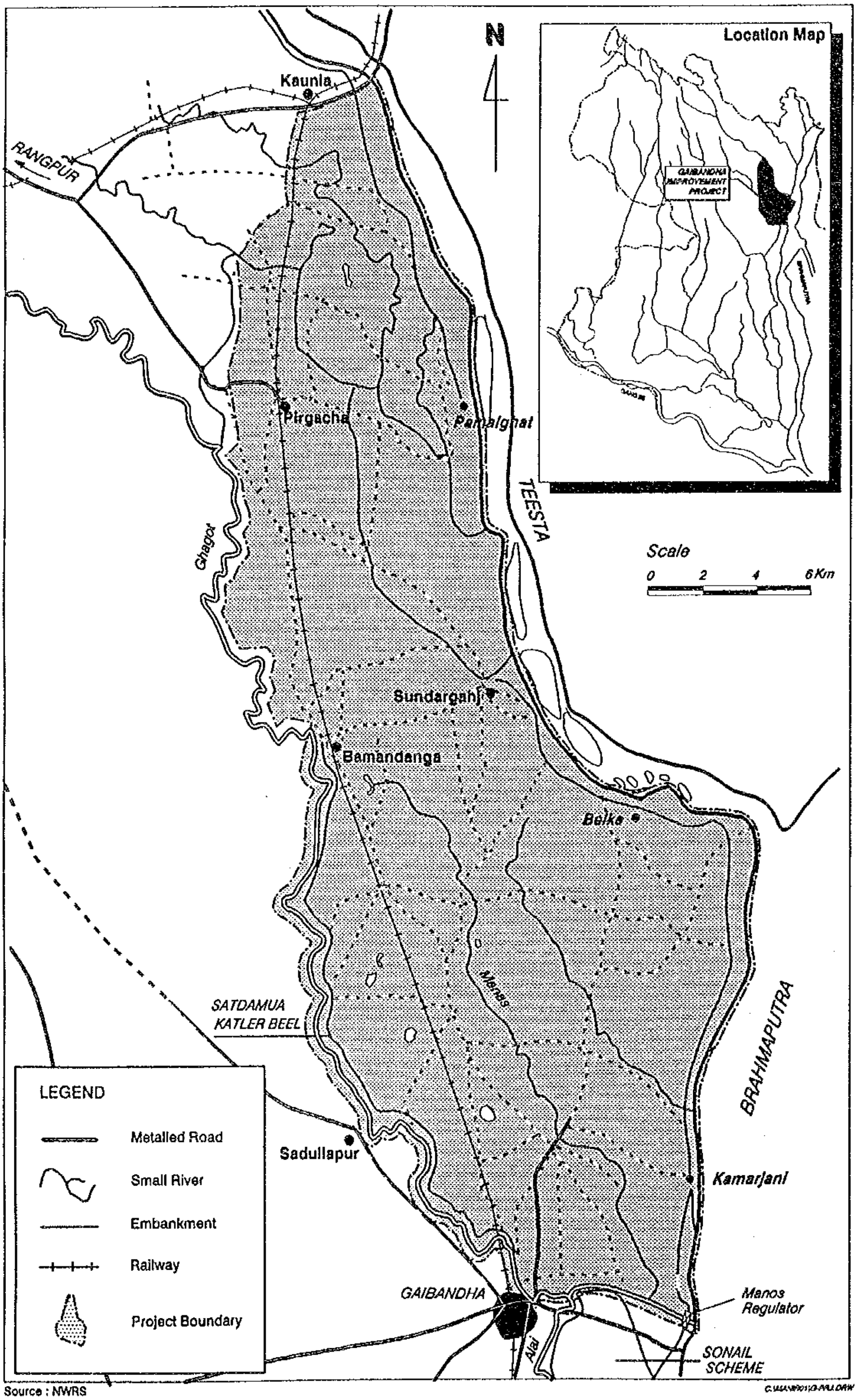
The preparation study for the project forms part of the North West Regional Study (NWRS), which is one of the major components of the Flood Action Plan (FAP). The overall aim of the FAP is to limit the damage due to flooding and to remove the constraint that this places on long-term growth in the country.

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.

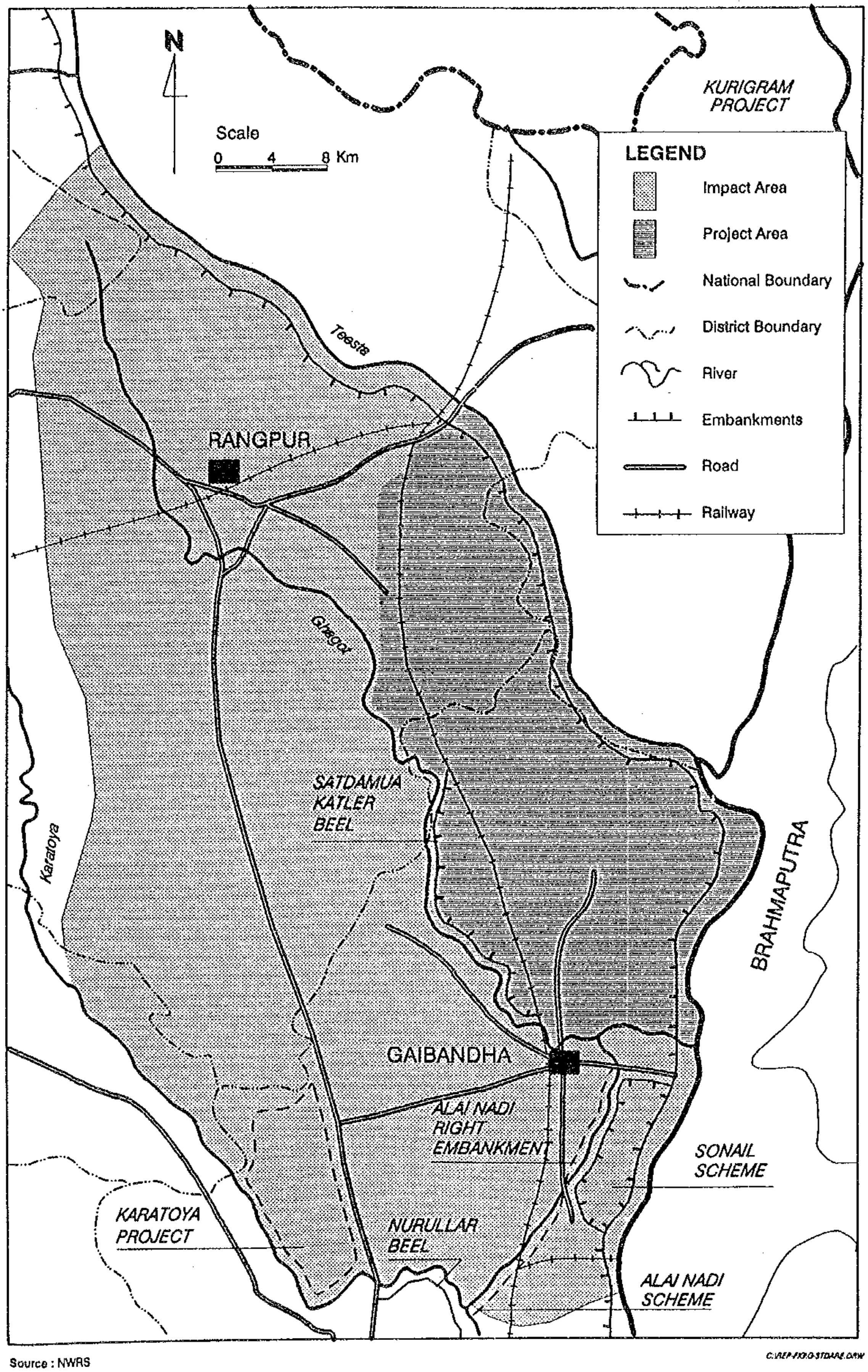
Figure 1.1
Project Area



Source : NWRS

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 charactericts). 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

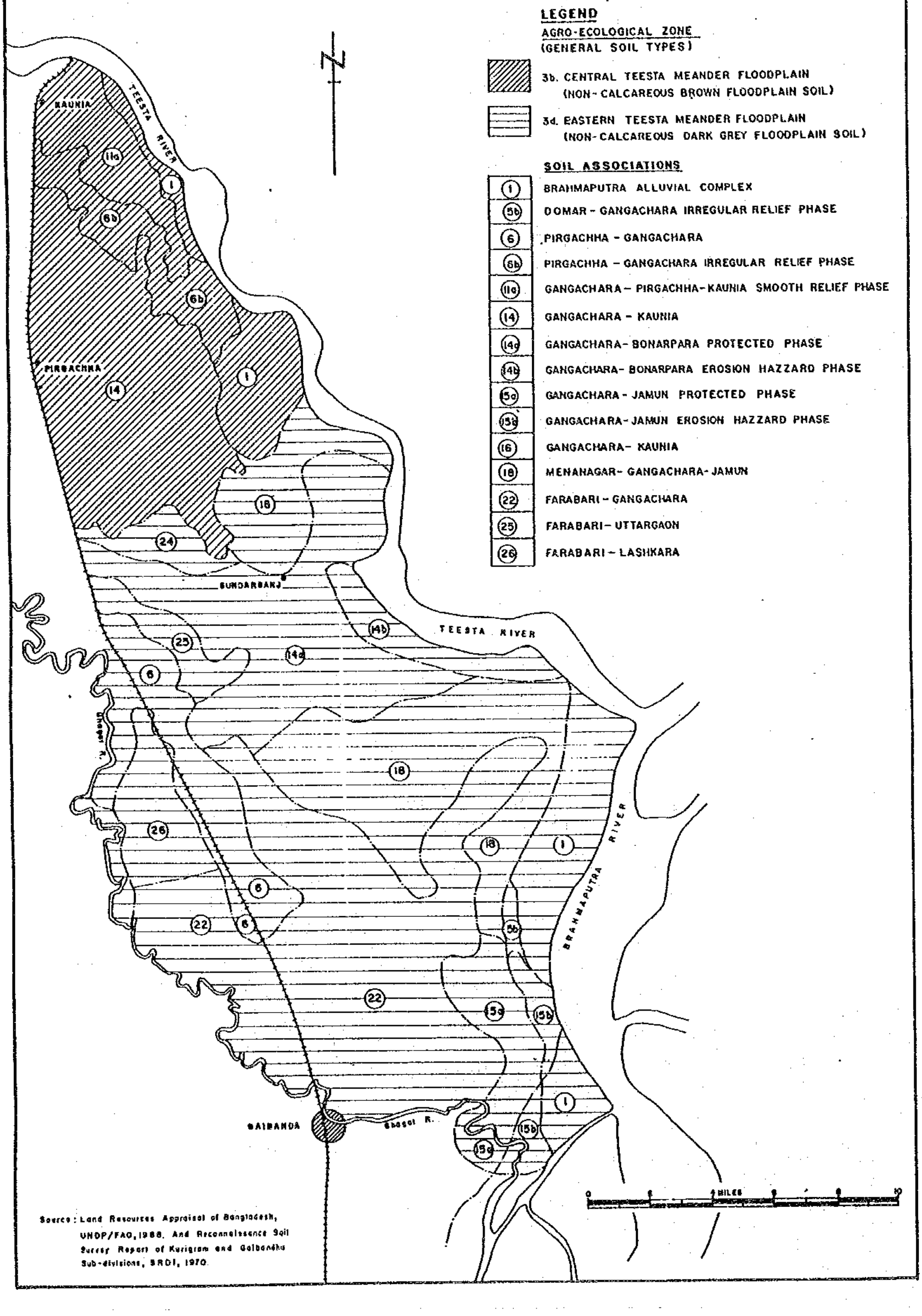


Table 2.3 Present Cropping Pattern, (% of NCA)

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.

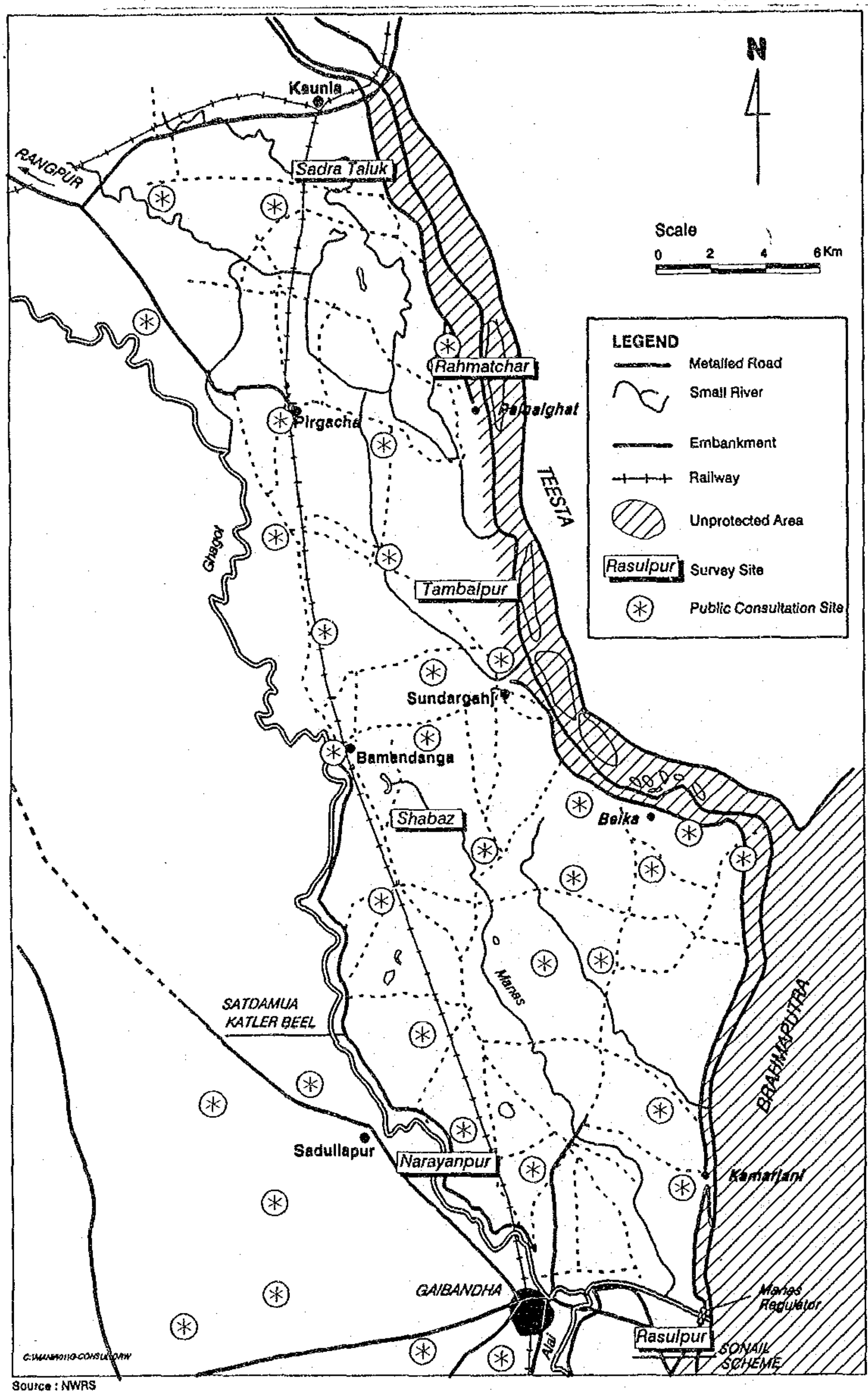
Narayanpur village is on the right bank of the Ghagot river which runs the entire length of Gaibandha district. It is close to the Gaibandha - Sadullapur road and from 1987 onwards has been subject to heavy flooding. Since then over ninety percent of the aman had been destroyed while for late-planted 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.

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

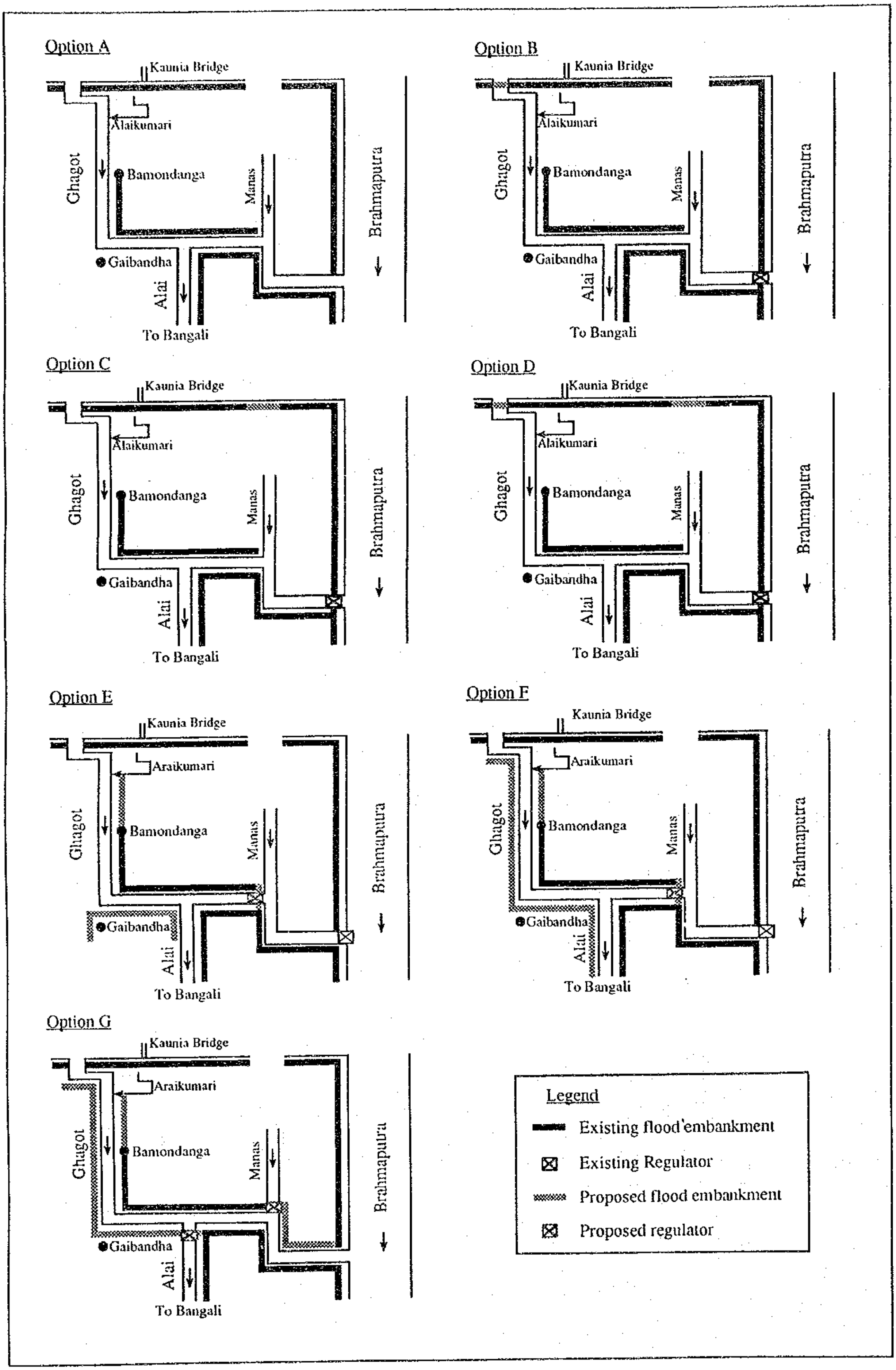
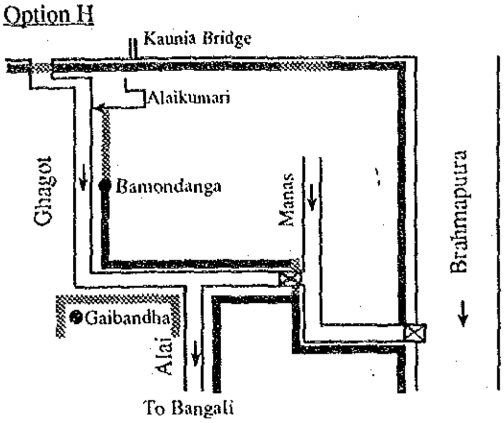


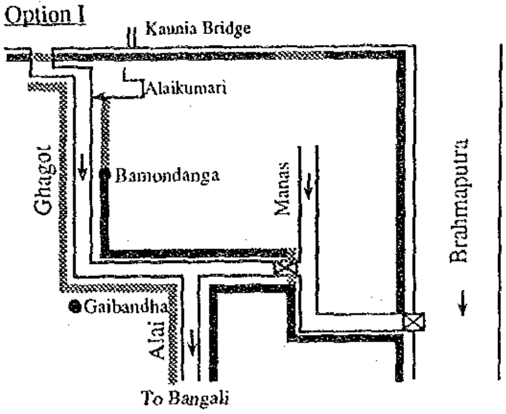
Figure 4.1 (2/2)

Initial Design Options

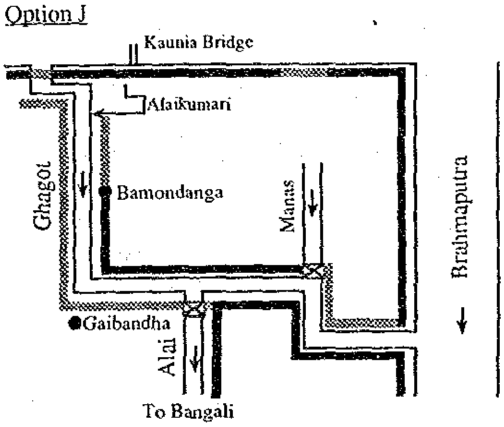
Option H



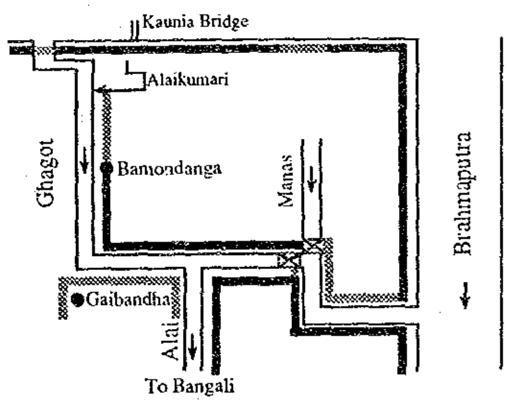
Option I



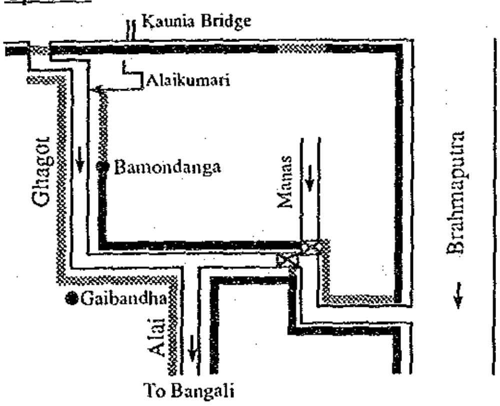
Option J



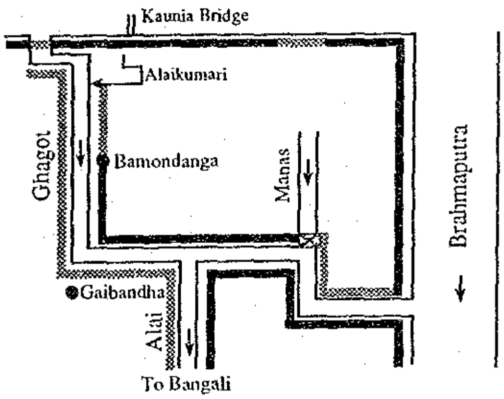
Option K



Option L



Option M



Legend

- Existing flood embankment
- Existing Regulator
- Proposed flood embankment
- Proposed regulator

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.

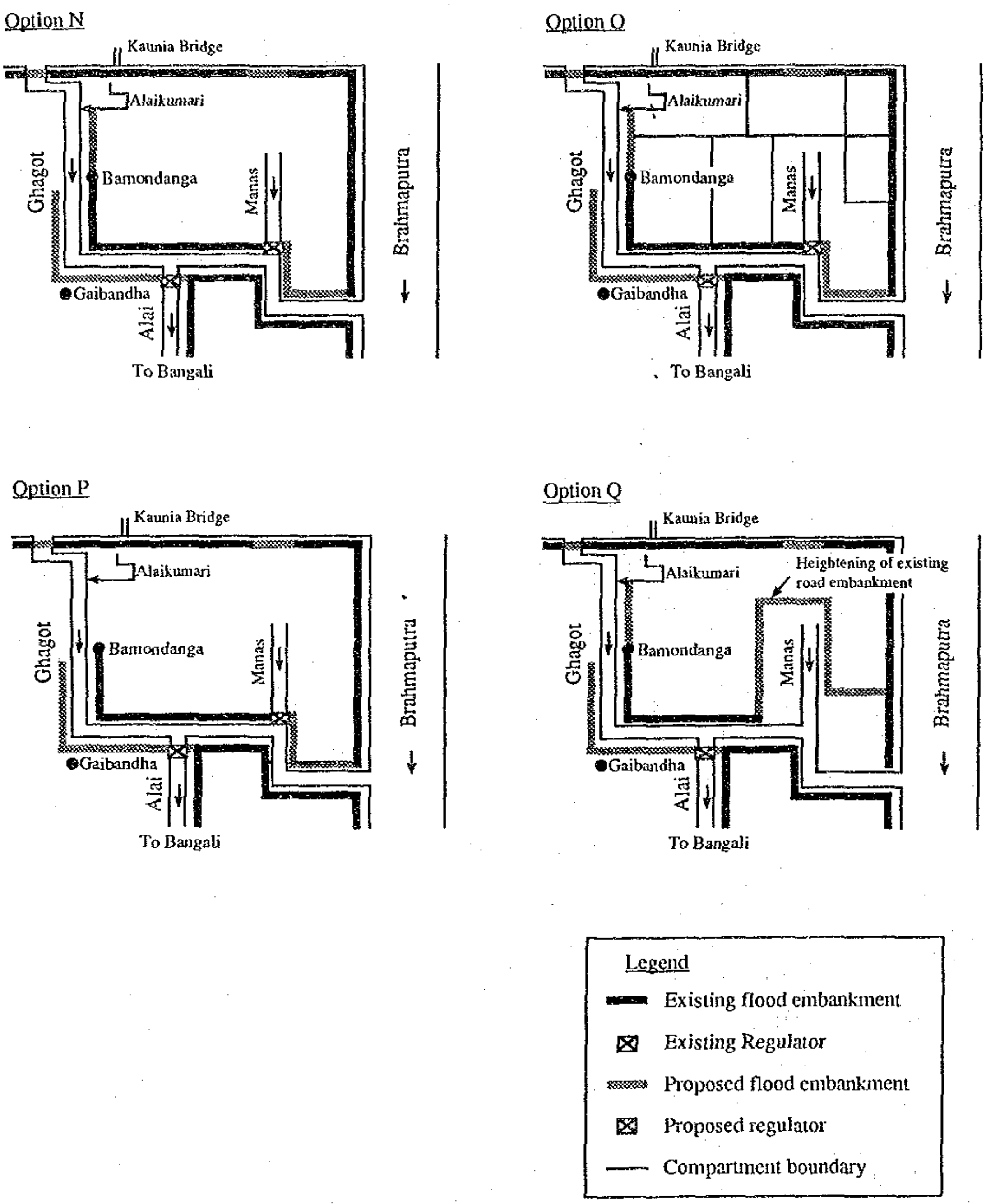
Figure 4.2 presents a schematic representation of each of these refined design options. Table 4.2 summarises each of the options.

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.

Figure 4.3
Flood Phase Analysis-Future Without

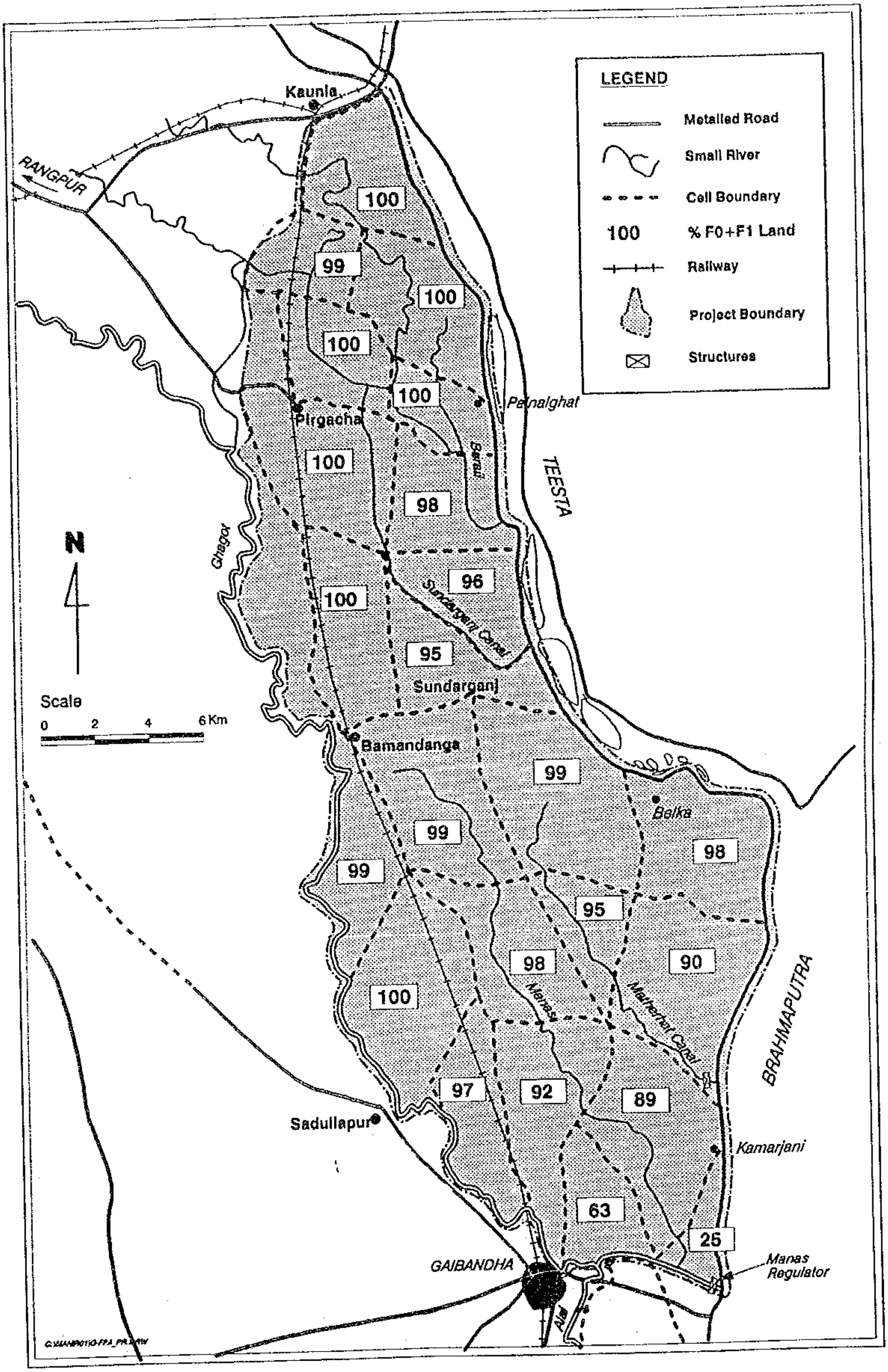
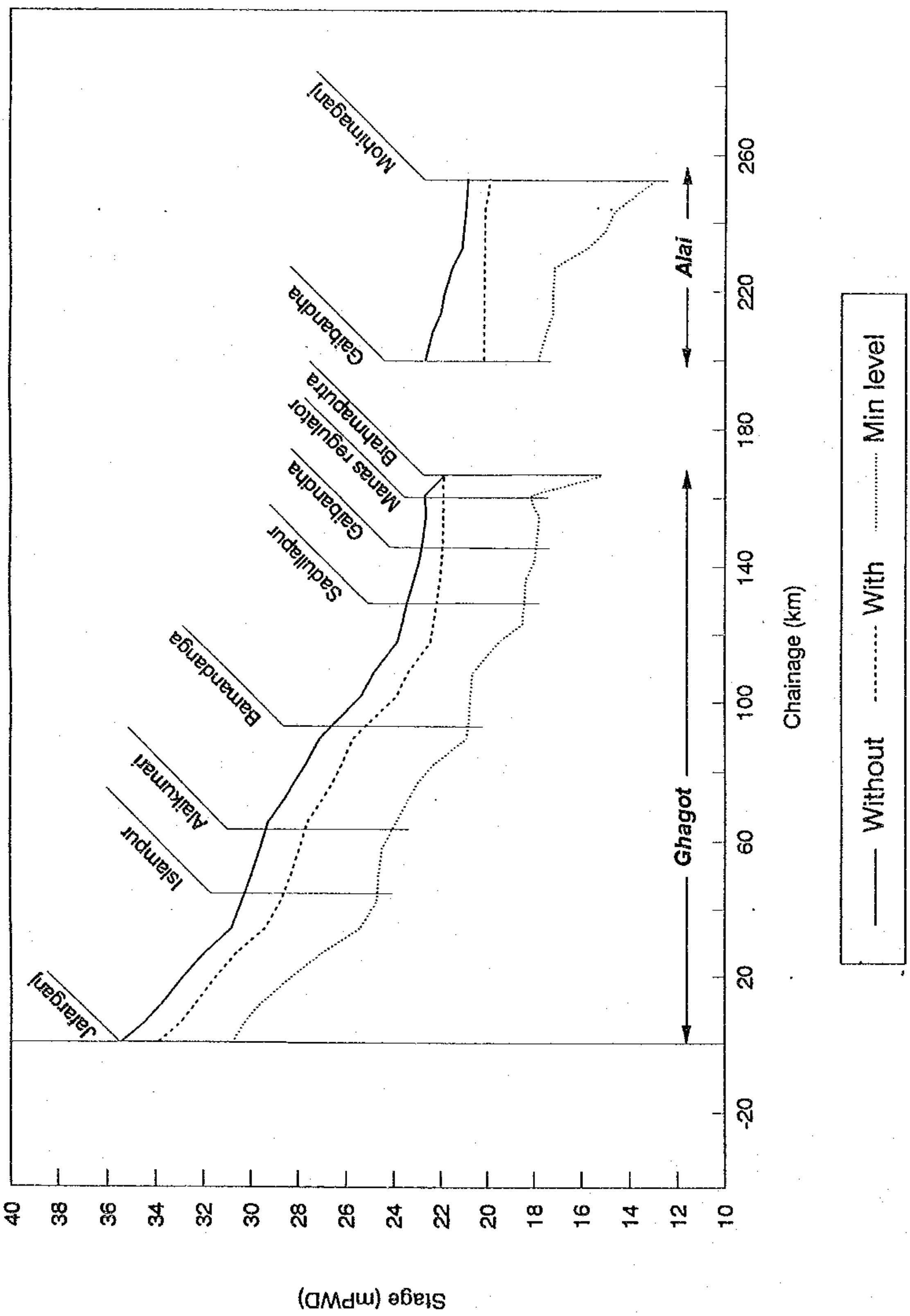


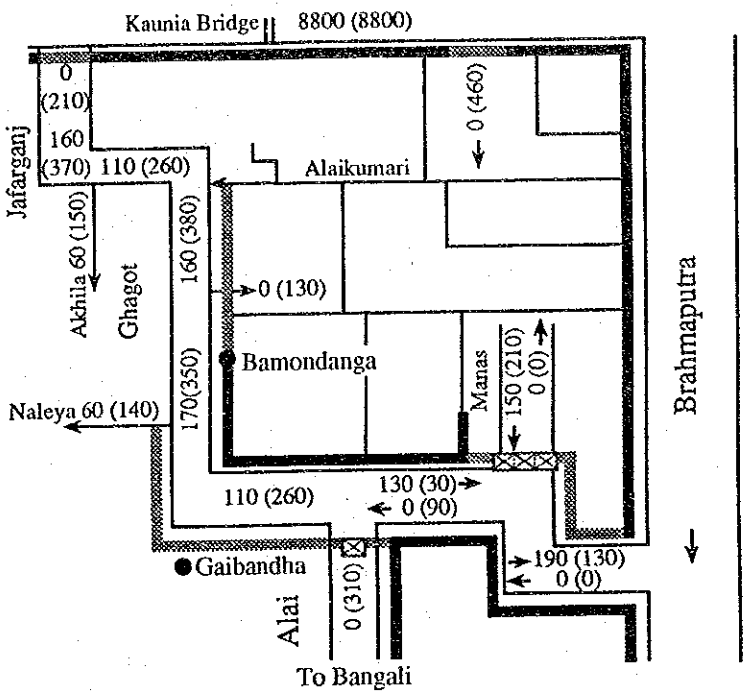
Figure 4.4
Long Profiles (1987) on Ghagot and Alai



C:\MANIRO1\FIG4_4.DRW

Figure 4.5

Peak Discharges



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

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.

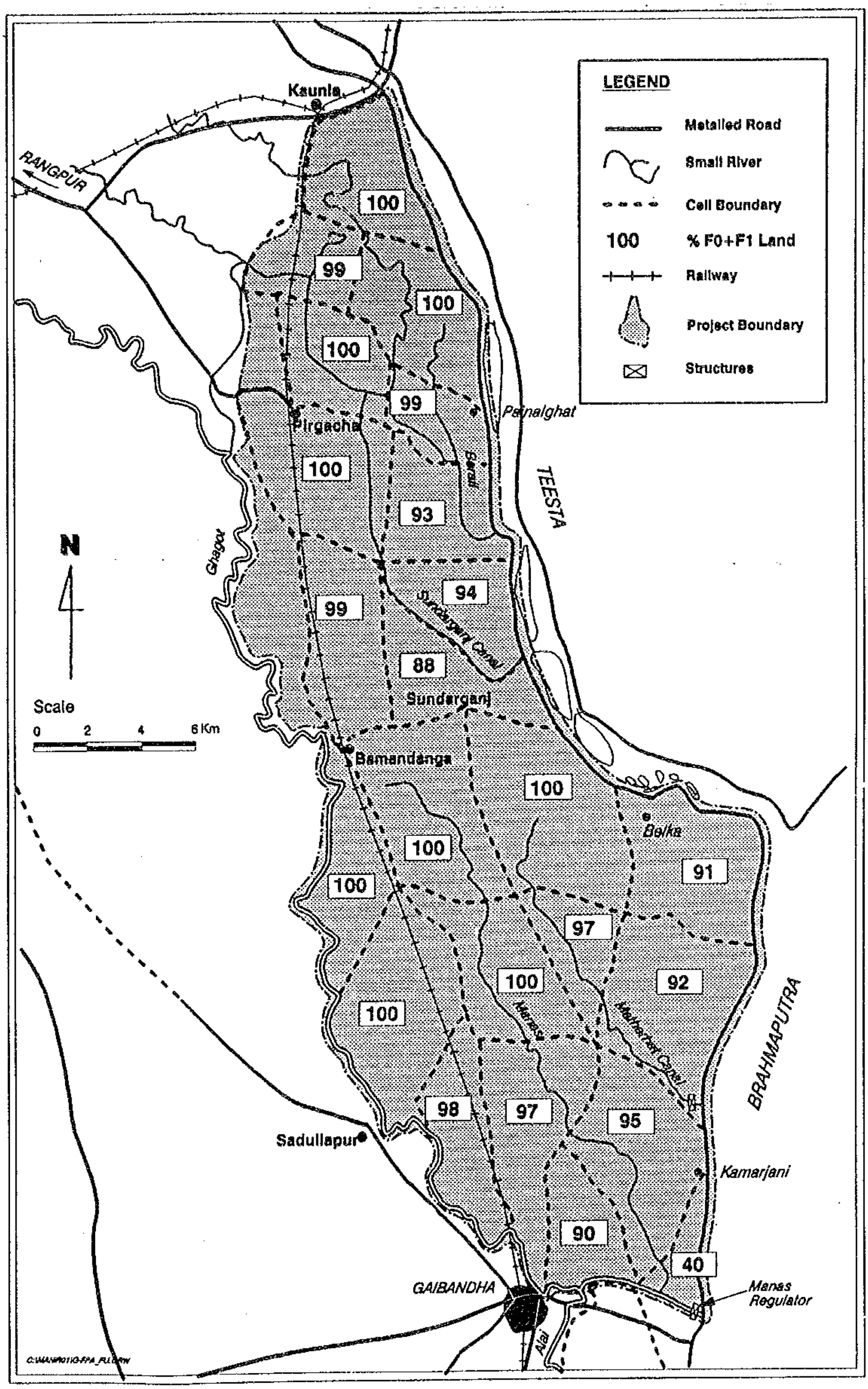
The impact of not sealing the TRE downstream of Kaunia on flood phases is relatively minor. In the areas adjacent to the Teesta the percentage of F0+F1 land is decreased slightly but throughout the majority of the region the flooding patterns remain unaltered. An area adjacent to the TRE was also shown 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.

Figure 4.6

Flood Phase Analysis-Future With



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	km²	0.94	7.89	4.42	3.10
Loss of land	km²	0.0	54.0	54.0	54.0
Production foregone	TK.m/km²	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.