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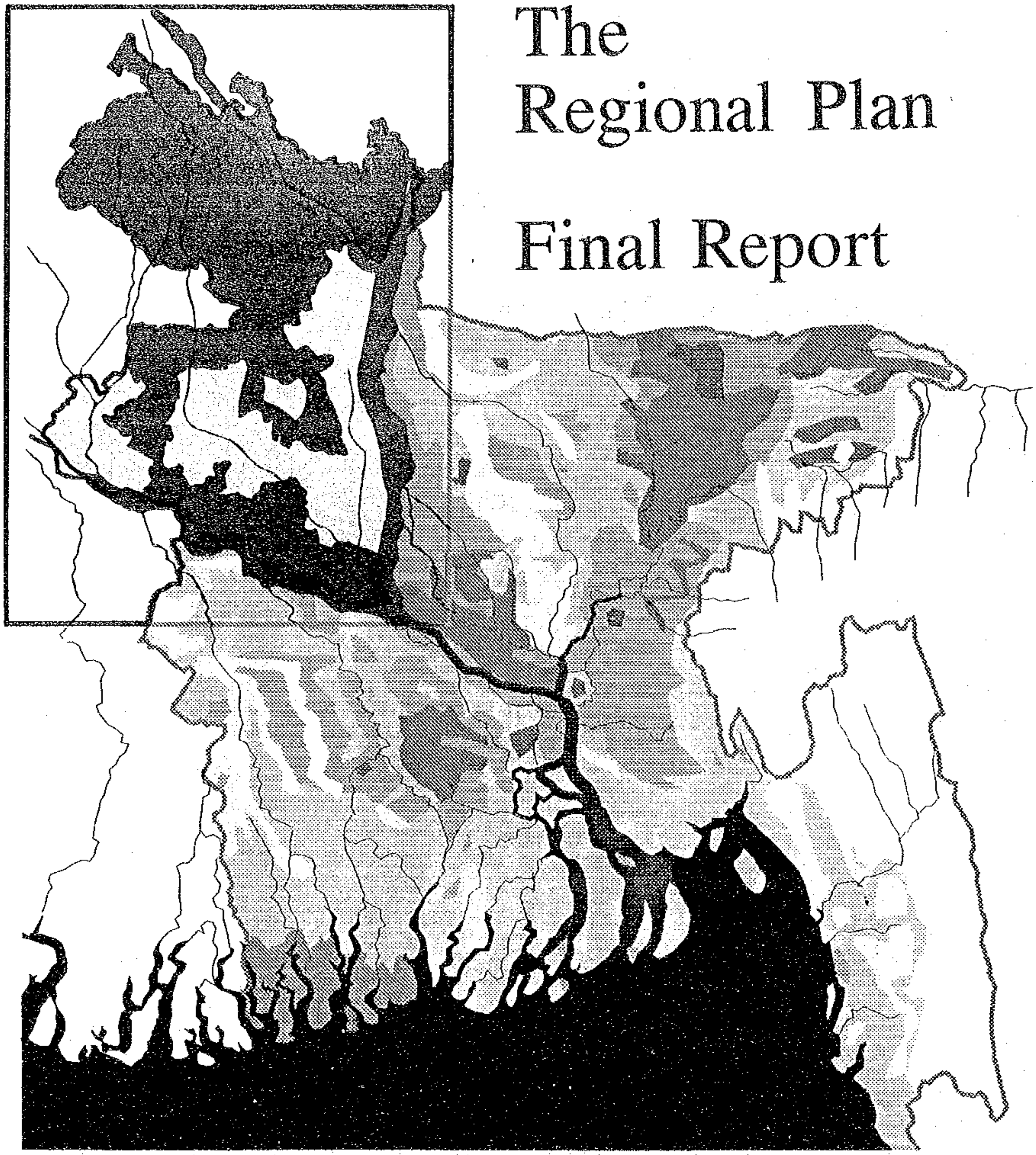
North West Regional Study (FAP2)

The Regional Plan

Final Report



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

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North West Regional Study (FAP2) The Regional Plan 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.
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PREFACE

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

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

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

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

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

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

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ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
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.DI	Flood Control, Drainage and Irrigation
FFW	Food for Work
GIS	Geographic Information System
GIP	Gaibandha Improvement Project
GLE	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 Dation (Water Level)
R&H	Roads and Highways Department
SIDA	Swedish International Development Agency
SIRDP	Sirajganj Integrated Rural Development Project
SRP	Systems Rehabilitation Programme
SSFCDI	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 REGIONAL PLAN

SUMMARY

1. Flooding and Drainage in the Region

The North West region (NWR) covers 3.5 million hectares (Figure 1), and has a population of 25 million people. It shows considerable variation, in relation to such aspects as climate, topography and water resources. These variations are reflected in the range of flooding problems existing within it.

The region has been divided into fifteen planning units in order to provide comprehensive coverage of these problems. Within each unit the flooding situation was assessed by a combination of field visits, primary data collection and analysis of secondary sources. The principle data used related to agricultural cropping, crop and infrastructure damage due to flooding, and water bodies and fisheries.This was supplemented by analysis of hydrological data and the development and use of a hydrodynamic model covering part of the region.

The east and south of the region is bordered by the major rivers, the Brahmaputra and the Ganges. The part of the region along the Brahmaputra suffers particularly severely from flooding caused by breaches in the main Brahmaputra Right Embankment (BRE). This type of flooding is very damaging in the disruption it causes to people's lives, and the losses to agriculture and infrastructure. Similar problems of a more limited scale occur along the Teesta, Dharla and Dudhkumar in the north east of the region. In the south, breaches from the Ganges are not a major source of flooding.

Within the region, flooding and drainage problems are mainly caused by the drainage patterns of the internal rivers. The majority of these drain to the south east to the Lower Atrai/Lower Bangali system, and thence to the Brahmaputra through the Hurasagar outfall. Outfall conditions are often constrained during the monsoon by high levels in the Brahmaputra, and this in turn results in backing up and extensive flooding throughout the Lower Atrai and Lower Bangali. Flooding over three metres regularly occurs over many parts of the Lower Atrai. However, while such flooding constrains agricultural production, it is not a problem in the same way as that caused by breaches from the major rivers since it develops more slowly and does not cause the same amount of social disruption.

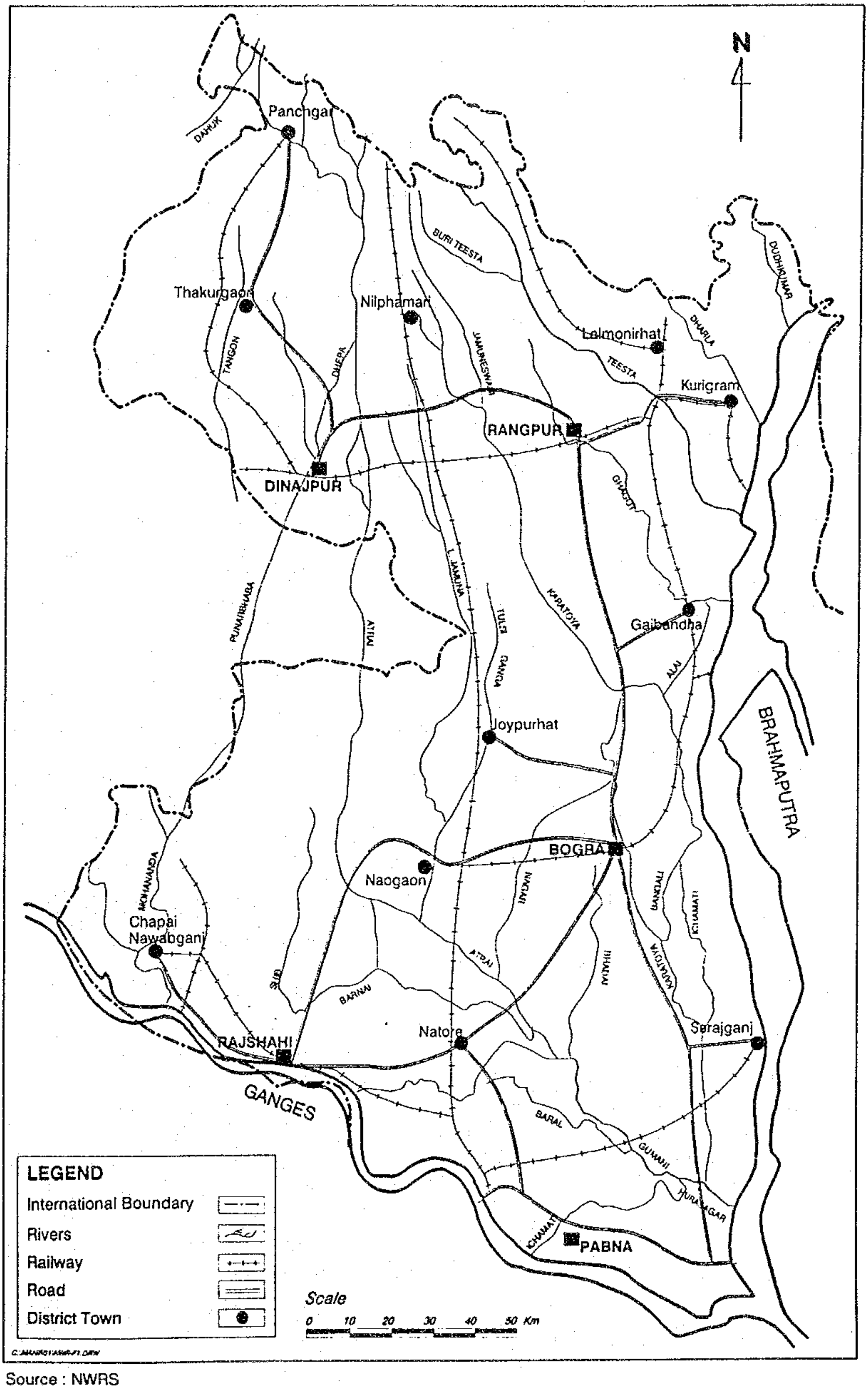
The upper reaches of the region are steeper than elsewhere and are susceptible mainly to flash flooding. In most cases the floods last only for a few days and do not cause a great deal of damage to crops, though they can do to infrastructure.

2. Approach to Planning

Planning for the region has been based on a number of broad principles. The main objective has been to create a stable flooding regime which gives local people the ability to plan their lives with some degree of confidence and which allows them control of the local natural resources. A second aim has been to create a sustainable pattern of development, which balances the requirements of agriculture, fisheries, navigation, groundwater and the environment. The third aim has been to safeguard lives and property to the extent possible at the time of major floods.

Within these broad objectives a number of other principles have been applied. The most significant feature of flood protection measures is the impacts that they have on adjacent and downstream areas.

Figure 1
The North West Region



Source : NWRS

Generally flood control in one area will lead to increased water depths or discharges and consequent disbenefits elsewhere. In extreme cases this leads to the cutting of flood control embankments by people, in an attempt to reduce level differences between the protected and unprotected areas. Such "public cutting" is widespread through the region. It causes significant loss and damage and is an important source of social conflict and tensions. For this reason a major policy adopted has been to avoid, as far as possible, any plans which would result in significant disbenefits downstream or elsewhere. While it is not possible to apply this principle always, it meant, for example, that structural measures have generally not been recommended in the upstream reaches, since this would have the effect of increasing discharges and flooding in the downstream reaches, where serious problems already exist.

Experience of previous developments indicates that small-scale schemes often perform better than larger ones, because they can be implemented more quickly and local people can more easily be involved in their management. Thus emphasis was put on small-scale schemes; however, these must take place within a regional or sub-regional context which tries to ensure, as far as possible,that disbenefits do not occur elsewhere.

Flood control and drainage (FCD) schemes are extensive throughout most of the region, and there are many existing and on-going projects. Considerable efforts have been applied to integrating the planning with these existing developments where appropriate, and to making the best possible use of existing infrastructure.

A broad range of responses to flood and drainage problems exist. Structural responses are based on embankments to exclude the water, and drainage channels and structures to drain it rapidly. Within the general policies of the Flood Action Plan (FAP) structural measures are intended to provide controlled flooding and drainage (CFD) facilities to the protected areas, which will allow the beneficial use of flood water for agriculture, fisheries, navigation and the environment, but exclude the damaging major floods. In parts of the region a modified approach needs to be applied, which provides partial protection only. This is intended to provide sufficient protection for the harvesting of the important dry season irrigated rice crop (boro) and perhaps for the transplanting of the deep water monsoon crop in the early part of the monsoon, but to allow flooding over the protected area at the peak of the monsoon. Partial protection, particularly in the Lower Atrai, reduces disbenefits to adjacent areas and allows a more predictable and stable flooding regime, than an attempt to completely exclude the peak floods.

Within the FAP efforts are being made to introduce the concepts of compartmentalisation, in which protected areas are sub-divided into smaller units provided with structures and facilities which will give local people control of flood and water resources. This concept has considerable long-term potential within Bangladesh but a great deal of work needs to be done to develop it within the socio-economic context of the country. In planning for NWR, compartmentalisation has been used to mean the provision of facilities which, as far as possible, eliminate cross-drainage basin water transfer,and therefore reduce volumes and discharges of floodwater. This is a first step towards more active water management policies but at the same time it reduces the need for close co-operation between different groups of people who may have different water management needs and priorities.

There are a considerable number of non-structural measures which can also be applied to reduce or mitigate flooding problems. These are grouped under the general term "flood proofing" and include such measures as raising important infrastructure on platforms above the expected flood level, instituting flood warning systems, and providing secure stores for emergency relief and grain. Such measures are relevant everywhere but particularly important for unprotected areas. Generally they should be seen as complementary measures to the structural measures discussed above.

3. Development Scenarios

Development scenarios were formulated for all the major parts of the region.

The Brahmaputra Right Embankment

Analysis shows that the most serious flooding problems occur along the Brahmaputra due to breaches in the Brahmaputra Right Embankment (BRE). It also shows that most of these problems can be eliminated, if it can be effectively sealed. Sealing of the BRE is therefore the priority measure for the region. This is the responsibility of the FAP1 project: studies are on-going and priority works at key locations are in hand. Long-term planning for the NWR has assumed that the Brahmaputra Right Bank can be effectively sealed by a combination of heavy engineering works or strategic bank retirement.

Upper Karatoya/Middle Bangali System

The Upper Karatoya basin is subject to extensive flooding at its downstream end where it joins the Bangali system. Proposals for this area include CFD works along both banks of the river. However, in keeping with the principle that upstream works should not lead to increased disbenefits downstream, these developments are associated with a major drain, the "Bangali Floodway", which connects the Upper Karatoya to the Brahmaputra, and diverts all flows apart from a residual flow to the main river. Thus the increased discharges due to the CFD works on the Upper Karatoya are not transferred downstream.

The most important measure in the Middle Bangali System is sealing of the BRE (as described above). If this can be successfully accomplished major projects to reduce flooding conditions are not needed, though there is potential for some drainage improvements, together with measures to improve dry-season water management. In addition, consideration has been given to providing a "second line of defence" against flooding if the BRE itself fails. Three possibilities have been examined but it is recommended that any available investment should be concentrated on the BRE itself rather than put into structural measures for a second line of defence. Flood proofing in the areas susceptible to damage from BRE breaches is an important associated measure.

The Lower Atrai/Lower Bangali System

Extensive development of FCD works have taken place in the Lower Atrai. On the whole these have not performed as well as expected due to problems of increased water levels, public cutting and consequent damage. Full protection along the Lower Atrai is now considered an infeasible solution. A number of alternatives were investigated to try to improve the situation, including major drains which would divert water entering the Lower Atrai and channel it to the main rivers, thus considerably reducing the water entering the Lower Atrai. These were found to be infeasible. An alternative engineering solution suggested was a large regulator at the Hurasagar outfall: however, since the problem at the outfall is the constraint set by the outfall level in the Brahmaputra, rather than backflow from the Brahmaputra to the Atrai, this structure would not be effective.

The main scenario examined for the Atrai has been the "Green River". In this, partial protection only is provided near the Atrai itself, so that at peak monsoon water flows over the floodplain, as it would have done in its natural state. Away from the river the existing infrastructure is utilised as far as possible to provide CFD facilities. The Green River scenario is intended to stabilise the existing situation so that local people can plan their lives accordingly; it enables considerable agricultural production to take place, while at the same time reducing the disbenefits due to confinement, facilitates floodplain fisheries and navigation and reduces adverse environmental impacts. Within the broad "Green River" scenario, a number of variations were analysed.

Teesta Basin Development

Breaches from the river Teesta cause similar problems to those along the Brahmaputra but on a smaller scale. The main development scenarios involve repairing and sealing the Teesta embankments, which already exist along both side of the river for most of its length. Drainage lines are from north to south so that the impacts of breaches on the left bank are relatively limited in extent. On the right bank, natural slopes mean that flooding from breaches can have effects far downstream.

The first component of work on the Teesta is the Gaibandha Improvement Project, for which a feasibility study was carried out as part of the North West Regional Study. The project comprises sealing of the Teesta right embankment, together with improvements to the internal rivers and compartmentalisation within the project area. The plan involves altering the configuration of the confluence of the Ghagot and Brahmaputra in order to discharge flows from the internal rivers to the Brahmaputra as far upstream as possible. This has benefits not only for the Gaibandha Project area but also downstream.

Other Areas

A limited number of proposals in other areas were investigated. This is in keeping with the general policy of not exacerbating downstream problems by further developments upstream, where flooding problems are in general not so acute anyway. On-going projects are in hand by others in the Kurigram area in the NE of the region, in Pabna, Baral, and Rajshahi in the south of the region, and there are numerous much smaller on-going developments. NWRS prepared proposals for the right bank of the Little Jamuna, where fairly extensive flood damage problems are known to exist, and for the right bank of the Mohananda.

4. Benefits

The main economic benefits of flood protection works are derived from agricultural production, and avoidance of crop and infrastructure damage. Cropping benefits derive primarily from a transition from the broadcast monsoon rice crop (b.aman) to a transplanted monsoon rice crop (t.aman), which needs much lower depths of flooding to be successfully grown, and to replacement of local by HYV t. aman. If the change from b.aman to t.aman can be successfully accomplished, financial and economic returns are high. In the NWR, the rivers rise relatively late at the start of the monsoon, after the boro crop has been harvested. This means that there are generally not significant benefits to flood protection works related to the protection of boro. Crop damage due to flooding occurs to both aman crops and is significant throughout the south and east of the region, particularly along the main rivers. Benefits to CFD works from avoiding this damage are significant.

The economic benefits to agriculture are offset by disbenefits to fisheries. However there are two components to the fisheries. Culture fisheries should generally benefit from CFD works, since it provides a more stable flooding regime and prevents losses. This is not normally sufficient to compensate for losses of capture fisheries on the flood-plains, which may be caused by blockage of fish migration routes between the rivers and the flood-plain. (There are, of course, other factors contributing to losses of flood-plain fisheries, notably over-population and overfishing).

Bank protection works along the main river banks are expensive because of the erosive nature of the rivers. In economic terms such projects may be marginal unless there are specific factors operating, such as the protection of urban infrastructure. Their social benefits are, however, considerable. CFD works within the region, by contrast, are relatively cheap, since they normally involve the rehabilitation or modification of existing facilities. This is particularly the case along the Lower Atrai. Returns to CFD projects can therefore be high.

Economic returns are very sensitive to the returns to agricultural production, and particularly to changes in the monsoon rice crop. Fisheries disbenefits are considerably less in economic terms (around 20-30% of agricultural returns) but depend on the area proposed for the development and the characteristic of the intervention works. Returns are not particularly sensitive to project costs. This means that plan and project appraisal needs to pay particular attention to forecast changes in rice cropped areas (it is assumed that CFD development will not cause changes in yields) and to rice prices.

Cost are naturally an important factor. Judgements are necessary, for example as to the relative merit of river training works against probable recurrent retirement of embankments. Not only are direct costs important (i.e. new land costs, new embankment costs) but social benefits need to be considered.

5. Impacts

Besides economic benefits, there are a number of important social and environmental impacts.

The social benefits of protective works along the main rivers are considerable. River erosion causes loss of land, displacement of population, and loss of social cohesion, as well as putting a strain on scarce local relief resources. Even for those who do not lose their lands to the major rivers, breaches through the main embankments are very damaging, disrupting living patterns, damaging crops and infrastructure and preventing development.

On the inland rivers, social benefits from flood protection are more mixed. Since the flooding takes place more slowly it is easier to adapt living patterns to it, and social disruption does not take place on the same scale. Moreover, successful CFD works tend to increase agricultural production, so that benefits go to those who already own land. (The benefits in increased employment for the landless, both during construction and thereafter for agriculture are, however, considerable.) Changes to fisheries also have important social consequences. Culture fisheries tend to increase, thus benefiting those who own the land on which it takes place. Capture fisheries tend to decrease, thus reducing access for poor and landless people to common property resources and an important source of nutrition.

There is evidence that health patterns may potentially be affected by CFD works, with attendant social consequences. However the situation is complex because of the inter-related factors of poverty and population pressure.

CFD works have a number of impacts on the bio-physical environment. The most important relate to bio-diversity, flood-plain fertility, the wetlands, groundwater, and morphology. All these impacts are significant and need to be appropriately taken into account during planning. However, in the case of bio-diversity, flood-plain fertility, and the wetlands, it should be borne in mind that CFD works are only part of a complete system which is putting great strain on these resources. The key impact on bio-diversity is the increasing reliance on HVY rices, but this is as much the result of irrigated boro cropping as CFD: indeed there is some evidence that bio-diversity increases on higher flood-free lands which support a variety of plant and animal species, and to that extent CFD may have a positive impact. The wetlands and water bodies have considerably reduced in extent over the last two decades but this is also due to pumping for dry season irrigation as much as to CFD works. The key role for the wetlands now lies in the part they play in fishing systems. Fisheries initiatives related to the regional plan are discussed in Section 6.

There is evidence that flood-plain fertility is increased by the fixing of nitrogen through blue-green algae which accompany extensive flooding. On balance, while this is a significant factor, it would not seem to be of over-riding importance in making decisions about implementing CFD measures.

Analysis carried out during NWRS indicates that the impact of possible works on the groundwater resource may be of significance but is also not of over-riding importance. The groundwater resource is generally fairly abundant throughout the NW and potential recharge is high. There are areas where constraints to groundwater development occur: these need to be judged on an individual basis.

Possible morphological impacts on internal rivers are significant but similar in degree to those already experienced within the region. However, if the pattern of damage and disruption from major river flooding is repeated throughout the country, an extensive programme of sealing major river embankments may result. The long-term morphological implications of such a programme need careful consideration at the national level.

6. The Regional Plan

Structural Measures

The main components of the regional plan are shown in Figure 2. They include the following:

- sealing of the BRE to the extent possible, under the FAP1 programme. An associated programme of flood proofing should be carried out in areas particularly susceptible to damage from breaches through the BRE. Developments behind the BRE related to the "second line of defence" should await the result of the Compartmentalisation Pilot Project at Sirajganj.

- the implementation of the Green River strategy in the Lower Atrai, to provide partial flood protection close to the river and full CFD facilities in upland areas. This would take the form of a sub-regional development plan, together with a feasibility study for the stabilisation and improvement of Chalan Beel Polders C and D (Polder 2 is under redesign this year through another project).

- development of the Teesta Right Bank, initially in association with the Gaibandha Improvement Project;

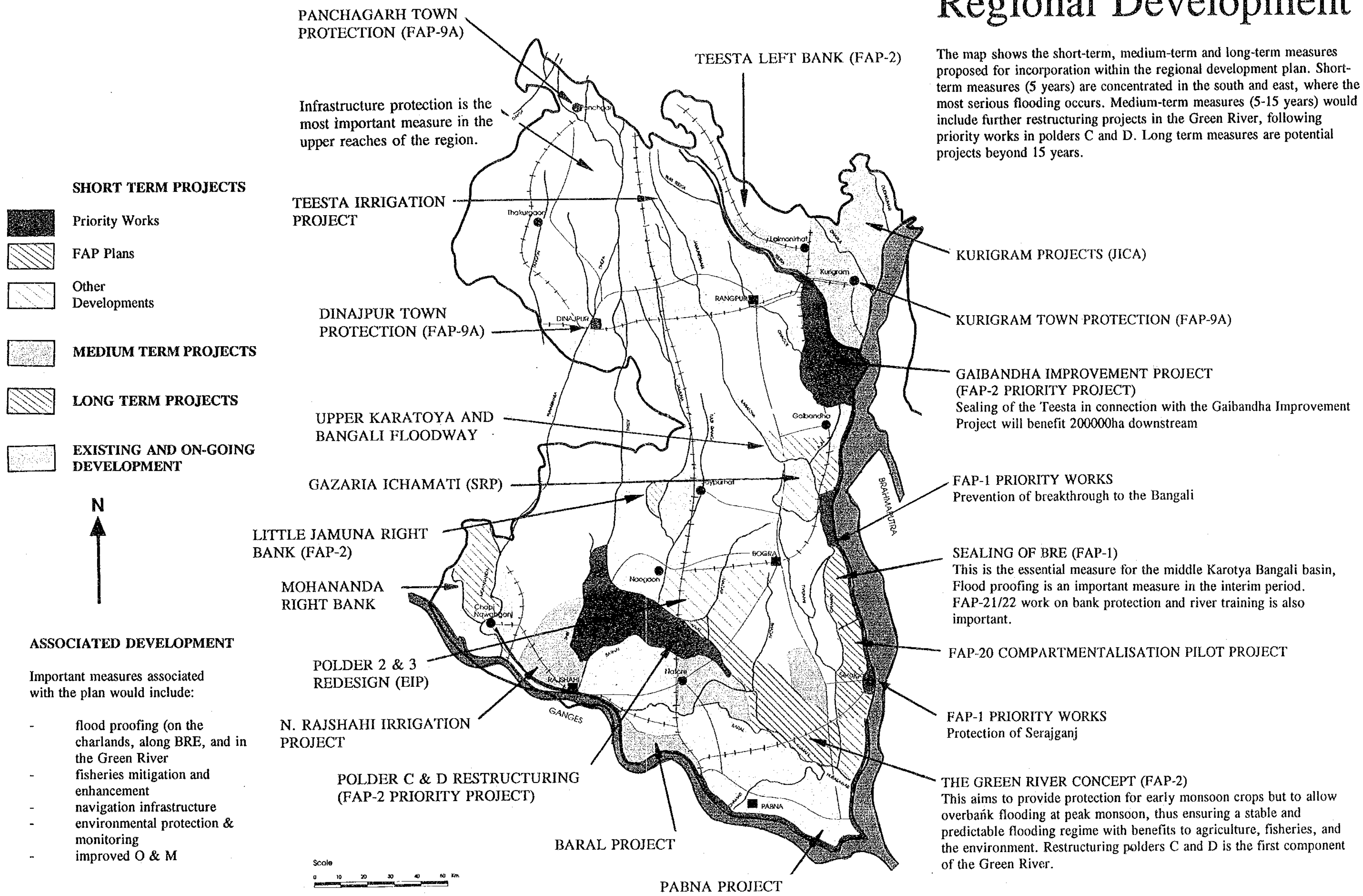
- development of flood protection and drainage measures by others in other areas, notably Kurigram South under JICA funds, Bogra Polder 2 redesign under EIP and improvement of Gazaria-Ichamati under SRP.

- flood proofing and protection of towns and other infrastructure in the upstream reaches.

Figure 2

Regional Development

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



ASSOCIATED DEVELOPMENT

Important measures associated with the plan would include:

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

- other schemes show lower returns but could be considered for development in the long-term. These include developments on the right bank of the Mohananda, and of the Upper Karatoya/Bangali Floodway.

The major drains and the Hurasagar Tail Regulator were found to be non-viable and are not recommended for inclusion within the regional plan.

Tables 1 and 2 summarise the main details of each possible component of the plan and ranks them into four broad categories. Economic returns are high for Green River developments in the Lower Atrai and for the small development on the right bank of the Little Jamuna. They are marginal for the Gaibandha Improvement Project and the Teesta Left Bank. Returns are low for the other major developments considered. Social and environmental impacts are generally shown as negative but are not of such magnitude as to necessitate rejection of the proposals. In the case of sealing the major embankments, social impacts are entirely positive. However, as noted above, the long-term morphological impacts in the main rivers if a widespread programme of major river embankment sealing takes place needs to be studied.

Associated Development

A programme of associated development is recommended for implementation with the plan. This includes:

- a programme to mitigate capture fisheries losses;
- programmes for the development of navigation facilities;
- programmes to mitigate adverse impacts on health status;
- a programme of flood proofing, particularly behind the BRE, on the unprotected lands in the main rivers (the chars), and in the upper reaches where major CFD interventions are not recommended.

Consideration must be given to tying the associated development programmes to structural intervention under FAP in order to ensure that sufficient emphasis is given to them by the other agencies involved.

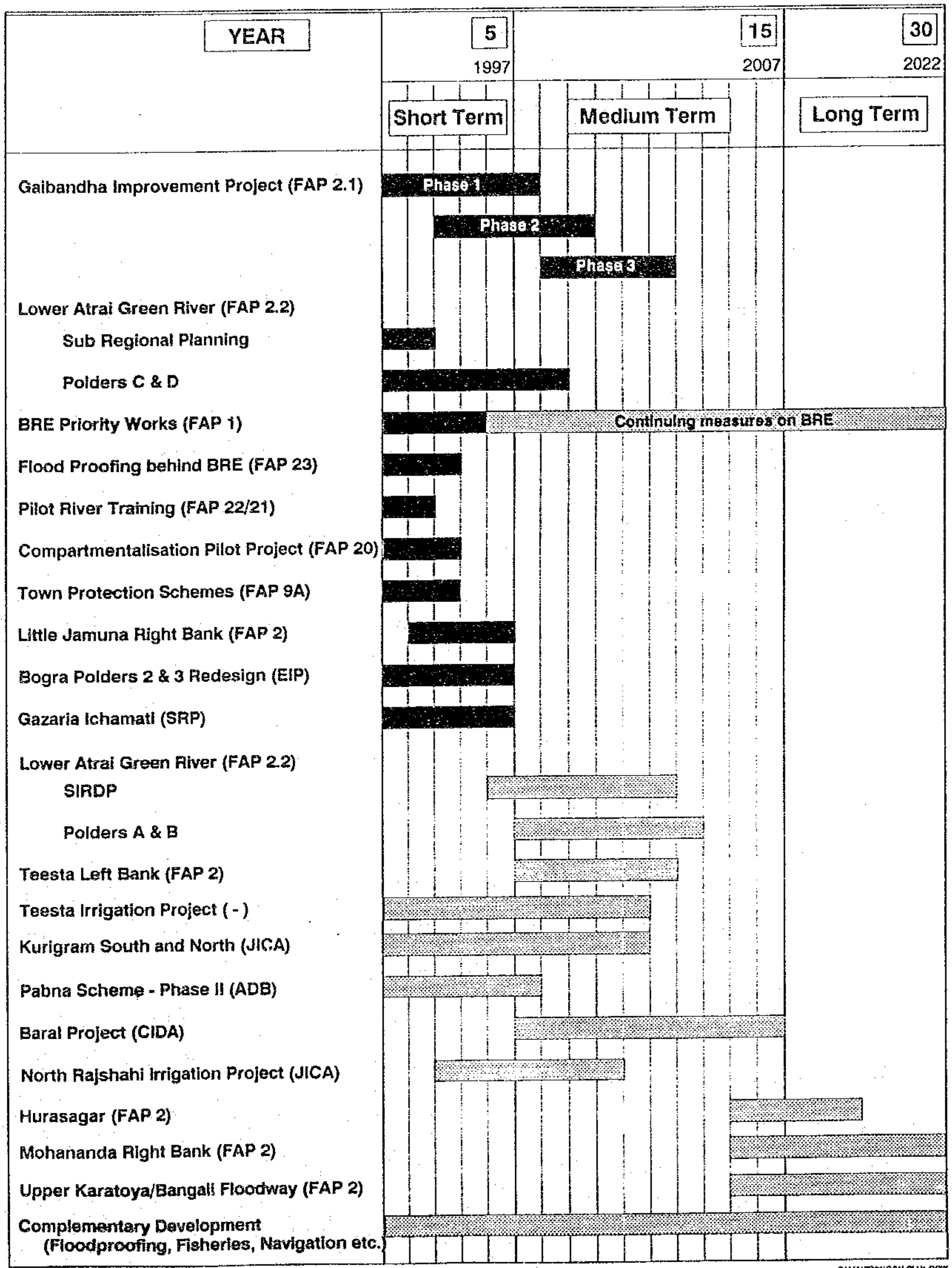
Plan Implementation

The schedule for implementation of the plan is shown in Figure 3. This divides into short-term, priority works, plans for the medium-term and possible developments in the long-term. Priorities have been determined on the basis of needs, economic returns, and the objective of achieving balanced development throughout the region where flooding takes place. A summary of the financing requirements for the plan is given in Table 3, which also gives financing requirements for other on-going and proposed water developments in the region.

Important issues remain to be addressed in relation to which also gives financing requirements for other on-going and proposed water resource developments in the region the implementation of the plan. These include:

Figure 3

The Regional Plan



Source : NWRS

- the relationship between recommended elements of this plan, and the work being done by other projects in the region;

- the balance between public and private involvement in implementation, and the need for public participation to the greatest extent possible;

- the need to ensure that implementation schedules are realistic and that they are achieved.

- the problems of standards of construction, particularly relating to earthworks;

- the problems of effective operation and maintenance of completed facilities. Two aspects of this need attention:

  (a) problems of maintaining main river embankments against erosion;

  (b) problems of involving local people in O&M and in achieving the necessary social cohesion for effective O&M.

7. Future Action

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

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

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

- further development of the sub-regional hydrodynamic model used by NWRS, as a planning tool;

- a continuing programme of public consultation concering possible development;

- liaison with FAP16 on wetlands needs assessment and FAP17 on fisheries development in the lower Atrai;

- co-ordination with other programmes working in the Lower Atrai, notably EIP on the redesign of Bogra Polder 2.

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

Table 1 Scenario Summary and Ranking Analysis - NW Region

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

Source: NWRS estimates

Notes:

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

Table 2 Project Summary and Ranking Analysis - Lower Atrai

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

Source: NWRS

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

Table 3 NW Region: Financial Requirements of the Short and Medium Term Plans (Tk. million)

Name of the project	Years														
	Short Term					Medium Term									
	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-2000	00-01	01-02	02-03	03-04	04-05	05-06	Total
A. ONGOING BWDB PROJECTS	1062.93	1758.55	1529.01	1543.50	1800.00	1800.00	1200.00	842.80							11536.79
B. PROPOSED BWDB PROJECTS	19.7	473	876.8	1186.1	2051	2391	1139	736	427	36					9335.6
C. PROPOSED FAP PROJECTS (Excluding FAP2)	194	1033	965	1032	539.8	723.7	716.7	677.8	600	600	600	600	600	600	9482.0
D. FAP-2 PROJECTS															
Gaibandha		41.7	54.4	218.1	399.8	470.2	230.5	91.3	35.6	41.7	60.3	26.5			1670.1
Sub Reg Plan		50	50												100.0
Polder C&D		20.2	20.2	20.2	51.6	120.4	137.6	34.4							404.6
Little Jamuna R B		3.4	9.1	15.1	6										33.6
Polder 3					9.8	13.3	31	35.4	8.8						98.3
SIRDP						7.7	7.7	7.7	21.9	51.2	58.5	14.6			169.3
Polder A&B							16.2	16.2	16.2	41.3	96.4	110.2	27.5		324.0
Teesta Left Bank							22.6	22.6	22.6	64.5	150.4	171.9	43		497.6
Flood Proofing		20	20	20	20	20									100.0
Environmental Management Plan		10	10	10											30.0
Sub-Total (FAP2)		145.3	163.7	283.4	487.2	631.6	445.6	207.6	105.1	198.7	365.6	323.2	70.5	0	3427.5
TOTAL	1277	3410	3535	4045	4878	5546	3501	2464	1132	835	966	923	671	600	33781.9

Source: Consultant's Estimates and BWDB.

Notes:

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

CHAPTER 1

INTRODUCTION

1.1 The North West Region

The North West Region of Bangladesh has a total area of 34,600 km2. Its principal features and extent are shown in Figure 1.1.

Topography and Soils

The region slopes from the north towards the south-east, with an altitude range of 90 m to less than 10 m above sea level. There is considerable physical diversity and micro-relief which has a major impact on agriculture and the incidence of flooding. The most basic division is that between the Barind and Alluvial tracts; the latter comprises three main geomorphological units, the Himalyan Piedmont Plains and the Alluvial Lowlands along the Jamuna and the Ganges. Slopes in the Barind tract, which has non-alluvial soils, are generally steeper and flooding is much less widespread than in most parts of the alluvial zone. Most of the region's soils are capable of high levels of productivity.

Population and Socio-Economics

The region has a population of over 25 million people. Although it has 25 urban municipalities, the total population of these is only 1.752 million, in an area of 465 sq. km. The urban centres with more than 100,000 people are Bogra (256), Dinajpur (126), Naogaon (101), Nawabganj (121), Pabna (104), Rajshahi (300), Rangpur (203) and Sayedpur (102). The importance of urban centres is growing as outmigration from rural areas increases but about 85% of the population in the study area live in rural areas. There are indications that the rate of population growth in the country is starting to decline, but even so, a population increase of 50% is forecast over the next 20 years. Population and other key indicators for the 16 districts of the region are given in Table 1.1.

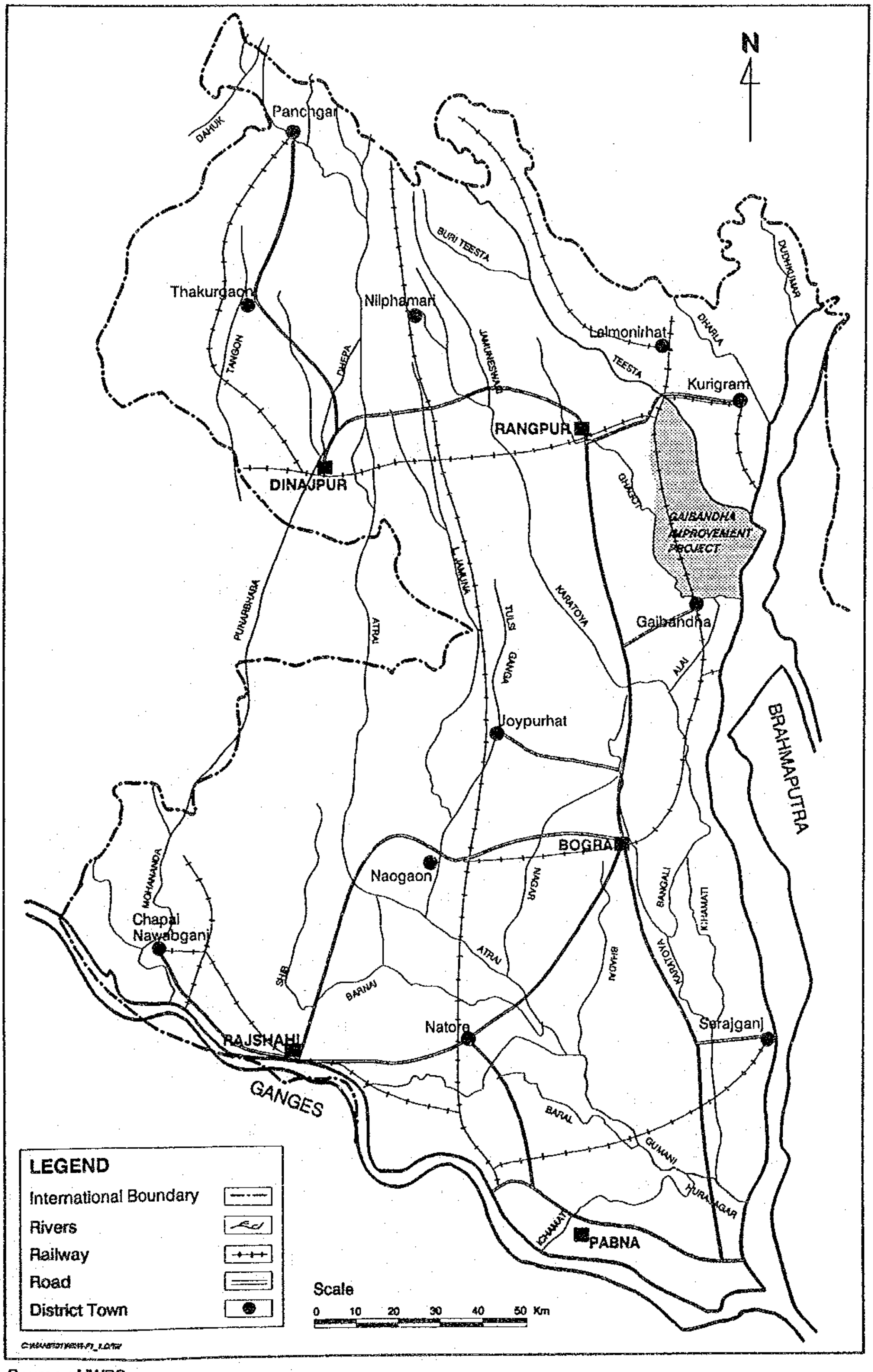
Average farm size has been declining over the last 20 years and the number of landless households is increasing. Agriculture is, however, expected to remain the main source of new employment in rural areas, both directly and indirectly, through linkages to input supply and processing industries.

Agriculture

Cropping intensity, the percentage of the cultivated area actually cropped each year, is about 158%, as shown in Table 1.2. Of this rice takes up 119%. The kinds planted are either broadcast (b) or transplanted (t); either local (l) or HYV. The nomenclature used with these prefixes is boro for rice planted before March 15th; aus until June 1st and aman after that date. The exception is b. aman, which is planted in early April.

Other crops in descending order of importance are wheat, jute, oilseeds (mainly brassicas and sesamum) sugarcane, pulses, vegetables and spices. Minor crops take up 8%.

Figure 1.1
The North West Region



Source : NWRS

The cropping pattern is largely dictated by flooding, soil drainage and soil moisture storage capacity although irrigation facilities and markets are among other factors which affect choice of cropping. Irrigated dry season paddy (boro) is increasingly popular as it is more reliable and productive than the wet season crop. This constitutes the bulk of agricultural production in the north-west.

Table 1.1 Population by District, 1991

District	Area (Sq.Km)	House holds (000)	Populati on (000)	Hh Size	Literacy rate all ages	Sex ratio M/F	Density (sq. km.)
Rajshahi Division	35,592	4,923	25,431	5.17	20.47	105.1	757
Panchagarh	1,405	138	696	5.04	23.65	105.5	495
Thakurgaon	1,774	189	978	5.16	21.61	106.5	551
Dinajpur	3,438	429	2,182	5.08	22.45	106.6	634
Nilphamari	1,641	264	1,339	5.06	17.00	106.0	816
Lalmanirhat	1,241	181	920	5.08	18.21	106.1	741
Rangpur	2,300	422	2,107	4.98	20.64	106.2	916
Kurigram	2,237	307	1,557	5.07	17.32	101.7	696
Gaibandha	2,179	379	1,855	4.89	18.35	102.0	851
Joypurhat	965	152	736	4.83	23.44	107.4	763
Bogra	2,659	516	2,565	4.96	22.04	105.5	964
Naogaon	3,418	404	2,058	5.09	21.95	103.8	602
Natore	1,883	244	1,296	5.30	20.43	105.2	688
Nawabganj	1,602	196	1,146	5.85	17.63	102.8	715
Rajshahi	2,026	360	1,882	5.22	23.43	104.9	929
Sirajganj	2,455	412	2,243	5.44	18.42	105.8	918
Pabna	2,369	323	1,863	5.77	20.86	107.0	786

Source: 1991 Census

Table 1.2 Agriculture in the Region

Name of Crop		% NCA	Name of Crop	% NCA
Rice			Others	
HYV	Boro	26	Wheat	8
	Aus	6	Jute	7
	Aman	28	Oilseeds	6
Local	Boro	1	Sugarcane	5
	Aus	20	Pulses	3
	T.Aman	28	Vegetables	2
Aus/Aman		5	Others	8
B. Aman		5		
Total:		119	Total	38
Total:		158		

Source: NWRS Estimates

Fisheries

Fish supplies an estimated 70 to 80% of the animal protein intake in the diet of the Bangladeshi people. Fresh water fish are preferred, and the inland waters provide 80% of the annual harvest. The fisheries production systems generally fall into two classifications: open water capture fishery, relating to rivers, beels and floodplains, and closed water culture fishery, mainly related to ponds (Table 1.3).

Most of the open water capture fishery is based on the river floodplains and these provide 70% of the fish yield in the region. Yields of capture fishery have decreased recently, as shown in Table 1.3: this is generally attributed to flood control and drainage (FCD) projects which limit the available area of beels and floodplains and restrict fish migratory paths. Declining water quality is also seen to be a contributory factor. Overfishing is an increasing problem which arises mainly from fishermens' attempts to maintain their catchates from resources which have been weakened as a consequence of FCD. Pond fish culture can benefit from FCD and is starting to expand but insufficiently to offset the loss of capture fish production.

Table 1.3 Fish Production in N.W. Region (Metric Tons)

	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89
Rivers	24507	22840	11883	7824	7865	3937
Beels	15141	12000	10638	8379	9466	8555
Flood-plain	42344	45343	52033	43237	44452	42183
Total Capture	81992	80183	74554	59440	61783	54675
Fish Ponds	25232	23257	26190	25493	26712	30135
Total	107224	103434	100744	84933	88495	84810

Source: DOF Statistics

Infrastructure

There is a good network of roads in the region, linking the main towns, as well as minor roads and village tracks. There is also a network of railways. The main river port serving the region is at Baghabari near the confluence of the Hurasagar and Jamuna rivers. Within the region, boats are an important means of transport especially during the monsoon season, particularly in the Lower Atrai.

1.2 The Study Context

1.2.1 The Flood Action Plan

The North West Regional Study (NWRS) forms one of the major components of the Flood Action Plan (FAP) which was formulated in response to the disastrous floods in Bangladesh in 1987 and 1988. 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.

During the conduct of the study, efforts were made to maintain close contact with those components of FAP where there were important linkages with NWRS. These were as follows:

FAP1 The Brahmaputra River Training Study

This is a key element of planning for the north west region, and is discussed further in Section 4.2.

FAPs 3 - 6 Regional Studies

The other regional studies were all at different stages during the NWRS. However, close liaison was maintained with them and common approaches discussed to specific problems.

FAP9A Secondary Towns Protection

FAP9A studied town protection schemes for a number of secondary towns throughout the country, including several in the North West region. Works at Dinajpur, Panchagarh and Kurigram have been taken up as a priority measure and are now in the detailed design phase. NWRS studies confirm that all these towns are indeed affected. Specific town protection schemes are an appropriate measure in the upstream locations of the region, where widespread and persistent flooding problems do not generally occur. The short list for the towns to be included in the next phase of the study includes Rajshahi and Gaibandha in the NW, but no progress has yet been made.

FAP12 Agricultural Study

This study was an evaluation study of past FCD/I studies. Rapid Rural Appraisals were carried out on seventeen projects and detailed Project Impact Evaluation Studies on six, distributed throughout the country. The results are of particular significance for regional planning and are discussed further in Section 2.2 .

FAP13 The O&M Study

The first part of the O&M study was completed in 1991, at the same time as FAP12. This part reviewed O&M performance and procedures in a number of completed projects, and compared this with experience in some other countries. A second phase of the O&M study is commencing in mid-1992. It is intended that certain projects should be taken up for pilot O&M development, and it has been suggested that one of these could be the NWRS priority project. The O&M study is discussed further in Section 2.2.

FAP14 The Flood Response Study

This is a detailed study of the responses of people to floods in a variety of situations and locations. Contact was maintained with the study team, and workshops attended.

FAP15 The Land Acquisition Study

NWRS investigations and evaluation studies from programmes such as EIP indicated the great need to improve land acquisition procedures. This relates not only to the more timely carrying-out of procedures and payment of compensation. It is also necessary to realise that acquisition of the land of poor and marginal farmers may effectively destroy the basis of their subsistence and survival strategies in a particular location, in a way which cannot simply be compensated in cash terms. FAP15 submitted a draft Final Report in 1992 but this was not generally available at the time of writing this report.

FAP16 The Environmental Study

FAP16 has been involved in developing guidelines and case studies for environmental impact assessment. These were reviewed and incorporated into the work of NWRS as appropriate. In addition, FAP16 undertook a number of special studies, including:

- charland surveys,
- floodplain and soil fertility,
- disease vectors,
- fish diversity,
- health and demography,
- water and algal sampling.

In most cases, results were not available at the time of carrying out the NWRS.

FAP17 The Fisheries Study

FAP 17 is conducting a series of studies on floodplain fisheries, including fish migratory and reproductive behaviour, the impacts of flood control schemes on fisheries, socio-economic aspects, and the feasibility of mitigation measures. One of the FAP 17 field stations is at Baghabari in NWR.

The second phase of FAP 17 is planned as a Pilot Aquaculture and Pilot Stocking project that will be implemented as an integrated part of the regional plans. Details of this part of the programme will be developed in Phase I and will be dependent on the outcomes of various stocking and aquaculture project presently underway.

FAP18 Survey and Mapping

SPOT imagery of the dry season 1990 was obtained and provided essential base mapping and land use data for the study. Second order bench mark data was made available for the topographic survey of the priority project for NWRS.

FAP19 Geographic Information System

A GIS for the North West region was developed by the NWRS study team, in collaboration with personnel from FAP19. The GIS also made direct use of data from the national database developed by FAP19.

FAP20 Compartmentalisation Pilot Project

This project is working on developing the concept of compartmentalisation in two pilot areas each of about 10,000 ha. The second of these is in the north west region, north of Serajganj. However, by the end of 1992, most of the FAP20 effort was concentrated on the first priority area in Tangail, in North Central region, and little work had been done in Serajganj. NWRS team members collaborated in providing data and discussing general concepts for the pilot project area.

FAP21/22 Bank Protection and Flood Plain Management Study

The objective of the project is to test different bank protection techniques at a limited number of sites along the Jamuna river. The type of bank protection works to be evaluated include groynes and bank revetments. The former will be investigated at Kamarjani, within NWR.

The bank protection and river training project (AFPM) pilot project is also considering the feasibility of applying soft recurrent measures as a form of active flood plain management. Measures might include dredging, permeable structures, vanes, jacks etc. The plan is to identify suitable types of soft protection and to test some of these at specific locations.

FAP23 The Flood Proofing Study

FAP23 issued a draft Issues Report and Interim Report in September 1992. These were reviewed by NWRS study team members and incorporated in NWRS planning as appropriate.

FAP25 Flood Modelling and Management

A major component of FAP 25 was the Flood Hydrology Study (FHS) which investigated the effects of engineering works on the main river, such as embanking the left bank of the Brahmaputra. The study also recommended methodologies for hydrological data analysis and estimation of return period levels in the regional studies.

1.2.2 The North West Regional Study (FAP2)

The chief outputs of the study are the formulation of a Regional Water Development Plan and preparation of a priority project for implementation.

The overall objective of the North West Regional Study is to plan the flood regime in order to raise living standards in the region. The 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 first element of the NWRS was the Preliminary Review carried out during May and June 1990. This collected basic data on the region, reviewed existing FCD schemes in the area and proposed tentative options for flood protection and drainage improvement. The proposals included two major options which were identified in the early stages of the FAP, the Interceptor and the Diversion Drains. Both of these options were primarily intended to relieve flooding in the Lower Atrai basin.

The Preliminary Review was followed by the Bridging Study which lasted until December 1990. The objectives of the Bridging Study were to provide a continuous link between the Preliminary Study and the Main Study, to undertake a hydrological data collection programme and to assist in the development of a pilot hydraulic model of the region for use in the Main Study. These objectives were successfully accomplished by December 1990, with the establishment of a data collection programme to supplement the on-going programmes of Bangladesh Water Development Board (BWDB) and Surface Water Modelling Centre (SWMC), development of rainfall-runoff models based on 33 catchment areas, and development of a pilot hydrodynamic model by considering a number of sub-models in the region.

The Main Study of the NWRS was carried out by a team of Japanese, British and Bangladeshi consultants under joint funding by Japan and UK. The German Government expressed an interest in funding projects identified as a result of the study, and was kept informed of progress.

The objectives of the study were to carry out a detailed assessment of flooding and drainage in the region, to draw up a Regional Water Development Plan and to prepare feasibility studies for priority projects.

The Main Study commenced in January 1991 with an initial period of data collection and analysis, culminating in the submission of the Inception Report in March 1991. The period up to October 1991 consisted of analysis of the major drains and 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 Interim Report was submitted in October 1991, and was formally reviewed on November 28, 1991.

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

During the study a large number of field surveys and data collection exercises were undertaken. These included a detailed topographic survey and geotechnical investigation programme in the Gaibandha project area, and formal surveys in agriculture, agro-economics, rural sociology, fisheries, ecology and environment, covering both the region and the Gaibandha area. There has also been a major exercise in public consultation concerning the Gaibandha project. All these are fully detailed in the appropriate volume of this report. In addition there were numerous informal visits and surveys conducted during the course of the study.

Besides these primary data collection exercises, a large quantity of data was collected from other sources. These include government departments such as BARC, BBS, BWDB (in particular WARPO and Surface Water Hydrology), consultants, NGOs and published material. A GIS of basic regional data was established, particularly of thana-level data.

1.3 Scope of This Report

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
- Supporting Annexes.

The Final Report is based upon a Draft Final Report of 15 volumes which was submitted in October 1992. This covered both the regional plan and the Gaibandha Improvement Project.

Chapter 1 of this report describes the region and the context of the study. Chapter 2 focuses on the hydrology of the region, and existing FCD infrastructure (including its performance, operation and maintenance). Chapter 3 describes responses to floods, the division of the region into planning units, the use of the GIS to identify flooding problems on a regional scale, and flood control and drainage options in the various planning units. These are then taken up in Chapter 4 into a number of regional development scenarios. Chapter 5 describes the hydraulic studies of the various scenarios. The economic and impact analyses carried out the discussed in Chapters 6 and 7 respectively, leading to the Regional Plan in Chapter 8.

CHAPTER 2

FLOODING AND DRAINAGE IN THE REGION

2.1 Climate and Sources of Flooding

2.1.1 Introduction

The North West Region of Bangladesh lies just outside the tropics between latitudes 23°50' and 26°40' N. The region has a typical monsoon climate. Figure 2.1 displays the climatic norms for Bogra which is centrally located in the region; the data is tabulated in Volume 10 of the Draft Final Report, together with values for some other example stations. With the exception of rainfall, the main climatic parameters generally vary relatively little across the region.

Average annual rainfall ranges from less than 1500 mm to just over 3000 mm, with a regional average of about 1900 mm. Well over 80% of the annual rainfall occurs during the five month monsoon season between May and September, and this rises to an average of 97% for the seven months from April to October.

In addition to the climate, the hydrology of the area is influenced by the topography and the drainage network, and in particular by the major rivers which bound it. The characteristic topographical feature of the region is its flatness even though it is not as flat as other parts of the country. Elevations vary from less than 10 m above sea level in the south east corner to just under 100 m in the far north west; most of the region lies below 30 m asl. In the southern part 1 m contours are typically up to 5 km apart, and even in the north west of the region average slopes rarely exceed 1 in 1000. As a consequence of the low gradients, the rivers and drainage channels within the region are generally heavily meandered, and capacity for rapidly passing substantial flood peaks is very limited.

The region is bounded on its lower sides (south and east) by two of the world's great rivers, the Ganges and Brahmaputra; the latter is known as the Jamuna within Bangladesh. These rivers, which join to form the Padma at the south east corner of the region, drain a total area of nearly 1.5 million km^2, of which only about 7% lies within Bangladesh. The catchments cover some of the wettest areas in the world, together with the major part of the Himalayan mountains. Snowmelt from the Himalayas combines with runoff from the monsoon rains to produce very large flood peaks on the lower reaches of both rivers. Besides the potential for spillage from breaches of the embankments, high levels on the main rivers (particularly the Jamuna) make a significant contribution to flooding problems within the region because drainage from regional rivers is severely impeded.

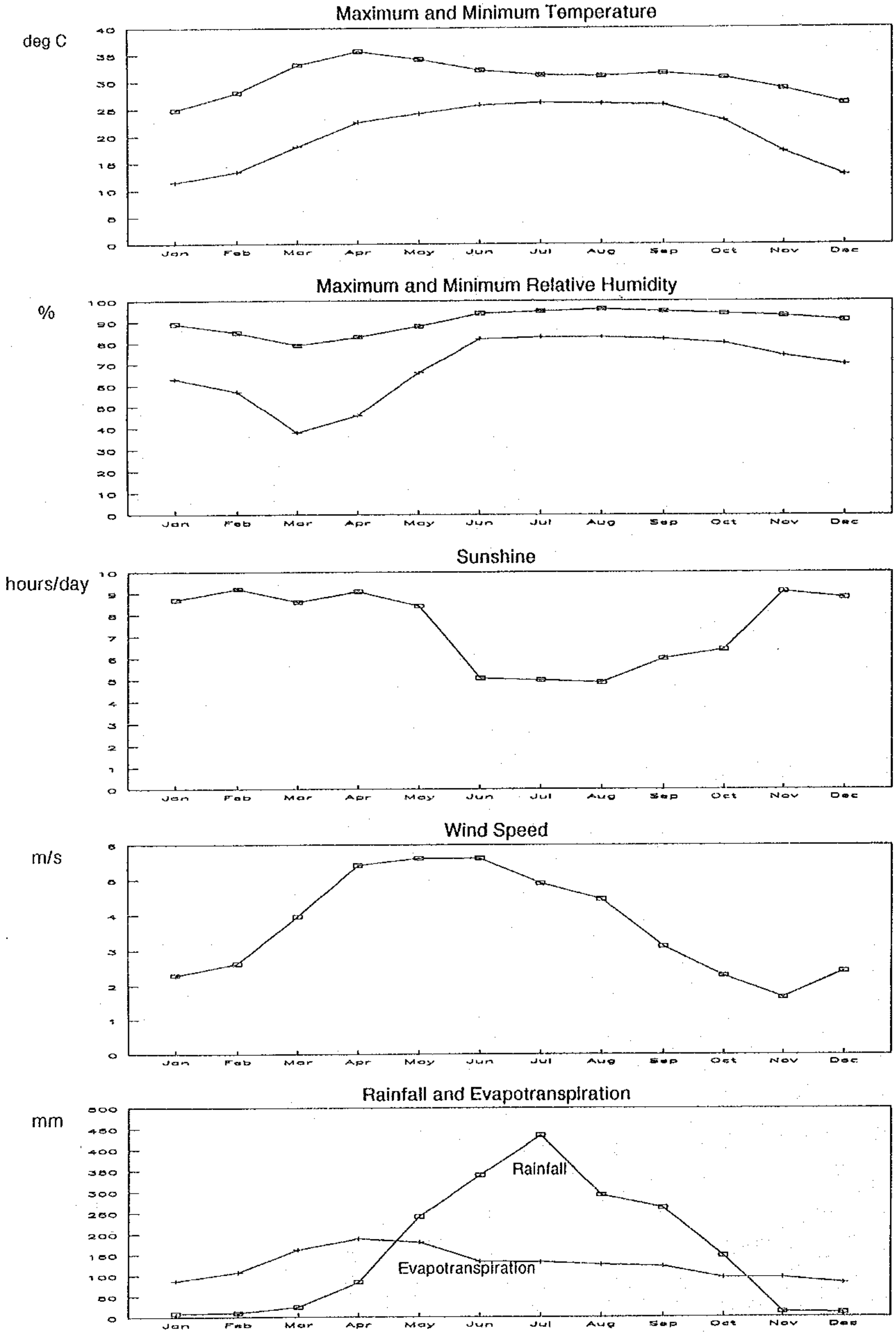
This chapter contains a summary of the region's climate and hydrology, particularly as they affect the problems of flooding; Volume 10 of the Draft Final Report contains a more detailed hydrological review, covering the studies and analyses undertaken during the Study.

2.1.2 Climate

There are two main seasons, separated by transition seasons. The monsoon season lasts from May/June until September and shows the typical monsoon characteristics of heavy rain and very high humidity. The dry season from November to February is sunny and relatively cool, with only occasional scattered showers. The transition from monsoon to dry seasons in October-November is fairly smooth, with declining temperature, humidity and storm frequency. The start of the transition

Figure 2.1

Climatic Norms at Bogra



File FIG21.WK1

period at the end of the dry season is also smooth, but the pre-monsoon period in April and May has somewhat unstable atmospheric conditions. This period is very hot and is characterized by thunderstorms and squalls, known as Nor'westers. This is also the peak season for cyclones in the Bay of Bengal which sometimes have catastrophic consequences in the coastal regions of the country. Cyclones themselves do not reach as far inland as the north west region, but the area may be affected by associated storms.

As a result of its sub-tropical location, temperature variations are more pronounced than in typical tropical regions; diurnal variation is a low 5°C during the monsoon but around 15°C in February. Maximum temperatures range from around 35°C in April/May to about 25°C in January, while minima peak at about 26°C in August and drop to 10-11°C in January. The monthly temperature pattern for Bogra, shown in Figure 2.1, is typical of the whole region; seasonal patterns and absolute values show relatively little variation with location. The occurrence of peak temperatures is closely connected with the passage of the monsoon; daily maxima occur just before the arrival of the monsoon, while the highest night-time minimum occurs at the peak of the monsoon season.

Humidity levels are consistently very high during the monsoon season, and only drop significantly for a relatively short period at the end of the dry season. Sunshine levels are of course low during the monsoon, but from November to May are consistently high. Wind speeds are at a maximum in the early part of the monsoon, but drop substantially by the beginning of the dry season.

Evapotranspiration reaches a maximum in April when temperature, sunshine and wind are all at or close to their maxima for the year, while humidity is a little below its peak. Evapotranspiration drops substantially thereafter as the humidity reaches very high levels and the other significant parameters all also become less favourable for evapotranspiration. Evapotranspiration is exceeded by average rainfall from May to October, while for the remaining months it is substantially higher than rainfall.

2.1.3 Rainfall

The region has an average annual rainfall of a little over 1900 mm; this is significantly below the estimated average for the whole of Bangladesh of 2320 mm (MPO, Technical Report Nr. 10, 1985). Figure 2.2 shows isohyets of mean annual rainfall for the region. The driest area is in the south-west of the region where the annual rainfall of around 1400 mm is the lowest in the country. The highest rainfall is in the far north of the region, where annual rainfall averages around 3000 mm; however, this is much lower than in parts of the north east region of Bangladesh where the annual average reaches nearly 6000 mm.

Annual rainfall shows considerable variability from one year to another as well as between different parts of the region in a single year. Over the period from 1962 to 1990 the regional average annual rainfall ranged from 1350 mm in 1972/73 to 2600 mm in 1987/88. The extreme annual rainfall totals at individual stations in this period were 554 mm at Bagdogra in 1962/63 and 5633 mm at Bhitargarh in 1974/75. There is some suggestion of a trend of increasing annual rainfall since 1962, but the available longer term records show that the variations in this period are of a similar magnitude to variations observed earlier in the century, so a continuation of the apparent recent trend cannot necessarily be expected (see Volume 10, Draft Final Report).

The average monthly rainfall pattern is shown in Figure 2.3 (a); the absolute monthly rainfalls vary considerably, but this average pattern remains approximately the same across the region.

Figure 2.2
Isohyet of Mean Annual Rainfall

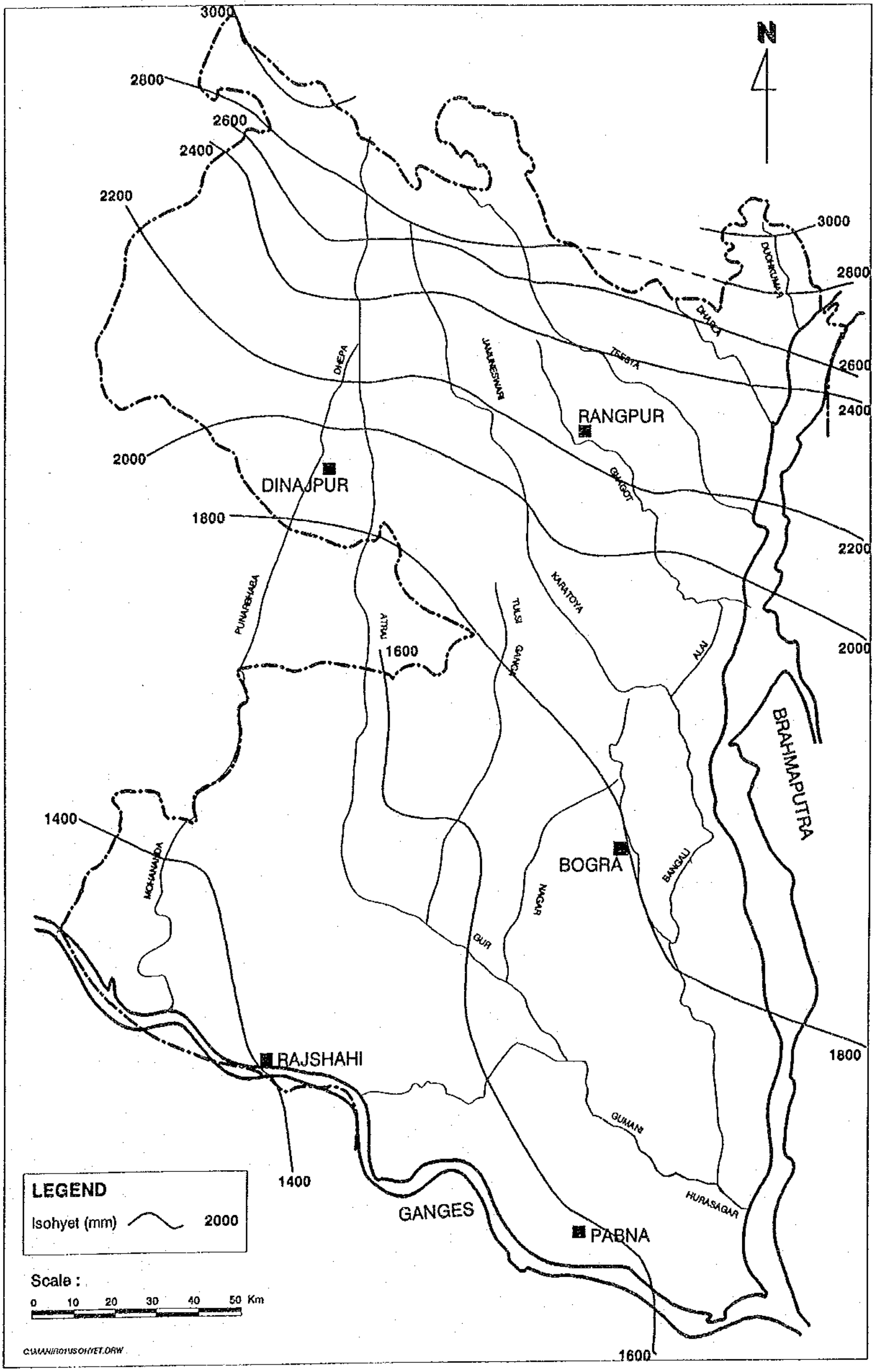
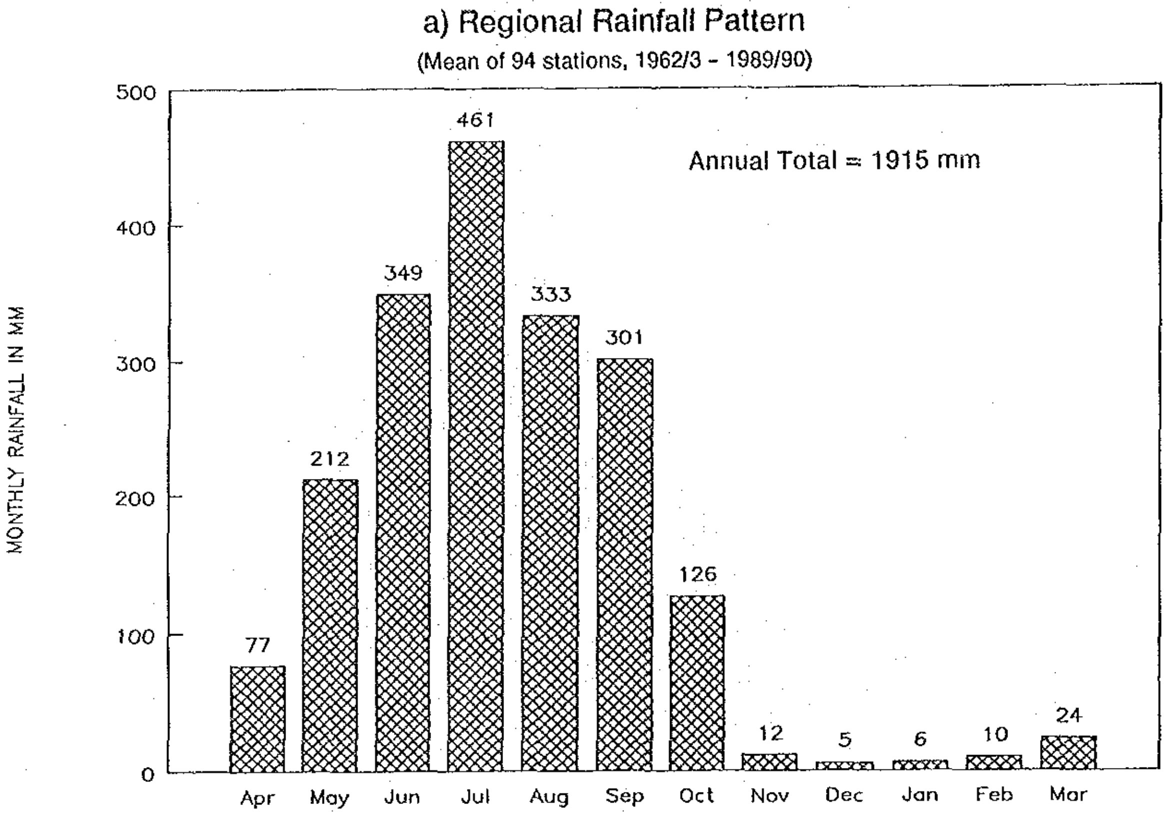
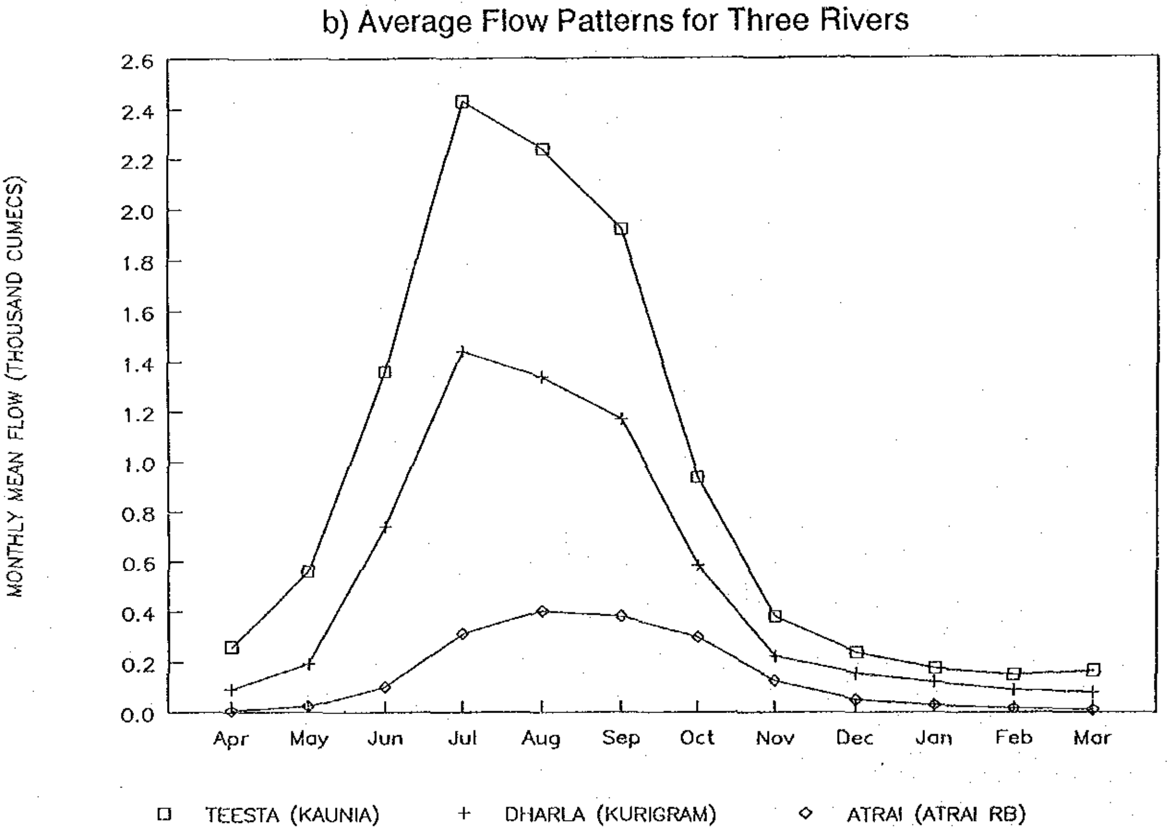


Figure 2.3

Monthly Rainfall and Runoff Patterns in the North West Region





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Storm rainfalls can be very heavy in all parts of the region. At almost all of the stations daily falls of 200 mm have been recorded, with the absolute maximum being 485 mm at Rajshahi (which is one of the driest places on the basis of long-term average rainfall) in 1965. 10-day totals of 700 mm or more are not uncommon, with the most extreme recorded value being over 1100 mm at Kaunia in 1987. Whilst heavy 1-day rainfalls can occur right across the region, the highest 10-day rainfalls are not surprisingly concentrated in the wetter northern part of the region. It may also be noted that at more than one third of the rainfall stations in the region the highest recorded 10-day rainfall occurred in 1987, which has already been noted as the wettest recorded year over the region as a whole.

Because of the unavailability of rainfall data for the Ganges and Brahmaputra catchments outside Bangladesh it has not been possible to investigate the correlation between wet years in the region and over the upper catchments, but a qualitative assessment based on the recorded flows in the main rivers suggests that there is some correlation, and consequently that severe flood conditions within the region are quite likely to coincide with, and be exacerbated by, severe floods on the main rivers.

2.1.4 The River System

The region is bounded, and effectively defined, by the Jamuna (Brahmaputra) to the east and the Ganges to the south (Figure 2.4). These two rivers, into which the entire area drains, meet up at the south east corner of the region and play a dominant role in constraining its drainage. Before the construction of the confining embankments, the Ganges and Jamuna rivers were major contributors to flooding in the region, and in more recent times they have also been so at times of breaches of the embankments. The major internal rivers are shown in Figure 2.4, together with the maximum monthly mean discharges for a selection of gauging stations. Monthly flows for three rivers are illustrated in Figure 2.3 (b), and monthly mean flows for a larger number of stations are given in Volume 10, Table 2.2 of the Draft Final Report.

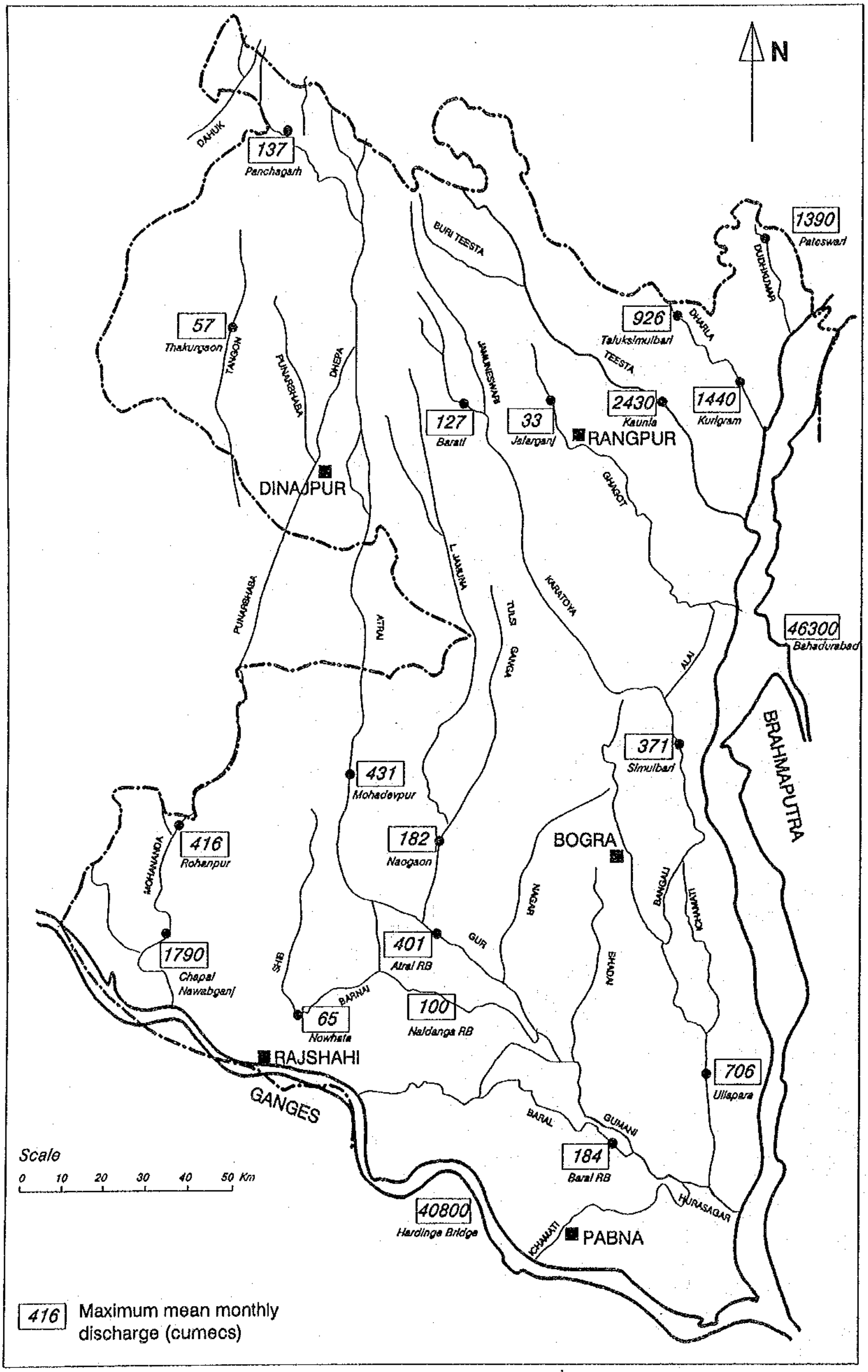
Three large tributaries of the Jamuna, the Teesta, Dharla and Dudhkumar, pass through the north east corner of the region, and the Mohananda, a tributary of the Ganges, passes through the south west corner. All other rivers in the region are connected to the Atrai-Karatoya-Bangali system which drains to the Jamuna through the Hurasagar at the south east corner of the region.

The Teesta, Dharla and Dudhkumar rivers originate in the Himalayas and Himalayan Piedmont Plains. Though they are large rivers they are relatively steep on entry from India into Bangladesh, and their floods can be flashy. On a number of occasions the Teesta has changed its course in the vicinity of its outwash fan, generally in an easterly direction, so that the watercourses internally draining most of the North West Region are in fact former Teesta channels.

The Mohananda river has a large catchment area in India to the west of the Barind Tract, but it is also fed by outflows from the north western corner of Bangladesh via the Tangon and Punarbhaba which pass through India before joining the Mohananda in the south west of the region.

The river Atrai rises in West Bengal to the north of Panchagarh. Its catchment area in India is fairly small, but it is subject to occasional spillage from the upper Teesta at times of exceptional flood flows. Together with the Tangon the Atrai drains the north west corner of the region. North of Dinajpur, it bifurcates into the western Punarbhaba branch and the eastern Atrai branch, both of which pass through the Indian Barind enclave and return to Bangladesh further south. Subsequently the Atrai turns south eastward and picks up various tributaries including the Little Jamuna, Nagor and Barnai before joining with the Bangali to become the Hurasagar which is the major outflow channel for the internal drainage of the region to the Jamuna.

Figure 2.4
The River System



The Karatoya rises as the Jamuneswari, which has only a very small contributing catchment in India. It also appears to be subject to occasional flood spillage from the Teesta. After flowing in a generally south or southeast direction, the Jamuneswari becomes the Karatoya and joins up with the Alai, part of the Ghagot system, a tributary flowing roughly parallel to the east. At times of low flow in the Jamuna, some of the Ghagot flow is discharged direct to the Jamuna via the Manas regulator. Further southwards, the Karatoya becomes the Bangali; channels bifurcate and rejoin at several places before joining the Atrai to form the Hurasagar.

In the south of the region the Baral joins the Ganges to the lower Atrai. Natural flows are from the Ganges inland, but these are now regulated by a structure at the offtake.

Within the region, the rivers in the north east corner have relatively steep gradients of 1 in 2000 or more, but in nearly all the remainder of the area river courses have very flat gradients of 1 in 5000 or less. The rivers are consequently heavily meandering and have limited capacity for passing flood discharges. The system is exacerbated in the lower areas by the tendency of some channels to overflow towards others during flood periods. An additional factor of fundamental importance to the flooding problems in the southern part of the region is the fact that flood levels in the Ganges and the Jamuna are often equal to or higher than internal river levels for long periods during the monsoon. The great bulk of the internal drainage therefore ponds in the lower Atrai/Hurasagar/Bangali against the backwater effects from the Jamuna. Even in a relatively dry year such as 1992 extensive areas are flooded for long periods. Past attempts to reclaim land in this area by constructing polders has in some cases seriously confined flood drainage courses, with a consequent increase in typical flood levels in other places.

2.1.5 The Flooding Regime

Flooding and drainage problems in the region may be separated into a number of categories depending on their cause and location. The Water Resources Planning Organisation (WARPO, formerly MPO) distinguishes between "areas normally flooded by major river spills" and "areas normally flooded by minor rivers"; the former naturally lie along the main river embankments and the latter cover most of the rest of the region.

The first type of flooding in the region is due to breaches in the embankments of the major rivers - primarily the Jamuna, but also the Teesta and to a lesser extent the Ganges, Dharla and Dudhkumar. Flood damage is only partially related to the severity of the flood event because accidental or intentional breaches can occur with "normal" as well as extreme floods.

The second type of flooding is due to outfall constraints, primarily from the Hurasagar to the Jamuna. This comprises flooding in the lower Atrai and Karatoya-Bangali systems, and is predominantly caused by high stages in the Jamuna causing backing up of levels in the river system. The severity of flooding is also related to rainfall conditions within the region (and to a small extent cross-border flows on the minor rivers from India) because the total flow volume from the internal rivers must be stored until the levels in the Jamuna permit natural drainage via the Hurasagar. The severity of the flooding is therefore directly linked to the severity (i.e. return period) of the conditions both in the main rivers and in the region itself.

It is appropriate to make a distinction between a backwater effect and backflow; the latter refers to reverse flow, while the former is the backing up of water levels caused by high downstream water levels inhibiting drainage. It is not possible to precisely define the importance of high river flows from upstream and of backing up from high downstream levels because the two are closely interlinked, but the problems in the Atrai system are substantially due to backwater effects caused by high Jamuna levels, the effects of which may extend to Atrai Railway Bridge or beyond (i.e. well in excess of 100 km) in a high Jamuna flood. Actual reverse flow in the Hurasagar is very rare, and would only affect a short distance near to the outfall. The problems of drainage from the Hurasagar are considered in more detail in Chapter 4.

Similar problems occur on the Mohananda and associated river systems when localised storm runoff coincides with high stages in the Ganges which constrain outflow.

A third type of flooding is that caused by storm runoff in the upper catchments of the region. These problems are often very localised in nature and may best be alleviated by specific localised measures.

Although flooding problems have been separated into different categories there is obviously considerable overlap between them. Flooding in the lower Karatoya-Bangali basin, for example, may be predominantly caused by the lack of drainage to the Hurasagar, but it is also likely to be exacerbated by spills from the Jamuna further upstream.

The flooding situation in commonly classified in flood phases according to depth of flooding as follows:

F0	0-0.3m
F1	0.3-0.9m
F2	0.9-1.8m
F3	1.8-3.6m
F4	> 3.6m

Available statistics, which are discussed in more detail in Chapter 3, indicate that for the whole region about 15% is in the deeply-flooded F2-F4 category. In the south east, where the main problems occur, the proportion rises to 40%.

Figure 2.5 shows the extent of flooding at the height of the 1987 flood. Inundation in the Lower Atrai caused by outfall constraints at Hurasagar are clearly shown, as is flooding by spillage from the Karatoya right bank. The contribution to flooding caused by a breach through the Brahmaputra Right Embankment (BRE) is also notable.

The severity of flood problems can be critically influenced by the timing of the flood peaks on the two main rivers. In 1988, which was by far the most severe year on record for flooding in Bangladesh as a whole, the peaks of the Ganges and Jamuna were both very high and were almost coincident. Recession from flood levels was further restricted by the peaking a few days later of the Meghna, which combines with the other rivers before they outfall to the sea. Parts of the centre and north of the region which escaped relatively unscathed in 1988 suffered greater flooding problems from more localised causes in 1991.

Figure 2.5
1987 Flooding in the NW Region

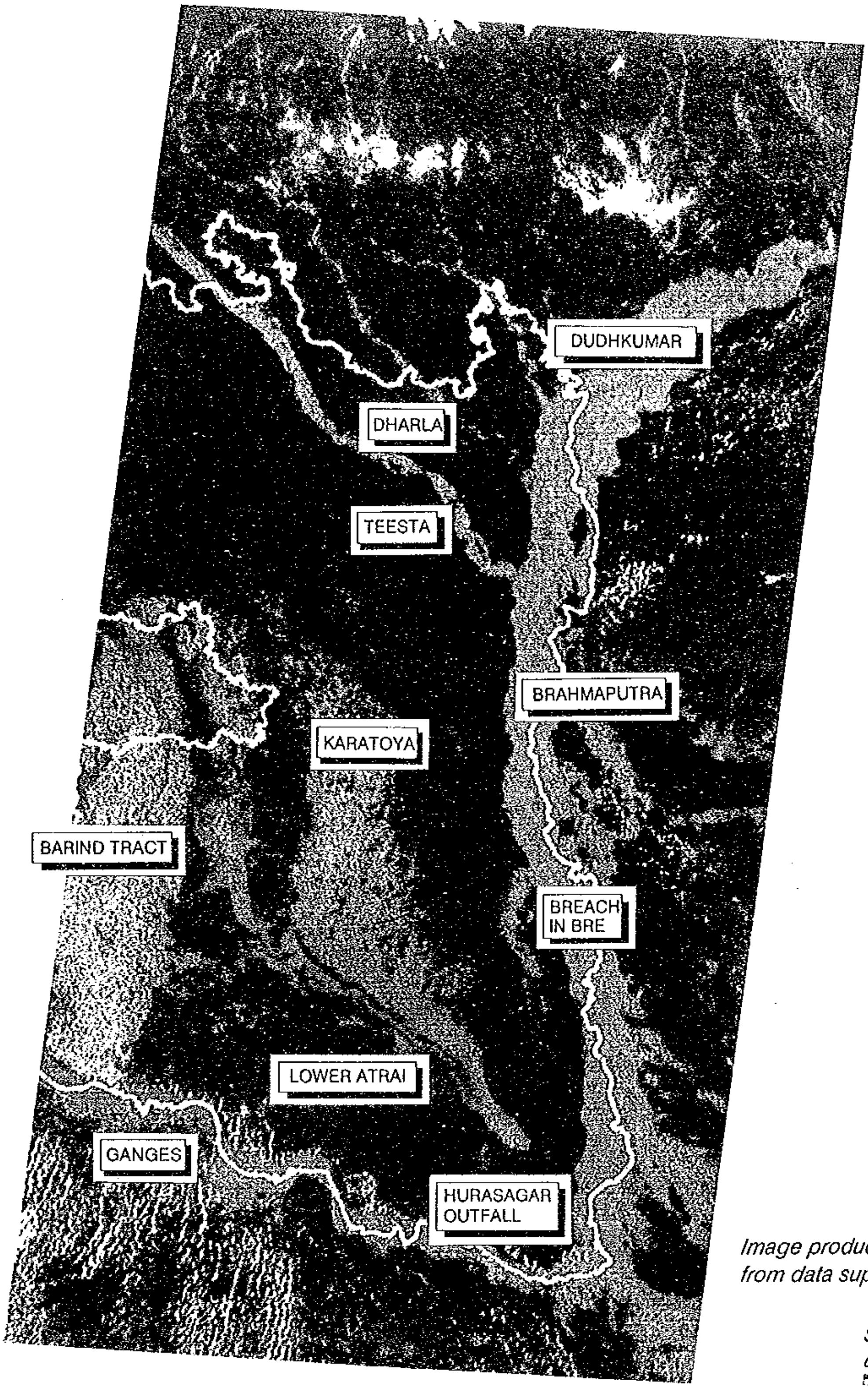


Image produced by FAP19 ISPAN from data supplied by SPARRSO

Scale
0 10 20 30Km

2.2 Existing FCD Infrastructure

2.2.1 FCD Development

As the result of the extensive flooding in the region,there are numerous existing schemes and important on-going programmes, particularly in the water sector. The net effect of all these is that there is practically no part of the region which has not been studied in the past and very few areas where some interventions in the water regime have not taken place for one reason or another already.

The most important element of the existing FCD infrastructure is, of course, the major river embankments, notably the Brahmaputra Right Embankment (BRE), but also the Ganges Left Embankment and embankments along the Teesta, Dharla and Dudhkumar rivers.

Within the region there is a large number of polder schemes, particularly in the Lower Atrai basin. The most significant of these (Figure 2.6) are the Chalan Beel Polders A, B, C and D, various schemes of the left bank of the Atrai, the Sirajganj Integrated Rural Development Project (SIRDP) and the Hurasagar scheme. Apart from Chalan Beel polders C and D, the others are provided only with embankments on the downstream side.

Details of important existing and on-going FCD and FCD/I schemes in the region are gives in the Appendix.

The region is provided with a significant coverage of irrigation facilities. This has developed over the last twenty years to the present situation which is dominated by tubewell irrigation. A large proportion of the original development was based on low lift pumps; however over recent years this has declined in popularity with a trend toward shallow tubewell units (STW). The current regional numbers of operating STW units is estimated at 105,000 units (normal abstraction 10-14 l/s). Deep tubewell (DTW) development has also been extensive since the Thakurgaon Tubewell Project was implemented in the north west of the area.in the early 60's. It is currently estimated that there are about 9400 working DTW units (normal abstraction about 40 to 60 l/s) in the region.

In addition to groundwater irrigation there are a number small scale irrigation scheme located mainly in north western corner of the region where irrigation in late monsoon is essential. These are in poor condition and require rehabilitation. The only important irrigation project in the south east, the Pabna Project Phase-I, is virtually complete but has not yet been bruoght into operation. The largest is the Teesta Irrigation Project in the north of the region, in which supplementary irrigation supplies are to be diverted by the Teesta barrage. Details of irrigation projects in the region are given in Table 4 of Appendix 1.

2.2.2 FAP 12, The Evaluation Study

Performance of the existing FCD infrastructure was evaluated in the FAP 12 study, which was undertaken between late 1990 and early 1992. Its principal objectives were to assess the impacts and performance of existing FCD and FCDI projects, recommend ways in which project design, operation and maintenance (O & M) can be improved and develop project guidelines and criteria for FAP.

Field work was based on a series of sample surveys with Rapid Rural Appraisals (RRAs) being undertaken for 18 existing schemes and more detailed Project Impact Evaluations (PIES) of five of these 18. All the main regions and project types were covered six projects in North West Region were included in the survey; their details are summarised in Table 2.1

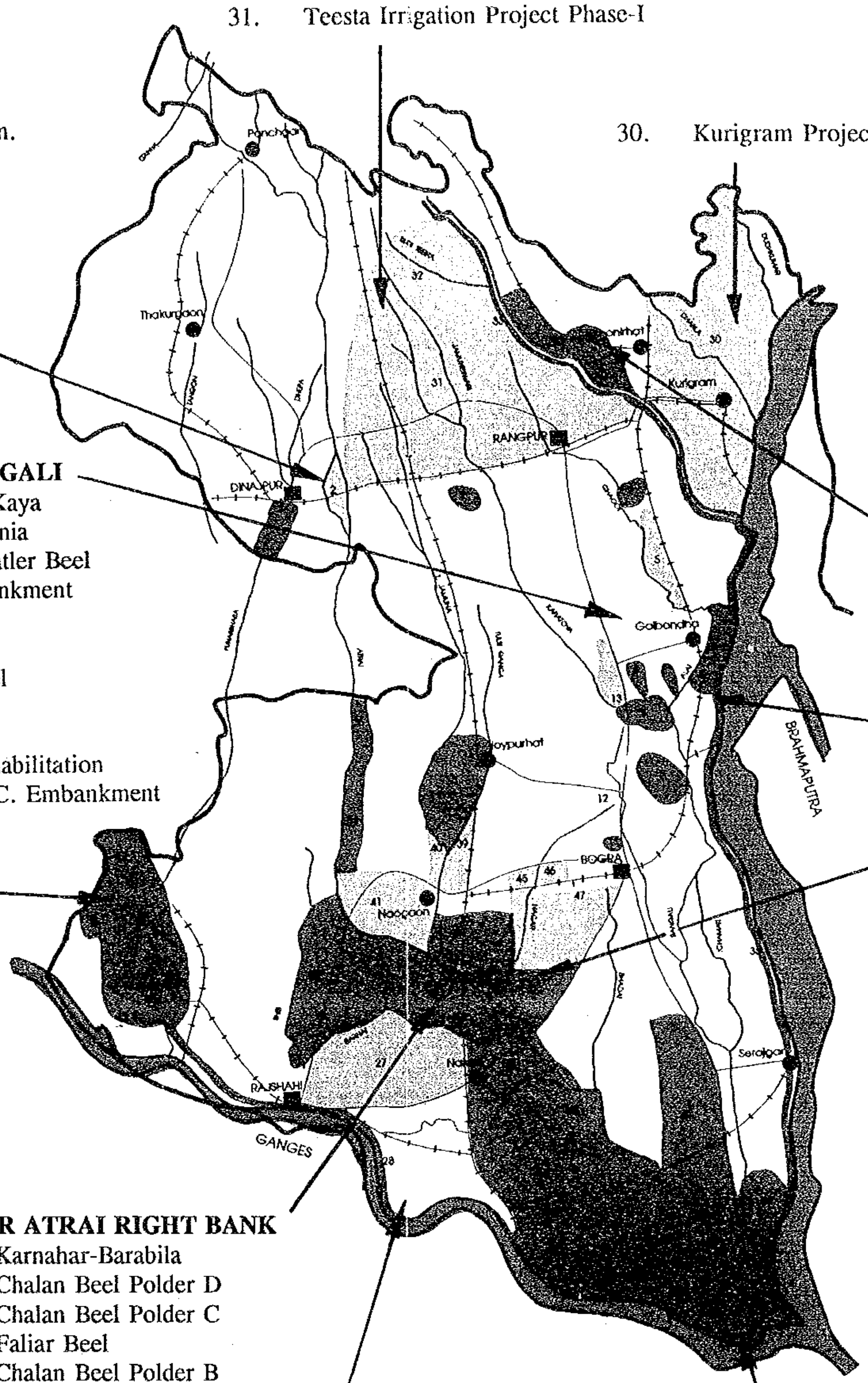
Figure 2.6

Existing FCD Infrastructure

This map shows the location and extent of completed flood control schemes and on-going projects in the region. There are numerous small-scale flood control and irrigation schemes which are not included.

Note:

1. Irrigation projects in upper reaches are not shown.
2. Small-scale schemes, mainly under SSFCDI, are not shown. Details can be found in Appendix 1.



N

COMPLETED PROJECTS

ON-GOING PROJECTS

Scale 0 10 20 30 40 60 Km

UPPER ATRAI
1. Punarbhaba Flood Embankment.
2. Atrai/Kakra

KARATOYA/BANGALI
3. Panchanala-Kaya
4. Sarala-Chalunia
5. Satdamua Katler Beel
6. Sonail Embankment
7. Sardagari
8. Naleya Beel
9. Nurullar Beel
10. Gazaria Beel
11. Sowra Beel
12. Gangnai Rehabilitation
13. Karatoya F.C. Embankment

MOHANANDA BASIN
14. Bhatia Beel
15. Toker Danra
16. Bhitabari Damos
17. Marichar Danra
18. Singri Beel
19. Kumiradaha
20. Shomeshpur Beel

LOWER ATRAI RIGHT BANK
21. Karnahar-Barabila
22. Chalan Beel Polder D
23. Chalan Beel Polder C
24. Faliar Beel
25. Chalan Beel Polder B
26. Chalan Beel Polder A
27. Barnai Project

28. Ganges Left Embankment

29. Pabna Project

30. Kurigram Project

31. Teesta Irrigation Project Phase-I

TEESTA BASIN
32. Buri Teesta
33. Teesta Right Embankment
34. Sati Nadi

35. Brahmaputra Right Embankment

LOWER ATRAI LEFT BANK
36. Chilimpur
37. Patnitola
38. Tulshiganga
39. Tulshiganga Left
40. Badalgachi
41. Naogaon Polder
42. Jamgaon Danra (within Roktadoha Lohachura)
43. Roktadoha-Lohachura
44. Nagor Valley
45. Upper Nagor Valley
46. Protappur Rehabilitation
47. Upper Nagor River
48. Nagor River
49. Serajganj Integrated Rural Development Project
50. Hurasagar

Figure 2.6

Existing FCD Infrastructure

Note:

1. Irrigation projects in upper reaches are not shown.
2. Small-scale schemes, mainly under SSFCDI, are not shown. Details can be found in Appendix 1.

This map shows the location and extent of completed flood control schemes and on-going projects in the region. There are numerous small-scale flood control and irrigation schemes which are not included.

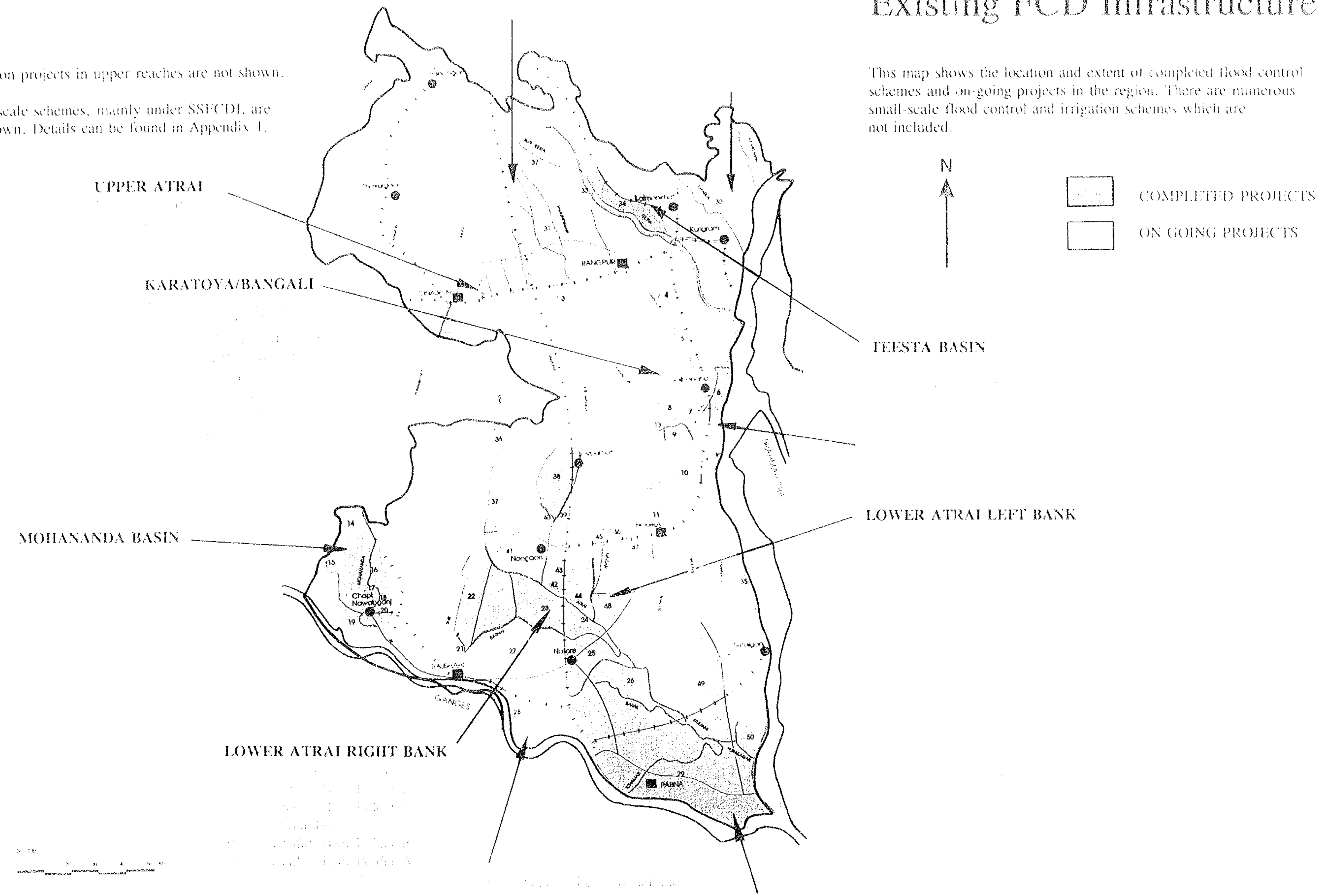


Table 2.1 FAP 12 Project Surveys in North West Region; Key Features

Project name	District	Gross Area (ha)	Completion	Level of study	Type of project
Chalan Beel Polder D	Rajshahi/ Naogaon	53,055	1988/89	PIE	FCD
Kurigram (South)	Kurigram/ Lalmonirhat	63,765	1983/84	PIE	FCD (Main river Embankment)
Protappur Irrigation	Bogra	5,200	1977/78	RRA	FCD/I
Nagor River	Natore, Bogra	15,400	1986	RRA	FCD
BRE-Kamarjani Reach	Gaibandha	10,100	1970	RRA	FCD (Main river Embankment)
BRE-Kazipur Reach	Sirajganj	10,500	1970	RRA	FCD (Main river Embankment)

Source: FAP 12

On the basis of the summary given in the FAP 12 Draft Final Report of December 1991 the general findings of the evaluation of past performance (rather than the findings for the specific projects in the NW region) were as follows:

Planning, Design and Implementation

Planning was generally carried out with little collaboration with other government departments or the intended beneficiaries. In some cases essential regional hydrological studies were not made.

On the design side the greatest problem appears to have been that of drainage congestion due to the lack of an adequate drainage network and faulty hydrological assessments.

Most projects took longer to implement than planned and there were usually cost over-runs. Embankment compaction was often inadequate.

Operation and Maintenance

Inadequate O & M is a severe problem and many of the projects were in a poor state of repair, with little routine maintenance being undertaken. In almost all projects there was little or no public participation in either operation or maintenance. The other over-riding constraint on O & M was lack of finance.

Effects on Flooding and Drainage

Almost all the projects have at least partially achieved their hydrological objectives. Nagor River Project, in NW Region, was the only major exception, its failure being attributable particularly to a inadequate understanding of the regional hydrology, and persistent embankment cuts by the local people. In many projects flooding has sometimes occurred after FCD facilities have been provided, due to high floods, river erosion and embankment failure.

In general, attempts to delay early floods were successful and in many projects normal monsoon season flood depths were also reduced. Drainage success was more variable, with drainage congestion being a frequent problem. Drainage congestion was frequently due to a lack of provision for drainage structures often caused by financial constraints. Several projects also had modest irrigation objectives, which were often achieved.

Agricultural Impacts

Effects on crop production have generally been positive, the main impacts being increased rice output due to transplanted local and HYV amans with a consequent increase in yields. Where early flash floods occur (e.g. in the north east region but not much in the north west) FCD protection against such floods has led to an expansion of boro cropping.

FCD projects have rarely resulted in increased cropping intensities. Where flood protection is reliable there is evidence of increased levels of input use on HYV paddy and other crops.

Impacts on live stock numbers and production appear to be mixed and of much less significance than the impacts on cropping. Bovine population tend to be adversely affected, due to a reduction in grazing opportunities on lost (flooded) crops and the shift from local to HYV paddy varieties, which produce a lower quality straw. There was no clear pattern of impact on small stock and poultry. Draught power requirements have risen with the expansion of transplanted aman.

Fisheries Impacts

FCD projects have generally had a major adverse effect on capture fisheries, due to reductions in the areas of permanent beels and flood plain flooding and the blockage of fish migration routes. In general, the reduction in capture fisheries output and employment is the largest negative impact of FCD. Although culture fisheries have expanded, they have not expanded nearly enough to compensate for the loss of capture fisheries output and their benefits do not go to the disbenefitted capture fishery community.

Social Impacts

FCD infrastructure has led to increased employment in construction and maintenance and to road transport benefits but there have often been negative impacts on navigation, due to closure of waterways. Some of the employment benefits from construction and O & M have gone to women. Women suffer particularly during floods, due especially to their household obligations, so the reduced flooding resulting from FCD has benefitted the population in general.

Employment and other social benefits from FCD have not been evenly spread (for example, farmers have benefitted whereas fishermen have not) and social tensions have often been exacerbated. Conflicts can arise between farmers and fishermen, farmers and boatmen and "insiders" and "outsiders".

The process of land acquisition (rather than the levels of payment) for siting project infrastructure is a common source of dissatisfaction.

Environmental Impacts

A large number of positive and negative environmental impacts was listed in the FAP 12 report summary, but these appear generally to be of less significance than the flooding, agricultural, fisheries and social impacts noted above.

Economic Returns

The projects showed a very wide range of internal rates of return (IRRs) ranging from four with negative IRRs to five with IRRs of over 50% , Nine of the 18 projects had IRRs above 12%, the mean IRR of the group being 22% Capital cost per hectare for the purely FCD projects were not high, with a maximum of TK 18,000/ ha. at 1991 prices. Rather than costs, the most important factor affecting economic success were the level of benefits, implementation time and project size; the seven projects with the highest IRRs all had gross areas of less than 9,000 ha.

Projects in the North West Region

Only one of the FCD projects in NW Region (Kurigram South) was economically successful, and Nagor River and Chalan Beel Polder D had negative IRRs. Reasons for the poor performance of the five projects included:

- failure to consider external impacts at the planning stage which led to regular public cuts by disbenefitted people outside (Polder D);
- persistent drainage congestion, embankment erosion due to poor planning, and very poor O & M (Kurigram South);
- failure to plan the project within a regional context (Nagor Valley);
- high capital and O&M costs (Brahmaputra Right Embankment).

2.2.3 FAP 13 The O & M Study

The operation and maintenance (O&M) of flood control systems is generally seen as a major constraint to their effective functioning.

FAP 13, the Operation and Maintenance Study was carried out in close liaison with FAP12 and assessed O&M on the projects which were being evaluated. The following problems, constraints and difficulties in current O&M were identified through this assessment :

a) The main organisation involved in the O&M of projects is BWDB at the central level. In BWDB, O&M Divisions are responsible for repairs and rehabilitation of projects as well as for routine O&M. The Local Government Engineering Department (LGED) was instructed in 1985 to take responsibility for the O&M of small completed schemes at District and Upazila levels, but in general this has not happened.

b) Funds for O&M are mainly the Revenue Budget, Food For Works(FFW), Development Budget and Cash Foreign Exchange Budget. The total of these funds is inadequate to allow effective O&M.

c) Operational problems include:

- inadequate design not taking operational requirements into account,
- weak institutional arrangements for operation,
- untrained operators of structures,
- frequent conflicts of interest over operating practice, and no procedures for conflict resolution.

d) Maintenance problems include:

- lack of routine maintenance of structures.

e) Other aspects:

- lack of public consultation in planning and design stages, and during construction and commissioning, which has led to misunderstandings about projects and subsequent O&M problems
- lack of O&M manuals, especially for field staff
- unclear tasks, responsibilities and accountabilities of staff involved in O&M.

A large number of programmes are now also involved in developing new approaches to O&M. These initiatives are : Systems Rehabilitation Project (SRP), Second Small Scale Flood Control, Drainage and Irrigation Project (SSSFCDI), Early Implementation Project, Ganges Kobadak Rehabilitation Project, BWDB Operation and Maintenance Cost Cell, LGED's Rural Employment Sector Programme and CARE's Food for Work and Rural Maintenance Programme. Although these initiatives are taking place in a wide range of institutional contexts, the majority of them put emphasis on more local-level involvement in O&M, involving local-level institutions, beneficiaries, and local disadvantaged groups (particularly landless labourers and poor women). Local-level involvement, preferably at all stages in the project cycle, is seen as an important element in a successful O&M strategy.

Most of these initiatives are recent and it is too soon to be able to adopt a proven O&M model on the basis of their experience.

FAP 13's overall recommendations for improving O&M are:

a) improved institutional arrangement;
b) public participation and consultation;
c) changing of planning and design of some project components to facilitate O&M;
d) establishment of specific operating rules for individual structures and preparation of

project-specific O&M manuals;

e) establishment of water management procedures, involving increased farmer participation where appropriate and including contingency plans for managing floods;

f) resource mobilisation, e.g. introduction of value-related land taxes in flood-protected areas, and multi-purpose use of FCD/I infrastructure for resource generation;

g) undertaking of routine maintenance;

h) monitoring of O&M costs and resource estimates based on clear guidelines;

i) staff training.

Some of these recommendations require action at national level, and most of them require further elaboration and trials at field level. Nonetheless they provide a basis for a sound approach to O&M. Suggestions have been made that the second phase of FAP13 should involve pilot O&M work with initiatives being developed within other FAP components. One possible initiative is the Gaibandha Improvement Project. This is discussed further in the Gaibandha Improvement Project Final Report.

2.3 On-Going Programmes in the Region

2.3.1 Programmes in the Water Sector

There are a number of important on-going programmes and developments in the region, particularly in the water sector. These include the Early Implementation Programme, the Systems Rehabilitation Programme, the Small Scale FCDI Programme, the Food-for-Work Programme and initiatives of the Local Government Engineering Department. In addition an important study has recently been completed on the Chalan Beel polders.

Early Implementation Projects (EIP)

The EIP project was set up in 1975 and is now jointly funded by SIDA and the Netherlands. The project, which is within the Directorate of Planning Schemes IV (BWDB), is responsible for identification, planning and monitoring of small-scale flood control, drainage and irrigation projects implemented by BWDB. It has implemented 20 schemes in the region, many of them on the left bank of the Atrai, and it is still actively working there. It is also involved in several schemes in and around the Gaibandha project area.

The fourth phase of five years for the project started in July 1990. In this phase the engineering infrastructural components of the programme are supplemented by socio-economic and agronomic ones. Another of the key issues of the present phase will become the formulation and implementation of an Operation and Maintenance (O&M) programme in selected, completed schemes. EIP is actively working with NGOs, and particularly Labour Contracting Societies (LCS) in implementation of projects.

Systems Rehabilitation Programme (SRP)

The SRP programme has two major components, rehabilitation and O&M. The programme started in September 1990 and will run for seven years. Technical assistance is funded by EEC, with construction funded by the World Bank.

The rehabilitation component includes feasibility studies, preparation of tender documents, and detailed design. Sixteen schemes were taken up for early rehabilitation in a project completed in early

1991, and a further 65 are now in hand. Several of these are in the region, including a small one within the Gaibandha project area, and have implications for regional planning.

The O&M component of the programme has several elements, of which the most significant to the study is the strengthening of O&M in Nawabganj. This component started in February 1991, and concerns the improvement of O&M in the six completed schemes in the sub-division. SRP is considering some physical works in the 6 projects to aid O&M but not undertaking basin-wide planning.

SRP also has a rolling 6-yr human resources development programme (HRD). It is focused initially on Nawabganj, Chandpur, Muhuri and Karnafuli irrigation projects, of which only the first is in NWR. It will later be extended to other BWDB projects.

There are two parts of the HRD component:

a) Staff development and manpower planning, including computerised inventory, job descriptions, work load etc for BWDB personnel.

b) Training for 5 target groups (Executive Engineers, section officers, kalashis (gatekeepers), farmers/beneficiaries, maintenance supervisors). Some BRDB staff are also included.

Other small schemes

There are a great number of schemes which have been implemented in the region over the last 30 to 40 years, many of those having also been under one rehabilitation programme or another more recently. Although many are operational, several no longer serve their intended purpose whilst other have been absorbed within larger schemes. A list of the more important small schemes is presented in Appendix 1 (Table 5).

Several of the projects given in the table relate to the Small Scale Flood Control, Drainage and Irrigation Programme (SSFCDI) and have been built with funds provided by the World Bank and the Government. Much of the work under this programme has related to structures, earth work components have normally been undertaken through FFW. Some pilot projects have also been implemented under the programme, funded by CIDA.

The criteria for such projects have generally been as follows:

- fully planned schemes; less than US$ 1.5 million base cost and 6000 ha each;
- appurtenant structures; less than US$ 400000 base cost each;
- rehabilitation; less than US$ 500000 per scheme;

Atrai Kakra is the only fully planned project which is under execution in the region. The project is expected to be completed in the year 1993-94.

The third Phase which is presently ongoing runs from 1990 to end 1993.

A list of the of the projects currently under O&M through SSFCDI is given in Table 6 in the appendix.

The Local Government Engineering Department (LGED)

The LGED has been responsible for formulation of thana plans, in co-operation with thana officials, and the preparation of thana maps, including maps of roads, FCD facilities and irrigation schemes.

As funds become available, the works proposed in the plans are implemented under the supervision of the thana engineer. Cash work is done through contractors, but the thana engineer also supervises Food-For-Work programmes.

SIDA has funded LGED work on water development in the Kurigram South area. The main emphasis of foreign-aided work by LGED is now, however, through the Rural Development (RD) programmes, most of which are directed towards rural roads and growth centres. RD programmes of this type cover the whole of the region. A similar type of work was done through the World Bank Flood Rehabilitation Project.

A new water resources development initiative through LGED is shortly to be implemented with funding from ADB. The regional distribution of this new programme is as yet uncertain.

The Food-for-Work Programme (FFW)

The Development-Orientated BWDB Food-for-Work Programme is concerned with planning, implementing and monitoring all FFW programmes for BWDB. A design directorate was set up under a Chief Engineer in mid-1991 for all FFW projects which are not co-financed. The BWDB FFW programme comprises approximagely 70% of the full FFW activities in the country.

If a project needs cash work, for example for structures, it is not normally suitable for FFW. However earthworks, canal digging and desilting are all appropriate and FFW carries out most of BWDB's works in these activities. The actual work is carried out through Project Implementation Committees (PICs), with an elected chairman organized at the thana level.

The problems of compaction, and vegetative cover for embankment stabilisation, have been under study through the programme.

The Assessment and Hydrological Studies of Chalan Beel Polders A, B, C & D

The draft final report for this study was presented in February 1992 and recommended rehabilitation to full protection. It noted that the ineffectiveness of Polders C and D, in particular, is caused by extensive public cutting of embankments. A total of 101 man-made breaches were made in Polders B, C and D during 1986-91, which clearly demonstrates the non-functioning nature of the system at present. The report suggested that, at least in the case of Polder C, the breaching problem should be solved "at the social level" rather than at the engineering level. However, there was no suggestion as to how this would be done. The large number of cuts being made every year indicates that confinement of the Atrai negatively affects a significant number of people. There is no reason to doubt that they will continue to cut the embankment as long as this situation continues.

The report suggested that there should be no further embanking on the left side of the Atrai. This would utilise the flood plain to reduce water levels but would also cause inequality of benefits between the left bank and the Chalan Beel polders, in the same way as there is currently inequality of (expected) benefits between people inside and people outside the embankments. It is therefore unlikely that such a policy (of embanking only the right bank) could be successful in practice, given the ease with which embankments can be cut. The issue of relative extents of gains and losses has to be addressed since it is crucial to the effectiveness and acceptability of any large CFD project

The report calculated high EIRRs for the four polders. General findings from work carried out under NWRS would confirm that, in theory, high returns are available from full and effective CFD. However, for these returns to be achieved, absolute effectiveness must be assured and full farmer confidence obtained. Experience in the Chalan Beel Polders to date suggests that these cannot be guaranteed. Theoretically, effective CFD might be achieved but only at the expense of many people outside and downstream from the polders: the inequity of this outcome is likely to continue to result in public cutting, which then reduces the actual benefits of those inside the polders.

Thus, while the report made a significant contribution to planning in the Lower Atrai and contained much useful data, its recommendations were not supported by work done during NWRS.

2.3.2 Other Programmes

Besides the water resource programmes described above, the Regional Water Development Plan has some important linkages to developments in other sectors. These include the World Bank-funded Road Rehabilitation and Maintenance Project. Under this project the Baghabari-Bogra-Rangpur road is currently being upgraded and recommendations have been submitted for improvements to the Pabna-Rajshahi route and Rangpur-Saidpur routes. An additional element of the programme has recently commenced concerning road connections from the Jamuna Bridge within the region. These proposals may involve construction of a highway to international standards from the bridge approach south of Sirajganj across to the Pabna-Rajshahi road. Embankments for major roads of this standard cannot normally be considered as part of flood control infrastructure, since the protection of the communication link requires that flood waters be passed across the route with the minimum of disturbance.

An important development concerning fisheries in the region is the IDA Third Fisheries Project, which is carrying out artificial stocking of beels. The project aims at :

(a) Increasing incomes, particularly of the poor, and fish production for domestic consumption and export,

(b) Supporting the fisheries development programme in the north west and south west with emphasis on private sector participation,

(c) Accelerating the expansion of fish production in flood plains and beels.

CHAPTER 3

FLOOD CONTROL AND DRAINAGE OPTIONS

3.1 Responses to Floods

A broad range of responses to flooding can be identified. These include a variety of structural interventions and modes, from schemes intended to provide full flood protection to those offering only partial protection. A number of alternative responses based on non-structural interventions are also important.

Schemes designed to provide full protection aim to completely exclude external flood waters, and to minimise internal flooding by the provision of appropriate drainage structures. This is the basis on which most FCD schemes in Bangladesh have been planned hitherto. Whilst the benefits of a successful scheme can be shown to be high, they have on the whole failed to deliver the expected benefits, as has been shown by FAP12 and numerous other studies, and they also bring with them a number of other disbenefits and risks. The Flood Action Plan has therefore emphasised the need to modify the approach to FCD through the concepts of controlled flooding and drainage (CFD) and compartmentalisation. CFD involves the provision of facilities which allow farmers and others within the protected areas to predict the depth and timing of flooding for the maximum beneficial effect, as well as excluding peak flood waters which can be very damaging. Improved drainage facilities would allow more rapid drainage of retained flood waters. In the case of NWRS, the possibility of implementing major drains, which would completely alter the hydrological regimes of the Atrai and Karatoya basins, necessitated the analysis of full CFD development in these basins. It is unlikely that the high cost of such drains could be justified by anything other than the maximisation of potential benefits in the river basins downstream, which in turn requires that full CFD facilities should be provided.

In most of the areas under study, analysis included the provision of partial protection, in which the area being served is divided into higher land, for which full protection is appropriate, and lower land, for which it is not possible or desirable to provide full protection and which will therefore suffer some degree of flooding. For a particular area it might have two agricultural objectives :

- protection of the boro harvest from flash floods (as in NE Bangladesh)
- control of the level and rate of rise of monsoon water levels so that TDW aman can be grown.

Analysis shows that TDW aman may have returns higher than b. aman and that farmers are beginning to adopt it in increasing numbers. Partial protection, whilst it reduces the agricultural benefits achieved, also reduces some of the disbenefits of full protection, notably the interference with floodplain fisheries and diminution of potential groundwater recharge. In the particular case of the lower Atrai and lower Bangali, it also reduces the confinement effect on the lower Atrai and lowers maximum river levels.

The concept of compartmentalisation was used in NWRS planning. For instance, in schemes or areas where CFD is under consideration the protected areas are sub-divided into smaller internal compartments using existing village roads or other infrastructure. This decreases the volumes of water which must be managed or excluded, as well as reducing level differences between different parts of the protected area. Both these factors lead to difficulties of design and operation in large polder schemes. The purpose of compartmentalization is to reduce flood flows and volumes to make them more manageable, and to distribute the flooding from rainfall runoff to internal and main rivers. However, the option of compartmentalization must also be adopted with caution, since the concept is not yet fully tried and developed and it may simply add to conflicts which already exist. Many aspects of operation and maintenance (O&M) of flood control facilities remain to be clarified, particularly in the case of compartmentalisation. The results of FAP 20 are obviously important here even if they will not be clear for some years. In this study, a modified concept of compartmentalisation or sub-poldering was considered, primarily to allow improved drainage, but also to divide areas where flooding will be permitted from areas where CFD will be developed.

Structural flood control interventions are based either on embankments, for excluding or delaying entry of external flood waters, or drainage channels and structures, for removal of internal rainfall and run-off. Wherever possible, improved drainage is considered as the first priority. Recent experience with embankments in the region shows that people do not readily accept water level differences across them and will quickly cut them if they perceive that they are being flooded by an embankment protecting other peoples' land. Improved drainage may produce similar disbenefits in downstream or adjacent areas (by decreasing retention times and increasing flows and depths) but differential depths of flooding are not so readily apparent, nor is it so easy to take action to reverse the situation. On the other hand, planning for improved drainage must take account of the fact that dry season supplies for irrigation are also a problem, which may be made worse with better drainage.

The possibility of pumped drainage from poldered areas was examined prior to the submission of the Interim Report. This was done by analysing the marginal increase in production due to reduction in flood depths from pumping at a range of capacities (10, 20 and 30 m^3/s) in a sample area. The analysis, which was described in detail in Annex 7 of the Interim Report, clearly showed that drainage pumping is not a feasible solution, either at financial or economic prices. It was not, therefore, considered further as a viable option for the Regional Plan. The only situation under which drainage pumping might be viable is where it can be combined with pumping for irrigation with reversible pumps, as in the Pabna Project.

Great interest has been shown in alternative responses to floods, which do not involve structural interventions. These include initiatives to increase HYV boro production without recourse to flood control interventions, programmes to encourage small-scale horticultural production around homesteads, pilot projects in improved systems of storage for crops, fodder and fuel, improvement in materials and techniques for house construction and public infrastructure, and the creation and systematic development of embankments and other elevated areas as refuges for people in time of floods. This range of measures was studied through FAP14 (the Flood Response Study) and FAP23 (the Flood Proofing Study). They are an appropriate measure in many parts of the region but are likely to be particularly important on completely unprotected areas such as charlands. Flood proofing is discussed in more detail in section 3.5. In many cases non-structural measures are not alternatives but complementary measures which are desirable in themselves. For instance, increased boro protection would appear to be a worthwhile objective for a number or reasons, including the increased security which it brings to owners of small farms. It does not itself affect the desirability or otherwise of taking measures which modify the flood regime during the monsoon. Economic analysis and impact assessment of the structural measures under consideration here provides information on whether, on balance, it is better to undertake them, or not. The do-nothing alternative is represented by the "Without Project" situation.

3.2 The Planning Units

For comprehensive planning, the whole region has been divided into planning units. These are normally delineated by rivers, the international border or major infrastructure such as railway embankments. Planning units are not generally co-incident with the planning areas defined by WARPO, since these are primarily intended for resource assessment rather than flood protection planning. Considerable use has nevertheless been made of the data on planning areas available in WARPO. The 15 planning units are listed in Table 3.1 and shown in Figure 3.1.

Table 3.1 North West Regional Study Planning Units

No.	Planning Unit Name
1.	Thakurgaon
2.	Upper Atrai
3.	Teesta Right Bank
4.	Teesta Left Bank
5.	Kurigram
6.	Upper Karatoya
7.	Gaibandha
8.	Middle Bangali
9.	Joypurhat
10.	Western Barind Tract
11.	Mohananda Basin
12.	Atrai Left Bank
13.	Atrai Right Bank
14.	Lower Bangali
15.	Pabna

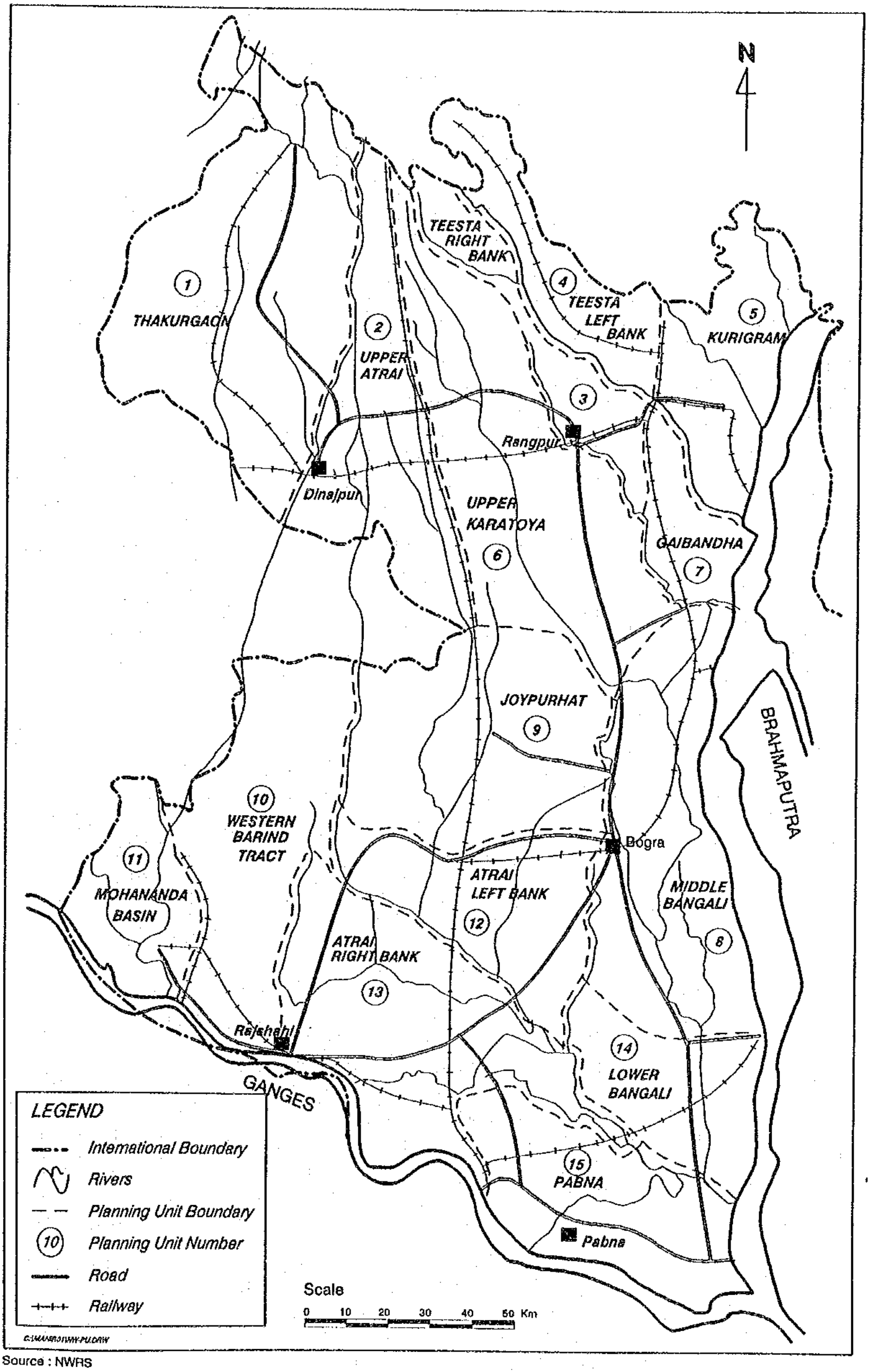
Within each planning unit the identification of areas with flooding problems was done on the basis of hydrological factors, flood phase data, cropping intensity, and field and secondary data on crop and infrastructure damage. Whenever possible use was made of the GIS system to overlay thana-level data to build up a consistent and comprehensive picture of flooding and drainage problems. Hydraulic models were developed for the key areas of the region (Lower Atrai and Lower/Middle Bangali, and the GIP area). In non-modelled areas comparison was made between the theoretical discharges (derived from an analysis of the NAM rainfall-runoff catchment) and conveyance capacities at surveyed river cross sections to assess locations of flooding problems or drainage congestion. In downstream reaches model analysis was used to identify these locations. These were then integrated into the review of each individual planning unit in Section 3.4. In general, the deepest flooding occurs in the downstream basins (Lower Atrai and Lower Bangali) which are also heavily influenced by the backwater effect of the Jamuna River. These downstream basins may also be influenced by flood control developments upstream. Therefore a region-wide approach is necessary to take into account interactions within the region.

The options to be considered are partly governed by policy decisions on the distribution of flood discharges within the region. For example, two clear alternatives are :

(a) to retain flood water in each sub-unit in the region, or,

(b) to pass the flood flow to the downstream basins, necessitating the development of flood control measures there.

Figure 3.1
NWRS Planning Units



Source : NWRS

In general, the proposed plan attempts to follow the principle that developments in one area should not cause a significant increase in discharges elsewhere. This principle introduces an element of equity in dealing with floods, although it is difficult to apply everywhere throughout the region. There will be a natural tendency for those upstream to gradually seek improvements which will tend to increase downstream discharges.

3.3 Regional Data Base

3.3.1 The Geographic Information System

Regionally - available data was analysed using a GIS system. This consisted of data on

population
cropping
irrigation development
flood phase
soils
crop damage
water bodies

Population data was from the 1981 census because 1991 information was not available. This data therefore needs updating as the new census data becomes available.

The crop figures were from BBS surveys of 1980 and 1987. 1989 figures were obtained but not used because of inconsistencies in the data. Present cropping intensity and crop damage were available on a thana basis. Irrigation development data came from the Ministry of Agriculture, AST project. Data was available for 1981 and 1989. This data is thought to be relatively reliable.

Flood phase data was available from BARC and MPO datasets. Both were originally derived from SRDI 1:125 000 scale soil association mapping. Because of disparity between the estimated areas of each land type the MPO data was used.

Soil information was based on the reconnaissance soil survey reports published by the Soil Resources Development Institute (SRDI). The reports for the North West Region were published over the period 1968 - 77. District and thana boundaries were taken from thana maps of the Bangladesh Department of Land Records and Survey.

The 1985 report on standing water bodies in Bangladesh (SPARRSO) produced for MPO was used to assemble statistics on water bodies in the North West.

A large range of tabulations and maps were produced from this data and are discussed in Volume 2. Key maps and combinations which were used extensively in an assessment of flooding problems within the region are discussed in the next section.

3.3.2 Flood Planning

The GIS presents a large range of possible indicators of flooding within the region, all of which can contribute in a variety of ways to building up an overview of flooding problems. However, for regional planning it was decided to concentrate on three key indicators:

- flood phase (Figure 3.2).
- cropping intensity (Figure 3.3)
- crop damage (Figure 3.4)

While the cropping intensity map may need further interpretation because low cropping intensities may be due to various factors such as lack of irrigation, flood phase and crop damage both give simple indicators of the location of possible flooding. These maps confirm that, in general, flooding problems are more severe in the south and east of the region.

In order to use the GIS as a planning tool, it was decided to combine these three indicators and classify the region according to their combined effect. The basic aim was to identify appropriate flood control measures in broad terms as a framework for considering options in particular planning units.

The whole region is classified according to the three indicators above with two ranges within each of the indicators. There are therefore 8 categories: every thana will fall under one of these 8 categories. The characteristics of each category can be broadly stated, as below:

Category 1: F2-F4 < 50%, cropping intensity > regional average, low crop damage (less than 25%) - these areas are the most developed agriculturally and suffer little crop damage. Flood control is probably not a high priority.

Category 2: F2-F4 < 50%, cropping intensity < regional average, low crop damage - such areas would normally have high potential for intensive cultivation but have so far not attained it, but flood damage to crops is low. Unless these are areas of perennial crops, lack of irrigation is probably a constraint, and flood control may be a relatively low priority.

Category 3: F2-F4 > 50%, cropping intensity > regional average, low crop damage - such areas, although low-lying, have attained relatively high cropping intensities, probably due to irrigation. Crop damage is generally low and output relatively high, therefore there may be few grounds for major flood control measures in such areas.

Category 4: F2-F4 > 50%, cropping intensity < regional average, low crop damage - such areas are less developed agriculturally, perhaps because of the presence of large low-lying areas, but they suffer little crop damage, and might be important for capture fisheries. There may therefore be few grounds for major flood control measures in such areas.

Category 5: F2-F4 < 50%, cropping intensity > regional average, high crop damage - such areas are highly developed agriculturally but they suffer high crop damage. There may therefore be grounds for control measures to prevent flood damage in these areas.

Category 6: F2-F4 < 50%, cropping intensity < regional average, high crop damage - such areas would normally have high potential for intensive cultivation but have so far not attained it. One reason could be the level of crop damage experienced, and therefore there may be grounds for flood control in such areas.

Category 7: F2-F4 > 50%, cropping intensity > regional average, high crop damage - such areas, although low-lying, have attained relatively high cropping intensities, probably due to irrigation. Crop damage is however high. There may then be a case for flood control measures, but with the proviso as above that such measures may be only partial due to the deep-flooded nature of the area.

Figure 3.2
Flood Phases

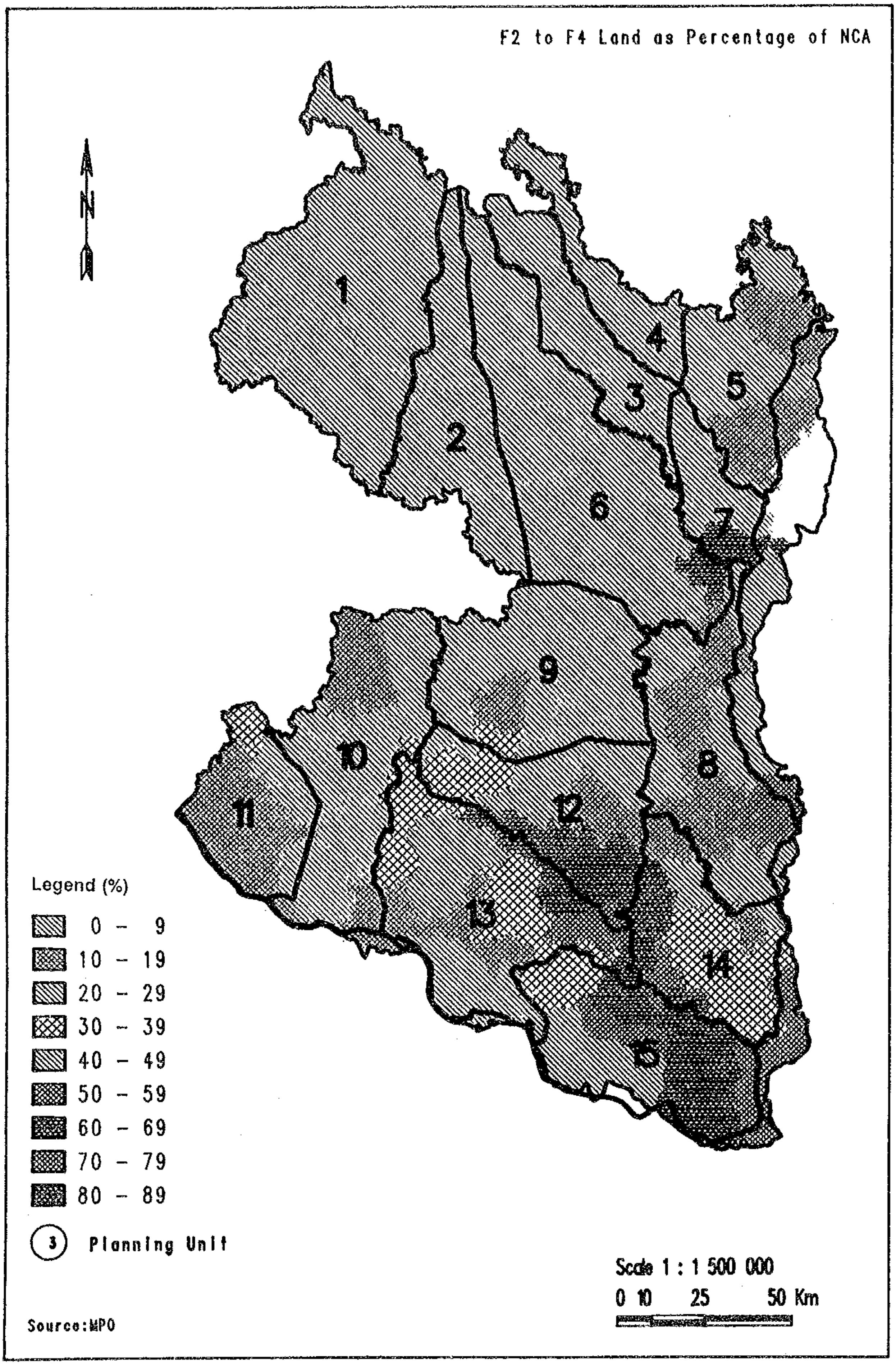


Figure 3.3
Cropping Intensity

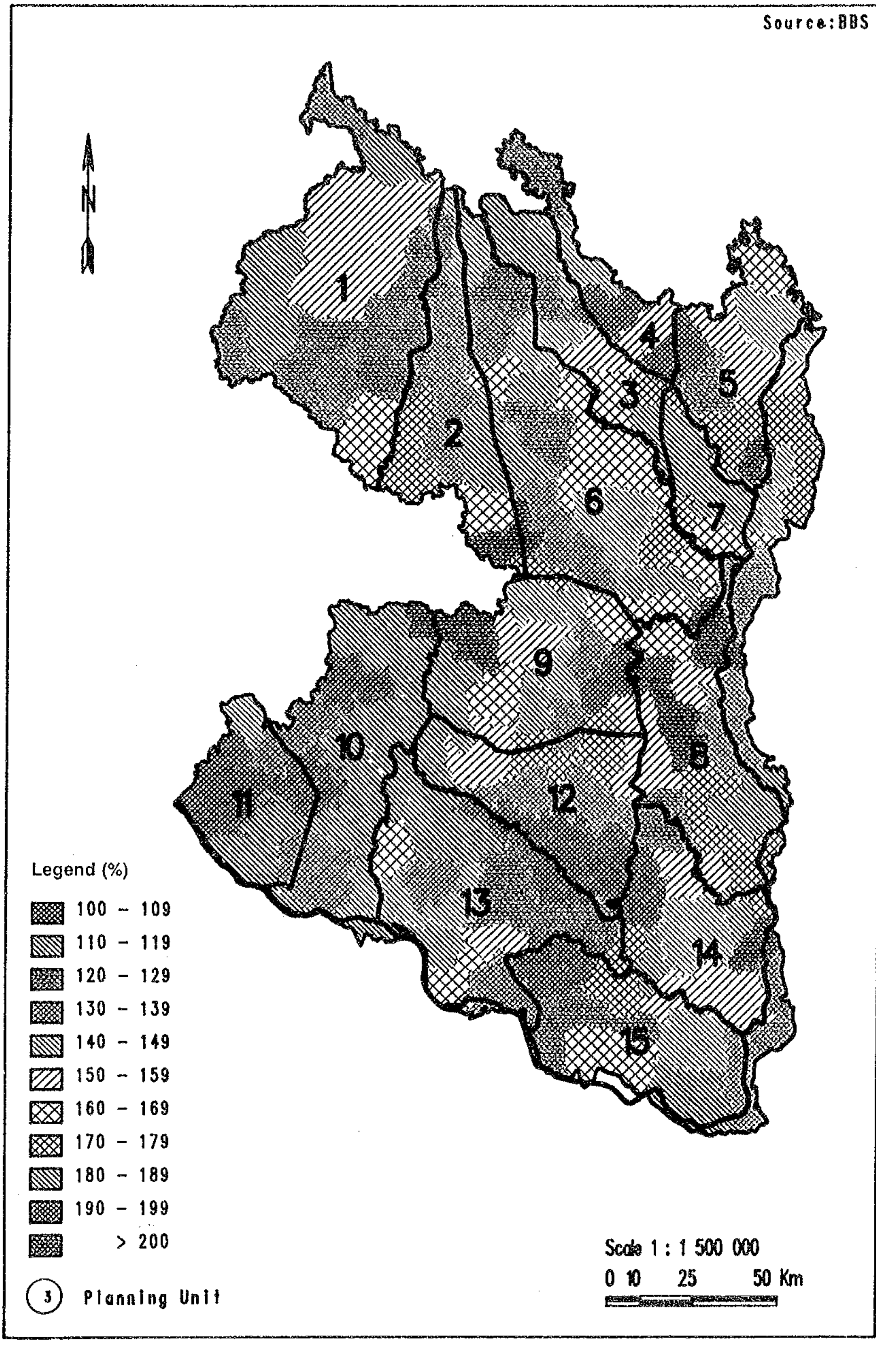


Figure 3.4

Crop Damage