People's Republic of Bangladesh
Ministry of Irrigation, Water Development
and Flood Control

Flood Plan Coordination Organisation

JAMALPUR PRIORITY PROJECT STUDY

Caisse Francaise de Developpement
and
Commission of the European Communities

FAP 3.1

FINAL FEASIBILITY REPORT

Annex 3 Environmental Impact Assessment

January 1993

Consortium

SOGREAH/ HALCROW/ LAHMEYER

in association with
Engineering & Planning Consultants Ltd.
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2

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ANNEX 3

ENVIRONMENTAL IMPACT ASSESSMENT

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GLOSSARY

acre	-	0.4047 ha
Aman	-	Early dry season paddy planted before or during the monsoon and harvested November-December
Aus	-	Early Monsoon paddy planted during March-April and harvested during June and July
B.Aman	-	Broadcast Deep-Water Aman Paddy
BARC	-	Bangladesh Agricultural Research Council
BBS	-	Bangladesh Bureau of Statistics
BCAS	-	Bangladesh Centre for Advanced Studies
Beel	-	Bangla term for an area of open water away from a river
Bigha	-	A unit of area measurement = 0.33 acre or 0.14 ha
Boro	-	Late dry season paddy transplanted in December-January and harvested April-May
BRAC	-	Bangladesh Rural Advancement Committee
BWDB	-	Bangladesh Water Development Board
Decimal	-	Unit of area equal to 0.01 acre
DEM	-	Digital Elevation Model
District	-	A large administration unit under the authority of a Deputy Commissioner, now known as a Zila
DoE	-	Department of the Environment
DOF	-	Department of Fisheries
EIA	-	Environmental Impact Assessment
FAO	-	Food and Agriculture Organisation of the United Nations
FAP	-	Flood Action Plan
FCD	-	Flood Control and Drainage
FCDI	-	Flood Control, Drainage and Irrigation
FPCO	-	Flood Plan Co-ordination Organisation
FRSS	-	Fisheries Resource Survey System
GIS	-	Geographical Information System
GPA	-	Guidelines for Project Assessment (FPCO Guidelines for the Flood Action Plan)
ha	-	Hectares = 2.4711 acres
HYV	-	High Yielding Variety
IUCN	-	International Union for the Conservation of Nature
Jalmahal	-	Bangla term for Government leased fishing rights
JPPS	-	Jamalpur Priority Project Study
kg	-	Kilogram = 1.11 Sher
Khal	-	Bangla term for a drainage channel or canal either natural or man made
Kharif	-	Summer/Wet Season

MCC	-	Mennonite Central Committee (an NGO)
MOEF	-	Ministry of Environment and Forest
Maund	-	A unit of weight = 37.5 Kilos
Mauza	-	A village revenue collection and cadastral mapped unit
MPO	-	Master Plan Organisation
NCS	-	National Conservation Strategy
NEMAP	-	National Environment Management Action Plan
NGO	-	Non Government Organisation
NOAA	-	National Oceanographic and Atmosphere Administration (of the USA)
ODA	-	Overseas Development Administration (UK Government)
ODI	-	Overseas Development Institute (UK)
PMO	-	Project Management Office
POE	-	Panel of Experts (of FPCO)
Rabi	-	Winter/Dry Season
SCI	-	Service Civil International (an NGO)
Sher	-	A unit of weight = 1/40 maund = 0.94 kg
SPARRSO	-	Space Research & Remote Sensing Organisation (of Bangladesh)
SPOT	-	System Pour Observation de la Terre (French Remote Sensing Satellite System)
SRDI	-	Soil Research Development Institute
T.Aman	-	Transplanted Aman Paddy
Thana	-	A sub-division of a Zila or District
Tk	-	Taka, Bangladesh Currency, 1 Pound Sterling = Tk 66 at October 1992
TM	-	Thematic Mapper
ton	-	An Imperial Ton = 1016kg
umoles	-	Micromoles, Unit of electro-conductivity, a measure of salinity
UN	-	United Nations
Union	-	Sub-division of a Thana or Upazila
Upazila	-	A subdivision of a Zila or District now known as a Thana
WHO	-	World Health Organisation
WO	-	Without, as in Without Project situation
Zila	-	A large administration unit formerly known as a District

FOREWORD

This Environmental Impact Assessment was produced as the culmination of 3 person-months expatriate environmental planning input in the main feasibility study period between November 1991 and May 1992 followed by 1.5 months in the extension period up to the end of October 1992. In addition a further 1.5 person months was spent on the FAP 3.1 Char Study which forms Annex 9 of the Final Feasibility Study Report. There was a Bangladeshi Environmentalist working on the main study or the Char Study through out the full period up until 15th October 1992. There were very short specialist inputs of one week on Health Issues, Nutrition and Ecology. In addition the expertise of other specialists on the study was used to cover the following disciplines and identify and summarise considerations for impact assessment and where appropriate mitigation measures:

- Surface Hydrology
- Groundwater Hydrology
- River Morphology
- Land and Soil Resources
- Sociology and Socio-Economics
- Agriculture and Agricultural Economics
- Fisheries
- Engineering

The aim has been to produce a self-contained document following the broad requirements of the FPCO Guidelines Annex 8 (previously 5B), and the then Draft FAP 16 Environmental Guidelines (the edition of August 1991 was actually used for planning the work for the extension period) as far as was possible within the major constraint of the resources made available to the project. It aims to identify the major negative environmental impacts to a proposed intervention and then modify the nature of the intervention to mitigate and minimise these as an intrinsic part of its configuration.

SUMMARY

Aims, Introduction and Methodology

The aim of this Final Environmental Impact Assessment (EIA) Report for the Jamalpur Priority Project Study (JPPS, also known as FAP 3.1) is to produce a free-standing document that outlines the present environmental situation in the Immediate Study Area (both in terms of the natural environment, the human environment and their interaction) and identifies the major issues, so that an appropriate range of intervention options could be drawn up for consideration in the feasibility study. This allowed the likely impacts of the proposed range of project interventions to be assessed. These have been indicated on a matrix and ranked against each other and the predicted without project situation, for both positive and negative impacts. In addition the issues that are considered important have been highlighted, both from the perspective of a detached "technical" viewpoint and also those considered important by local people. In addition the external impacts created by the proposed interventions were also addressed. This entailed a major special study of the adjacent Char lands which has now been incorporated into the Total Study Area and is written up in Annex 9 of the Final Feasibility Report.

The results of this subjective analysis were used as one of many criteria for selecting two of the options (flood proofing and drainage improvement of the whole study area (OPTION A) and controlled flooding of the largest part of the study area with flood proofing and drainage improvement for the rest (OPTION B)) for more detailed study. This has resulted in the recommendation of a variant Option B5 which has been studied to feasibility level, and the drawing up of Terms of Reference for the following detailed design phase. The recommended options for the entire study area include the provision of controlled flooding and drainage measures over as large an area as possible within the Immediate Study Area and, in parallel to this, the provision of flood proofing measures on the remaining unprotected areas of the setback, attached and island char lands. To mitigate against the increased risks of flooding caused by the flood control embankments, it is further recommended that the suggested pilot programme for flood proofing is implemented as part of the embankment project.

As far as the resources for the study allowed, and with in the constraints of data availability, particularly the nature and accuracy of the output from the hydraulic model, the EIA has attempted to identify and indicate the nature of the likely impacts. In addition the major negative impacts have been quantified and where possible valued with mitigation proposals being put forward and costed. This has allowed the multi-criteria analysis to incorporate the costs of mitigation as an intrinsic part of the project cost and benefit assessment.

The EIA broadly falls within the scope of World Bank Operational Directive 4.01 and the Draft FAP 16 Environmental Guidelines of August 1991 which were used for programming the revised and extended work plan submitted in the re-submitted Inception Report of February 1992. However considerable further work is required, particularly on the hydraulic modelling of both the internal flood plain system and also the Jamuna and Old Brahmaputra main rivers before a more detailed EIA can be carried out which would allow spatial and social variation of impacts to be fully addressed.

It is recommended to carry out the above work as early as possible and in parallel to the detailed design phase of the option B5 scheme. The requirement remains for adequate data to fully consider the likely environmental consequences in sufficient detail to meet FPCO's GPA criteria as well as those of other organisations. It is noted that the present accuracy of the hydraulic modelling output is presently inadequate to do this.

Environmental Conditions in the Main Study Area

Both surface water flooding and drainage congestion are cited as major issues for people within the main study area, both those holding and farming land and also those who do not. However those people in the active river plain area cite land loss due to erosion as being a far more serious problem still. The spatial distribution of these erosion and accretion processes have been studied in some detail over the last 20 years using time series Landsat imagery. In summary it is a very dynamic river system but major trends over the last 20 years can be seen and borne in mind when drawing up shorter term development planning strategies for the area, particularly flood proofing in the unprotectable land. There is also a problem with sand carpeting as a result of flooding and sediment deposition, although this can be a temporary condition as grass species colonise these areas quite quickly and cultivation can take place within two or three years. Further studies are underway by FAP 16 at national level to investigate the fertility of silt deposits. Soil chemistry does not appear to be a constraining factor to agricultural development at present, but monitoring is required to see if changes in soil structure take place as a result of increased drainage of some areas and increased water logging of others that are coming under all year cultivation especially using dry season irrigation.

There is a very low level of flora and fauna in the area due to intensive human activity and the availability of "common good" resources is declining as agriculture intensifies, particularly the development of continuous rice farming using the abundant and easily exploited groundwater. The reduction in groundwater recharge as a result of any control of river water flooding into the area is not considered to be a problem due to the high levels of rainfall recharge. Even the provision of drainage improvements is thought unlikely to have significant negative effects on this and it has been predicted that irrigation development can continue to expand to over 80% of the study area and still allow shallow foot-pumped techniques of water abstraction to be used. The quality of water in the study area, both from surface and groundwater sources needs monitoring on a long term basis to allow meaningful analysis. To do this it is essential that a suitably equipped laboratory facility is made available close to the study area. The area has a moderate seismic risk but due to the nature of the geology and soils the consequences of a major seismic event such as those that have occurred at least twice in the last two hundred years could be serious. This would need careful consideration and appropriate design and planning, along with the provision and implementation of emergency procedures for such an event occurring. It is unfortunate that most of the major past seismic events have occurred in the monsoon period when the river is at its highest and the seriousness of the implications of catastrophic failure are at their greatest.

Flooding has implications for economic activity, particularly disrupting agricultural production, including wage paid labour for those who do not have their own land to farm. Flooding itself is not a significant direct cause of death in the mainland, but secondary impacts can contribute towards mortality, particularly with regard to waterborne disease. The situation is different in the Char lands where a significant number of people were drowned in the 1988 floods and more died from consequential causes afterwards. However these mortality figures are less than those for disease, particularly waterborne ones, which are the major cause of death although probably assisted by the poor level of nutrition of a large minority (44%) of the population. The level of risk in many households is high due to their very marginal nature. This includes natural environmental factors such as erosion and flooding but also vulnerability due to lack of economic assets, particularly the scarcity and uneven access to cultivable land. Access to common good resources such as fisheries, fodder and fuelwood is declining all the time as economic activity intensifies. The situation with regard to fisheries is dealt with separately in Annex 2. The number and quality of livestock, especial draught animals, is poor.

The general level of human health in the area is poor, the incidence of waterborne and vector-borne disease is quite high and certain types have been increasing in recent years. Of particular concern are diarrhoeal diseases, including cholera, along with malaria and Kala-azar (leishmaniasis) both of which have been on the increase in the last 20 years. Some of this is linked to sanitation, water supply and poor health education whilst others, such as nutritional problems, are primarily due to poverty.

There are two major industrial operations in the area, a sugar mill and a large modern fertilizer factory each having specific environmental issues, particularly effluent quality and disposal. In addition the fertilizer factory has serious problems of process water supply and boat access for distribution of the product, due to its location on an accreting river channel system. The transport infrastructure in the project area is variable, the railway links down the eastern side and the main Jamuna river down the western side of the study area being the most dependable. The road transport system is in a particularly poor state of repair. Despite a long history of settlement there appear to be no major buildings or culturally important sites in the study area, partly because of the absence of durable building materials and the dynamic nature of the landscape. It should be remembered that 220 years ago the Jamuna river did not even exist, the then main channel of what was then the Brahmaputra river was located in what is now the Old Brahmaputra flood plain.

Conclusions

The major conclusion of previous JPPS reports was that Option A has very few negative impacts but also far fewer positive ones than Option B, particularly those associated with the protection of agricultural land from high normal floods. The stated desires of local people in the mainland project area (both those occupying land and those who do not), are for the construction of embankments. However care has to be exercised in considering this, as local peoples perceptions are very much formed by a short time horizon, due to the precarious nature of many household's security. They tend to undervalue the significance of the longer term and indirect negative impacts, for example the nutritional consequences of loss of fisheries.

Option B for the mainland, without any mitigation is likely to have some serious negative impacts. The most significant of these is the resulting increase in flood risk to unprotected lands in the Jamuna. There are major welfare and equity issues here, in that those people who already have the most vulnerable livelihoods due to both flooding and erosion are likely to have this made even worse in order to protect the agricultural land of better off people who presently have a significantly lower flood risk. Now that the numbers of people are known it would seem to very seriously question the basic philosophy of the intervention as originally proposed. Some 602 000 people are likely to have their flood situation made worse for the sake of controlling the flooding of 631 000 people. In order to address this issue, it is now proposed to take up a complementary programme of flood proofing in the adjacent unprotectable area. This is regarded as an intervention in its own right and would entail a major programme of various degrees of homestead raising, communal refuge provision and multi-purpose use of embankments aimed at securing the lives and homestead assets of residents. This would allow more rapid post flood recovery to take place.

There are complexities in apportioning the mean increased flood risk of 0.3m in a peak flood situation between FAP 3.1 and other existing and proposed projects. However it would seem likely that local people will perceive, wrongly, that FAP 3.1 is the primary cause of this. The aim of the flood proofing programme would be to raise homesteads and provide flood refuges above the 1988 peak flood level plus the additional height required as a result of the confinement effects as a results of embanking. The incremental height raising will be only some 10% of the required total height and even this should be apportioned between other interventions, both present and past which have and will contribute to this. As a result the apportioned flood proofing costs attributable to the FAP 3.1 land protection intervention are likely to be relatively low at TK 31 200 000 or some 3% of the total mainland project costs.

The social impact assessment indicates that there could be benefits to landless people on the mainland, principally in wage paid employment during construction, operation and maintenance and perhaps some agricultural labour as a result of intensification. However the experience of the FAP 12 studies indicates that the latter could be very limited, as there is such oversupply of labour from within households owning land that they are unlikely to hire in much extra labour.

The whole question of risk levels and sustainability of the recommended option from social, economic, environmental, political and even narrow engineering standpoints is difficult to assess at present. It requires, inter alia, confirmation of the institutional framework for project implementation, including the nature of project funding (central to this is if it will all be grant aid funded or a recoverable loan), which should be established at the outset ideally with sustainability in mind, before this can be done.

If the decision is taken to implement the Controlled Flooding Option B5 on the mainland area then there should seem to be no alternative but to instigate a

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parallel programme of flood proofing in the unprotected lands, very preferably combined with an income diversification supprot programme. However, irrespective of decissions made for development of the mainland, there is a clear need from both social and humanitarian standpoints to improve conditions for those living in the areas not included within the proposed protected area. This report outlines a portfolio of measures to address many of their needs, including making fullest use of the mainland embankments as potential sources of both temporary and permanent refuge.

The loss of fisheries resources is also significant and mitigation of this appears to be possible for the small proportion of professional fisherman but not so easy for occasional fisherman who directly consume the fish they catch on an informal basis. The real issue is the provision of a sustainable programme of affordable protein replacement provision. More detailed nutritional surveys are required to obtain data on the present situation and draw up a suitable mitigation programme.

There are lesser issues with regard to the decline of waterborne navigation and these should be mitigated for as part of an improved road network that is likely to occur, ideally as a component of internal water management planning. The situation with regard to water borne diseases is presently unclear and a major national study is underway to tackle an understanding of these issues. This is presently being handled by FAP 16. There is a lack of data on possible changes in soil fertility as a result of all year mono-cultivation and a baseline and monitoring programme is required in the mainland area.

There still remain uncertainties due to the lack of defined overall aims and strategy for national environmental management, how these interface with the Flood Action Plan and how they are to be applied to the first sub-regional study area at Jamalpur. Guidance is required as to national, regional and sub-regional priorities and policies and how these relate to the presently embryonic ideas for national environmental policy. From the comments on the draft version of this report some policy direction can be inferred, however this needs rationalising into a coherent strategy. The role and concept of integrated rural development within the previously envisaged narrow perception of flood control needs to be resolved, particularly the role and capability of the BWDB to undertake non-engineering programmes with a social component. Central to this is the likely nature of the institutional structure for implementation of the Flood Action Plan and the degree and nature of active public participation that is to involved in it. FAP 3.1 have proposed that a Project Management Office (PMO) be set up under the BWDB. This would need to have an environmental management and planning cell with multi-disciplinary staff either taken on directly or seconded in from different organisations. This is further expanded in Annex 7 but is believed to be a necessary and welcome move in widening the scope of FAP interventions in comparison to FCDI work that has gone on previously in Bangladesh. The aim is to promote interventions that address the issues that in the past have proved troublesome and undermined their chances of success.

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Recommendations

From an environmental perspective, whilst the recommended Option B5 addresses many of the important infrastructural development needs of the mainland area, it excludes those people who have arguably a much greater need for flood protection. The mainland project is justified economically on the basis of the primarily agricultural benefits thus derived, whereas the parallel flood proofing programme considered necessary by observation on both social and humanitarian grounds, is far less amenable to economic analysis. The framework for assessment of the value of flood proofing measures is far less advanced than is the case for projects which directly benefit agricultural activities. From the discussions held during the FAP 3.1 study, it appears that more work is needed in order to fully address the requirements of both project assessment techniques as well as an overall framework for defining policy and investment criteria for these unprotectable areas.

In consideration of narrower natural environmental issues there is a basic lack of data, with the result that many of these cannot be considered in a sound technical manner in the EIA work for the JPPS and the FAP programme in general. These require long term national monitoring programmes (the short term and episodic nature of FAP 3.1 is a totally inappropriate vehicle for such work) and need to address the following issues:

- National water quality monitoring including surface water, groundwater, industrial pollution (both rural and urban), agro-chemicals, including nitrate problems of fertilizer use along with herbicides and pesticides, particularly under conditions of all year round cultivation and dry season irrigated agriculture.

- The nutritional implications of present fish consumption and how this is likely to change under FCD interventions, considering production (species diversity change) and consumption patterns. This also needs to consider alternative affordable sources of protein intake, particularly for marginalised households.

- A baseline data collection exercise to monitor likely soil chemistry changes as a result of all year mono-cropping and dry season irrigated agriculture.

- A study and monitoring programme of the likely effects of all year standing water (due to irrigation) on the incidence and nature of waterborne disease, particularly diarrhoea, Kala-azar and malaria.

Many of these programmes would be best carried out by a reinforced and assisted national Department of the Environment, but this needs to be part of a conscious policy not just a one off, ad-hoc arrangement for FAP 3.1.

In the absence of this, then adequate full time environmental staffing must be made available on a permanent basis as part of the Detailed Design and following work programme.

Specific recommendations for the JPPS environmental component are outlined in the following section on the future work programme.

Future Work Programme

As part of the detailed design phase of the proposed project, it is felt that there needs to be a significant amount of resources given to the non-engineering issues to ensure that wider environmental and social factors are considered adequately during engineering design. This includes the institutional structure for project implementation and the degree of public participation. A crucial issue is land acquisition policy and procedures. A copy of the draft of the TOR for the detailed design are included in Appendix D of this report. This will require significant skilled staff inputs, both generalists and specialists, from Bangladesh and outside it.

The specific environmental items that need to be addressed include:

- A full, internationally credible EIA under World Bank Operational Directive 4.01 and the newly released and approved FAP Environmental Guidelines. To this end it will be useful to improve the hydrology modelling of both the internal project area network and the main rivers (both the Jamuna and Old Brahmaputra), incorporating output from Digital Elevation Models (DEM's) that allows mapping to be produced that shows time series extents, depths, durations and timings of floods under a full range of with and without project situations. This would allow a suitable data collection programme for detailed ecological assessment to be drawn up. In addition it would then be possible to do more detailed impact analysis that allows a comparative assessment of spatial and social variation of impacts and development needs among the six or even eight sub-areas within both the mainland and unprotectable land implementation areas.

- Baseline monitoring data of water quality will need to be continued along with the planning of an evaluation and monitoring programme for the whole project.

- The detailed nutrition and health baseline studies need to be instigated.

- More detailed assessment work can be carried out on ecology as a result of the hydraulic modelling results.

- Fisheries considerations in the detailed design of drainage networks will need to be addressed along with the details of the fisheries mitigation and management programme.

- Environmental considerations for design, particularly construction impacts, land acquisition policy and procedures including compensation.

In addition the following issues with wider environmental considerations need to be addressed and followed up:

- the institutional framework for the implementation of the project, including construction, management, operation and maintenance.

- liaison with local people to form a participation strategy to obtain detailed planning data. This is particularly crucial to any flood proofing work which will need a large component of social planning, including group formation.

In order to comply with the requirements of the latest FAP Environmental Impact Assessment Guidelines there would need to be a full 12 month period of data collection on the natural environment. For the human environment the 1991 BBS data for the area would need to be made available to fully address the issues of spatial and social differentiation of both positive and negative impacts. However, the most important requirement is for mapped outputs of the hydrological modelling which show the with and without project conditions under a range of different flow conditions. This would be a pre-requisite for commencing a full EIA and requires FAP 25 and FAP 14 to have completed the relevent parts of their work at least 6 months before the FAP 3.1 EIA could be completed.

1. INTRODUCTION

1.1 Aims and Objectives

The aim of the Environmental Impact Assessment (EIA) component of the FAP 3.1 Jamalpur Priority Project Study (JPPS) was to identify and prioritise the likely environmental issues and impacts of proposed development options to allow environmental considerations to be taken into account when selecting a recommended option for feasibility study. The major issues were to be quantified where possible and if relevant, valued. At pre-feasibility stage this required the ranking of the likely comparative impacts of four alternative project options (see Section 1.8 for details of each option) against each other and also the without project situation. The conclusions of this analysis were given in the JPPS Interim Report of April 1992. During the feasibility stage of the study the major impacts identified at pre-feasibility level were assessed in greater detail, with a programme of relevant data collection for the two options which were selected for more detailed study. This included a special study commissioned for the adjacent Char land area which is subject to the most serious negative impacts under the favoured option. Where possible the major impacts were quantified and mitigation possibilities identified and investigated. Due to the limited resources available for the environmental component of the study, the impact assessment concentrated on negative impacts with mitigation being centred upon those issues that could be avoided or minimised by appropriate consideration of steps to provide alternative livelihoods and resource use for those people adversely effected. The costs of these measures were to be included in the project multi-criteria analysis. By paying attention to present environmental conditions in the area, it was possible to advise on appropriate measures to maximise benefits by similar means. Provided the project is deemed by policy makers and donors to have an acceptably low level of impact, then the detailed design phase could commence. This requires close liaison and interaction between the engineering design team and supporting study specialists to ensure that the environmental issues are tackled as an intrinsic part of the planning process.

1.2 Scope of the Environmental Studies

The scope of environmental studies covers consideration of both the natural/biophysical environment and human issues, especially their interaction and how this changes due to project interventions, particularly as a result of induced impacts. A basic philosophy behind such studies is the notion of environmentally sound and sustainable development, with a proviso that no person is to be worse off as a result of the project intervention, although in the context of resource use in Bangladesh it must be recognised that this is very difficult if not impossible. The whole notion and definition of sustainability, particularly in the context of Bangladesh is complex and has many interpretations. A definition is outlined by the IUCN in the World Conservation Strategy, although this is from a rather narrow perspective. This has apparently been subsequently revised but is not as yet published. Within the context of Bangladesh the National Conservation Strategy (Draft of 1991) deals with sustainability by issue and discipline. The actual application of this is to be addressed as part of the, as yet unpublished NEMAP.

The practical application of this at project feasibility study level is that the more serious negative impacts are to be mitigated for and the costs included in the project economic analysis whilst others are to be addressed using environmentally sound construction and management practices and procedures. All these steps are to be incorporated into a sustainable environmental management plan for the project.

1.3 Environmental Procedures and Guidelines

The procedures for EIA to be used in the Flood Action Plan (FAP) are contained in Section V and Appendix 8 of the Guidelines for Project Assessment (GPA) latest edition of May 1992. Ecological Impact Assessment is covered in Annex 5. Unfortunately all of these Guidelines were not available at the time the Terms of Reference for the study were drawn up. Even at the time of writing the revised FAP 3.1 Inception Report (November 1991) the only document available was the first edition of the GPA dated July 1991, the EIA Annex 5 for which had yet to be drafted, and the first draft edition of the FAP 16 Environmental Guidelines. These FAP 16 Guidelines were subsequently revised (draft edition May 1992) and Volume 1 of a Manual added. The FAP 16 Guidelines have very recently been revised by FPCO and the DoE and issued as approved documents. Volume 2 of the Manual has also been completed. The EIA work proposed in the Detailed Design stage of the project now needs to be carried out according to these.

All these Guidelines generally follow the provisions of World Bank Operational Directive 4.01, released in October 1991, (again after the TOR for the study were drawn up), which clearly state the criteria for deciding if an EIA is required, what it shall comprise and if anything else is necessary before the World Bank will consider funding. Any flood control, drainage, large scale irrigation, dam, reservoir or river basin development project plus any that involves resettlement is classified as in the highest level Category A, requiring a mandatory EIA. The Jamalpur Priority Project would appear to fall into this category on at least two counts. More details are given in the World Bank two volume Environmental Sourcebook, published as Technical Papers 139 and 140.

As stated above, none of these documents were in place when the Terms of Reference for the Jamalpur Priority Project Study (JPPS) were drawn up. The perception of environment was considered in very restrictive terms as mainly comprising narrowly defined ecology, (interpreted specifically as water quality and some flora and fauna work) with little concern for the human interaction in the resource system. This resulted in the environmental component being seriously underresourced in terms of staff time and range of expertise and very narrow in vision to enable a credible EIA to be carried out under the present FAP Guidelines. During the re-drafting of the Revised Inception Report a work programme was drawn up which tackled those issues in the original TOR within the context of the study staffing expertise and time available, and as far as possible using the framework of the FAP 16 Environmental Guidelines of August 1991. This was reinforced as a result of a verbal briefing given to the FAP 3.1 Expatriate Environmentalist by the relevant members of the Panel of Experts. In the Revised Inception Report a recommendation was given to make more resources available for the non-engineering components of the study so that it could tackle these issues in the light of the revised Guidelines. As a result, an extension to the study was agreed which included increased resources to address some of this shortfall and in addition a special study on the Char lands. Even so there is a problem with the assessment of natural environment issues due to the lack of even medium term baseline data and also the episodic nature of the work programme and lack of specialist discipline back up for some areas. Further work will need to be done in the Detailed Design Phase of the project, although much of this will require the hydrological modelling work to be substantially refined with an interface to a digital elevation model data providing mapped outputs of the extent, depth, duration and timing of flooding under a range of flow conditions in both a with and with-out project situation.

At the national level in Bangladesh, environmental policy is handled by the Ministry of Environment and Forest (MOEF) with the Department of the Environment (DoE) being the implementation and enforcement agency. There is in place a Draft National Conservation Strategy (NCS) drawn up with assistance from the International Union for the Conservation of Nature (IUCN) and whilst its aims are very laudable it is at this stage primarily a statement of intent. There remains the task of implementation, including the rationalisation and drafting of appropriate legislation and setting up suitable institutional arrangements for this. The National Environmental Management Action Plan (NEMAP) is under discussion by Government at the moment but no details of this have been officially released to the project study team.

The Flood Action Plan is presently operating from within the FPCO which is part of the Ministry of Irrigation, Water Development and Flood Control. The institutional framework for the actual implementation of the Flood Action Plan is at present unclear and associated with this is the lack of definition of the overall aims and objectives of the FAP, specifically the degree to which it wishes to involve itself outside the narrow perspective of water engineering. The institutional arrangements that would be required for broad environmental resource management programmes would need to be very different than those presently in place. From the comments and discussions on the draft version of this report it would seem that it is proposed that the mainland project would be implemented through the BWDB which will be reinforced to include multi-disciplinary capabilities for environmental planning, management and implementation work.

There exist procedures for land acquisition (the Land Acquisition Ordinance II of 1982 and the Land Acquisition Act IX of 1989) which have been the subject of scrutiny by FAP 15 as part of their study on resettlement. They have concluded that major changes are needed to these to ensure that their operation is speedier and that there is a more equitable settlement of claims. Without this happening they are likely to constitute a major constraint to the implementation of any infrastructural works under the FAP.

1.4 Approach and Methodology

The methodology for environmental assessment used for the FAP 3.1 study follows that given in the FAP 16 Environmental Guidelines of August 1991 as far as they were appropriate to a sub-regional feasibility study and possible with the resources allowed for the study. In addition a verbal briefing was given to the expatriate Environmentalist by relevant people in the Panel of Experts which confirmed that the broad procedures to be followed were those previously used in other similar projects, incorporating integrated impact assessment of the natural and human environment.

The first stage was to review the available environmental data (normally secondary and historical data) for the area. To do this the study area was defined geographically, (known in the jargon as bounding), including the actual targeted area for intervention plus those areas likely to be influenced by external impacts. This included downstream or adjacent areas, but also upstream areas where development in the targeted area may pre-empt future development options upstream of it. This is shown in Figure 3.1.1 and discussed further in Section 1.6. The review of the secondary data then allowed a description of the existing and (with the help of Government Gazetteers), the past environmental situation in the wider study area to be drawn up. Following this, the major existing environmental issues were identified (known as scoping). This process highlighted those areas and subjects where data was deficient to do this. A programme of new data collection was then drawn up that was appropriate to the likely issues of concern, both from the perspective of the existing environmental situation and also the possible range of development options that could be considered for the area. Ideally this data collection exercise needed to be set up to provide sufficient relevant information to allow quantification and if possible or appropriate, valuation, of likely major impacts for different development options and also a comparison to a without project situation.

The degree to which the process would normally be followed in pre-feasibility and subsequent feasibility studies was complicated in the case of FAP 3.1 where the pre-feasibility stage should by rights have been part of the FAP 3 North Central Regional Planning Study. However as the feasibility study phase of FAP 3.1 preempted the pre-feasibility stage

Regional Planning Study for the area, the two stages had to be telescoped into each other. As no environmental profile existed for the area this had to be drawn up by the FAP 3.1 environmental component as part of the early feasibility stage study. A first draft of this was included in the FAP 3.1 Interim Planning Report of March 1992. This identified areas where data was lacking and attempts were made to cover these using existing staff resources. However what additional resources were eventually agreed to be provided were not confirmed until the main study period was virtually complete. There was thus not the promise of continuity of staff inputs nor availability of specialist inputs to cover for some of these issues, particularly ecology. In addition, a major weakness was that the original study period only covered, at the maximum, six months and although this was extended to cover a further four months, confirmation of this was not given early enough or the specialist staff provided to allow year round baseline data collection for wider natural environmental issues. The exception is water quality sampling which was carried out for both dry and wet seasons, although this stretched the limited project budget.

This whole process requires constant interfacing and feedback from local people as part of a specific programme of Public Participation. This is commented upon in Section 1.7 of this report. The initial problem was that the whole concept of Public Participation had been omitted from the Terms of Reference for the study and was only first addressed during the discussion of the original, unapproved, FAP 3.1 Inception Report of October 1991. This allowed a limited participation programme to be incorporated into the socio-economic questionnaire, canvassing respondents views (including NGO's and Administrative Officials) as to their preference of possible project options rather than starting at an assessment of local people's possible priorities, perceptions, aspirations and needs. The latter technique was used in the Char land area surveys as part of the process of drawing up possible development strategies for the area.

Impacts can be positive and negative, effecting both the natural and human environment. They can also be immediate, medium or long term. Some are likely to become apparent very quickly and can be easily rectified, others may be only temporary but quite severe (such as some construction impacts) whilst some could be very long term but irreversible. This is particularly the case for the natural environment where present equilibriums can be slowly changed causing gradual decline which is difficult to identify and harder still to reverse. There are also threshold levels which when transgressed can trigger sudden irreversible declines. Some impacts are the direct result of a change in the existing situation, where as others are secondary and it may often be harder to identify and predict possible outcomes. A major consideration are those impacts which are felt outside of the project area (known as externalities), particularly those negative impacts of a project which effect communities who are unlikely to benefit from it.

For human impacts, a most important consideration is the spatial and social variability of any effects. It is important to know who is likely to gain or lose what, by how much, where and when. The selection of development options needs to be made with sufficient knowledge of the likely outcomes of these decisions and how they fit with policy aims at national, regional and sub-regional levels as well as local peoples priorities and aspirations. The methodology for identifying the likely impacts has used a checklist approach (See Biswas) which forms the basis of the vertical scale of the impact matrix (Figures 3.3.1 and 3.3.2).

Once a development option or strategy has been selected then major negative impacts can be identified and studied in greater detail. This should include quantification, where possible, and valuation, including financial costings if practical. Mitigation measures for negative impacts need to be considered and assessed for their ease and likely success of implementation as well as the degree to which they will redress the loss in comparison to their implementation costs, split in terms of both capital and running costs. This should feature in the risk and sustainability assessment of the project which is seen in the widest terms of social, economic, ecological and political sustainability. These should be integrated into an Environmental Management Plan which also includes a monitoring and evaluation programme both for short and long term impacts, allowing for feedback and changes in policy to try and avoid, prevent or minimise any newly discovered or on-going negative impacts. In addition the institutional framework for mitigation and monitoring also needs to be given. In the case of this study there is insufficient hydrological knowledge to take the impact assessment to this stage on a broad level. However targeted programmes for the two major negative impacts, (increased flood risk to unprotected land and fisheries losses) have been designed and costed and incorporated into the multi-criteria analysis for the project.

1.5 Interface with Other Disciplines

The environmental component of the study has relied upon the outputs of other disciplines in the FAP 3.1 Study for impact analysis work. This has included Surface Water Hydrology, River Morphology, Groundwater Hydrology, Land and Soil Resources, Sociology and Socio-Economics, Agriculture and Agricultural Economics and Fisheries. In addition the findings of the following FAP and related studies have been directly used:

- The FAP 3.1 Char Study Report
- Work carried out for the FAP 16 Resource Inventory of Chars in the Brahmaputra and Jamuna River System.
- FAP 25 Flood Modelling and Management Study
- The Jamuna Multi-Purpose Bridge Environmental Impact Assessment work.

The FAP 3.1 environmental work has thus concentrated on the following five major areas of data collection:

- water quality
- soil chemistry
- flora and fauna
- human health, including nutrition and particularly waterborne diseases
- archaeology and cultural sites

1.6 Definition of the Project Area

The initial project area was defined as being between the main left bank of the Jamuna river (i.e. the limit of peak "normal" flooding) and the railway lines between Bahadurabad Ghat, Jamalpur and Jagannathganj Ghat. This was subsequently extended eastward to the right bank of the Old Brahmaputra to fully include the four nucleated settlements of Jamalpur, Melandah, Islampur and Dewanganj. This is shown in Figure 3.1.2 based upon Landsat imagery of March 1992 and also in Figure 3.1.3 based upon SPOT imagery of November 1990, the differences illustrating the very dynamic nature of Jamuna river action, particularly in the Char land. In addition the environmental impact analysis included consideration of external impacts. This covers induced impacts in the adjacent Char land and both mainland and Char land areas downstream of the project area. However as a result of the comments made on a previous report, this work was concentrated on the adjacent unprotectable land, the downstream areas being deemed the prime responsibility of the FAP studies adjacent to those areas, in this case FAP 3.2 and FAP 1/2. These areas are shown in Figure 3.1.1. A special study was carried out on the adjacent Char lands which has provided the baseline data for impact analysis in the area. This area has now been incorporated into the project planning process and the findings attached to the main feasibility report as Annex 9. Consideration will also be given to possible upstream constraints to development from other potential development proposals, particularly in the North West and North East Regional Study areas. The major omission is consideration of induced increases in flood risk on the left bank of the Old Brahmaputra and downstream of Jamalpur. As suggested by FAP 3 this requires a special study to look at this with a large hydrological modelling component.

1.7 Public Participation

An intrinsic part of all development planning work should be public participation by concerned and effected parties. The nature of this can vary greatly however, from simple consultation in an attempt to secure acceptability of a pre-conceived idea through to the grass-roots total involvement of people on the ground in formulating policy and implementing the strategy themselves. The institutional frameworks required for these are very different. At present there appears to be no agreed consensus between Donors, FPCO and the POE as to the necessary participation structure for the Flood Action Plan. Guidelines for Participatory Development for the FAP are in the process of being finalised and incorporated into an Annex in the GPA. In the absence of these and in response to comments made on the original Inception Report, FAP 3.1 took the initiative and attempted to involve local people in the project planning process at the grass roots level as far as resources would allow. This has been done as part of the detailed household questionnaire data gathering exercise for both the mainland and Char land studies, by household case study work and structured group discussions. In addition, the views of NGO's in the study areas have been obtained and in the case of the Char land study a local NGO was actively used in partnership with the Consultant to carry out the work. The views of local administrators and officials were also canvassed. This work has allowed an assessment to be made of a wide range of people's perceptions and priorities as to flooding issues and associated subjects (erosion for instance) along with their needs and the level of commitment they are prepared to give to achieving these as well as their expectations. In addition the Char lands study opened out this work to cover all aspects of livelihood, not just flooding issues, in a needs led approach to drawing up a development strategy for the area. This whole process is seen as vital if a sound sustainable strategy that address peoples needs is to be sought. A major obstacle to this is the lack of an information and community awareness campaign to alert people to the philosophy and aims of the FAP and how this relates to their individual household situations.

Non Government Organisations (NGO's) have taken an increasingly prominent role in development work in Bangladesh in recent years. Many of the organisations working at a local level have an important role to play in "bottom-up" or "demand driven" development and some have made significant successful achievements in pioneering this approach. Of particular relevance is the role of Service Civil International (SCI) and the Mennonite Central Committee (MCC) who have jointly pioneered an integrated self help development programme centred around a flood proofing strategy on Attached Char land just to the south of the study area at Bhuapur. It is thus imperative to actively involve such organisations in any study programme and every effort has been made to do this to the extent of working through them for the Char land study. Similarly close relations were maintained with Action Aid through their office at Belgachha in the north west part of the study area. Both organisations are keen to participate in any relevant intervention work in the area.

From an international aid perspective it is well to bear in mind that environmental concerns have been increasingly moving to the forefront in recent years, particularly within influential sections of the societies in the donor nations. As a result of this there is a high level of sensitivity as to the likely environmental impacts of any aid funded programme and it is thus very important that any assessment is seen to be independent and have credibility within an international context. To this end it is important that sufficient resources are given to carry out such work in a technically sound manner. Even so it may also be necessary to have an independent external environmental review of the project. This is a requirement for some categories of project under World Bank Operational Directive 4.01, particularly those that require the involuntary resettlement of any people. This needs to be considered in the future planning of the work. In the past, organisations such as the IUCN have been brought in by donors to carry out such a task. Many donor nations are bound by much stricter environmental criteria than is the case for most developing countries and many bilateral donor organisations. They will be required by their own laws to ensure that these are not likely to be transgressed and will wish to carry out their own EIA work according to their own criteria. Thus the higher the standard of the project EIA work that is carried out the more likely is funding to be made available for implementation. This is directly related to the resources made available for environmental studies.

1.8 Development Proposals and Options

The JPPS Interim Planning Report (R2) outlined the four development options that were considered for the area. These covered a wide range of intervention possibilities from non-structural flood proofing measures through varying degrees of controlled flooding to the complete exclusion of all river water by polderisation:

- Option A was for flood proofing provision for all of the mainland and east bank Attached Char land study area. This would entail an integrated strategy of raising individual houses and the provision of clustered communal flood refuges, some of which would be for permanent settlement, particularly for homesteadless households. In addition there would be provision of a drainage provision programme to assist rainfall run-off in the congested centre part of the study area.

- Option B was for controlled flooding (i.e. allowing all normal flooding but preventing dangerous peak flooding) for the largest part of the study area possible. This would be achieved by constructing flood control embankments along the east bank of the Jamuna (using existing embankments where possible) and the west bank of the Old Brahmaputra. The proposed embankment alignments are shown in Figure 3.1.4 and the location of existing embankments in Figure 3.2.12. The embankments would have large openings in the places where there are presently river channels to and from the main rivers. Large gated water control structures would be built at these locations but designed to be run with the gates open to allow normal flooding. The gates would only be closed in dangerous peak flooding situations like 1987 and 1988. The parts of the study area, which due to engineering considerations could not be included in the controlled flooding area, would be flood proofed as for Option A, under a seperate but integrated programme. This would also include the multi-purpose use of the embankments as flood refuges and permanent places of secure residence, particularly for displaced, erosion victim and homesteadless households. In addition there would be drainage improvements to overcome present constrictions to the rainfall drainage network, particularly in the centre of the study area.

- Option C was for a similar programme of controlled flooding but on a smaller area (shown in Figure 3.1.5). This would thus have a much larger flood proofing component than Option B. The thinking behind this was to have a compromise between Options A and B, allowing the valuable agricultural land to be protected and the areas of more valuable floodland fisheries to be retained.

- Option D entailed the exclusion of all river flooding from the largest part of the study area as possible by building highly durable embankments in the same locations as Figure 3.1.4 but having no inlet water control structures, only drainage outlets. In addition there would be a flood proofing programme for the unprotected land on the left bank Attached and Set-back land, along with improved drainage for rain fed flooding the centre of the study area.

The Interim Report of April 1992 contained a preliminary Environmental Impact Analysis which included a comparative subjective matrix between all four options and also a without project situation. The aim was to provide sufficient information for a single option or strategy to be selected for feasibility study. The conclusions from this and the matrix are repeated in Section 3.1 of this report.

As a result of the POE reactions to the previous report (JPPS Interim Planning Report, R2) the conclusion of the summary of the Interim report (R3) raised the issue of a possible multiple development strategy, rather than a discrete option, being selected. However the comments on the draft revision of this report (R6) would seem to confirm that a discrete policy option in the form of B5 is to be followed for the protectable mainland area, with Option A in a parallel programme for the unprotectable land.

The presently recommended FAP 3.1 Flood Action Plan is based upon Option B controlled flooding for the maximum area of land which can be protected, with a flood proofing programme adopted for the land which can not be protected, including the adjacent Char lands. The specific nature of the flood proofing programme is, by necessity, open at the moment, pending detailed consultations with the beneficiaries. However it is envisaged that it will cover a range of possibilities and scales from individual house and homestead raising through to the provision of communal refuges, the size, spacing and locations to be decided with very close consultation with local people. In addition the multipurpose use of embankments will be a major element, both in terms of a place of temporary flood refuge but also as permeant flood proofed homestead sites, particularly for erosion displacees, homestead-less and landless households. Comments on the draft version of this report infer that a policy of separating the intervention in the mainland from that of flood proofing the char land would be favoured. This would lead to the development of two separate but inter-related interventions being developed simultaneously to each other but in parallel to each other. Close coordination of the two programmes at the outset is strongly recommended.

2 ENVIRONMENTAL PROFILE OF THE STUDY AREA

2.1 Introduction

A draft of the initial broad environmental profile of the study area (see Figure 3.1.1 for a map of the regional context of the area and Figure 3.1.2 for a map of the immediate study area) was prepared and included in the JPPS Interim Planning Report of March 1992. This was written after a preliminary site reconnaissance and aimed to retrospectively cover what was felt to be a gap caused by the telescoping of the Regional Study (FAP 3) project selection process and the pre-feasibility stage leading to formulation of a range of policy options.

This profile has now been revised, bearing in mind the POE comments on it and updated as more information has been collected. It has been constrained by the resources available for the work, particularly for the natural environment, and the lack of a full year's clear programme of data collection. The work has included:

- collection of a sets of dry and wet season water quality samples in an attempt to provide some sort of baseline data. These have been analyzed in a laboratory for both chemical and organic content but agro-chemical analysis could not be carried out as the facilities were beyond the budget of the study and not easily accessible.

- collection and a review of the existing soil chemistry data and mapping for the main study area with an assessment of likely trends as a result of flood control and improved drainage

- a baseline inventory of fauna and flora in the study area with the aim of being able to establish the effects on species distribution as a result of habitat change caused by changes in flooding patterns, evident once the hydraulic modelling has been refined. This has highlighted the present important use of medicinal plants and the low level of remaining wildlife in the area.

- a review and verification of existing data on the present state of human health in the area. This has indicated that there are serious problems with waterborne disease in the study area with a large number of deaths from diarrhoeal diseases and a high number of malaria cases. There is also an outbreak of Kala-azar (Leishmaniasis) and goitre is a very serious problem in some highly concentrated areas. The biggest problem is prediction of likely future trends in disease patterns as a result of flood control and drainage interventions, particularly the expansion of irrigation resulting in all year standing water in places where previously there was none and the reduction of the movement of river flood water through the area reducing the present flushing effect. This requires pre and post project flood mapping and the results of the FAP 16 health studies.

- a preliminary survey of waterborne navigation in the area considering the main routes, both perennial and seasonal, the types and sizes of craft using these and the loads they are carrying along with route distribution, length, frequency and trends in all these factors.

- collection of data on possible archaeological and other sites of historical and cultural interest. This has included reviewing the settlement history of the area which has determined present settlement patterns and has had a considerable influence on the nature of present day resource use.

In addition, a considerable amount of new data has been acquired by the project which has proved useful in resources assessment and analysis. This included dry season time series Landsat satellite imagery of the area for 8 occasions over the last 19 years, 1973 - 1992. The image for 1973 is shown in black and white with an overlay of the present map of the area in Figure 3.2.1. This shows very well the extent of right bank main river erosion in the last 19 years. The latest image is for 8th March 1992 which is shown in black and white in Figure 3.2.2. This data is invaluable for river morphology studies, specifically erosion and accretion and also for studies on the Char lands which are so dynamic. Interpretation work has been done as part of the Char land study in collaboration with FAP 19 (GIS) and included interactive image processing to analyze land age and utilisation as well as main bank erosion and accretion. The most recent image acquired (Landsat TM dated 8th March 1992) has been used for report illustrative base map production as it shows significant recent changes since the last, admittedly better resolution, SPOT image of 20th November 1990 which is shown in black and white in Figure 3.2.3. The project has also acquired some time series SPOT imagery for December 1988 and December 1990 which, when combined with the Landsat TM data of November 1988, existing FPCO SPOT of February 1989 and recently received FPCO SPOT data of 26th November and 3rd April 1990 have given some valuable data on flooding and drainage patterns. In addition some wet season imagery has been acquired with the help of SPARRSO and FAP 19. The most useful is a Landsat scene of peak flood day at Bahadurabad Ghat of 18th August 1987. This is shown in black and white with an overlay of the present project area map in Figure 3.2.4 and in colour as Figure 5.3 in the main report. However to fully realise the potential of this data, both time and resources are required to carry out digital analysis with access to large format hard copy facilities.

The biggest and most serious constraint to impact analysis work for the study still remains the poorly developed hydraulic modelling of both the main rivers and more importantly the internal flood plain and drainage system of the area. The biggest problem stems from the lack of recent and suitably accurate topographic data of the area which seriously limits the usefulness of the hydraulic modelling. The present mapping is from 1963 and due to the dynamic nature of a significant part of the study area is badly outdated. Only when Digital Elevation Model (DEM) format data is made available, can it be combined with the hydraulic simulation model to give a much better indication of the extent, depth duration and timing of flooding. For hydraulic modelling work of the Jamuna river, FAP 25 are in the process of working through the development of a range of embanking scenarios under different flood flow conditions. At present their work has given preliminary results of a simulation of the present (i.e. without project) situation and also one with the FAP 3.1 Jamuna left embankment in place under peak flood conditions such as 1988. This has been used as the basis for assessing the increased flood risk to unprotected land, however a considerable amount of work is required to extend the simulation to other flow conditions and also to interface it with awaited topographic data to give mapped indications of induced change in flood extents, depths, durations and timings so that appropriate mitigation planning can be carried out. From the 18th August 1987 Landsat image it is apparent that there may be an induced flooding problem on the left bank of the Old Brahmaputra river under FAP 3.1 embanked conditions. At present suitable hydraulic modelling of this is not being carried out. This would seem to warrant a special study as proposed by FAP 3 as a matter of urgency.

The drawing up of this environmental profile has relied upon the inputs from other specialist disciplines, particularly surface hydrology, groundwater, soil and land resources, sociology and socio-economics, agriculture and agro-economics and fisheries. These all have separate Annexes to the main report which contain more details if clarification of their findings, which are summarised in this report, are needed.

2.2 The Natural Environment - Aquatic

2.2.1 Introduction

The understanding of the present surface water hydrological situation is the most fundamental element in the whole of the study. Analysis of the internal surface water system of the study area has been tackled for the main land study area by members of the project team using the techniques and computer simulation model MIKE 11 as specified by the FAP Guidelines and methodologies. This considers flooding patterns caused by peak flows from the river system and also from rainfall run-off utilising a flood routing network linked to topography. Annex 4 of this report gives the results of the analysis along with flood hydrographs of relevant points in the study area.

The primary requirement for use in any environmental assessment work is the production of flood and drainage distribution maps for different "typical" years (these being classified according to some consistent criteria) and also for the rise and fall pattern of each of these. From these and the model outputs it is necessary to produce predicted flood and drainage distribution patterns for the selected development option. This can not as yet be done in a meaningful way until the model is interfaced with the DEM. The present work is confined to the prediction of likely general changes in flood levels for each compartment area under different scenarios. This has been used for the fisheries impact analysis in Annex 2.

Consideration has also been given to analyzing time series land resources satellite imagery of the area for flood studies. Thirty nine different cloud free scenes are available for the area over the last five years and many more back to 1972. However there is very little data available between May and mid October for any year due to persistent cloud cover. A recently acquired peak flood Landsat image of 18th August 1987 is shown in Figure 3.2.4. From this and the overlain map of the present dry season situation the extent of peak flooding can be seen. This demonstrates the nature of this problem in the area, including the Char land. There is also some daily time series low resolution NOAA data of the 1988 flood held by SPARRSO. Enlargements of four of these have been obtained and the peak flood image of 15th September 1988 has been interpreted for approximate extents of flooded land. This is given in Figure 3.2.5, which indicates that some 75% of the study area was inundated at this time. The unflooded areas mainly comprise the higher land in the east of the study area. Surprisingly some areas of the Char lands appear to be only very shallowly flooded. Field verification has confirmed this, the land concerned being high, probably consisting of mainland fragments that have been isolated by the river and/or built up by wind blown sand deposition. An image of the 8th November 1988 is given as Figure 3.2.6 and is useful for showing a medium level river channel situation giving some idea of the limits of the river channels in such conditions.

If resources permit, further work could be carried out in the Detailed Design phase using digital analysis of the four SPOT scenes held by the study for 11th December 1988, 27th February 1989, 20th November 1990 and 7th December 1990. Density slices of the February 1989 and November 1990 images have been taken and are shown in Figures 3.2.7 and 3.2.8 respectively. These show the extent of water during the dry and wet seasons and give some indication of the interaction of the internal river flooding system. This is helpful in analysis of the beels in the study area and has been used for the fisheries impact analysis. However care must be exercised with this as they are not of the same flooding occasion and the dry season image is of a wetter year than the wet season one and has parts flooded which are not in the wet season image.

2.2.2 Climatic Conditions

Mean annual rainfall in the study area is between 175 to 250 cm with a pronounced seasonal peak during the monsoon period which can occur anytime between June and September. However these dates are highly variable, as are the intensity and distribution of rainfall. The monthly rainfall histograms for Dewanganj for the last 5 years are given in Figure 3.2.9 along with a comparison to the mean figures for the period 1902-1961. The main Jamuna river levels are also shown for comparison purposes. Temperatures are at their lowest in January with the daily mean being 17^{0}c, night time figures drop well below this and fog is common, particularly in Char land areas. Temperatures peak in March and April with the daily mean reaching 30^{0}c. Humidity levels are relatively high throughout the year, but are lowest in January to March before the onset of any pre-monsoon rains. These are brought in on south westerly winds which commence between March and May before the full monsoon rains arrive. They can be very strong and squally, posing a particular problem in Chars with long reaches of open water on their down wind side. From June to September the winds are variable but start to veer northwards and stabilise towards the end of this period continuing until February. In addition there are more generalised severe cyclonic storms with heavy rain and high winds which occur most commonly in March and April. There have been some five or six such incidents in the area during the last 30 years, causing some loss of life, damage to property and disruption to economic activity particularly agriculture. The Char lands adjacent to the mainland study area have similar climatic characteristics to the mainland but the effects of these are different due to the prevalence of large uninterrupted tracts of open water.

2.2.3 Main River Hydrology

Study of the surface water hydrology of the Jamuna is being carried out FAP 25 (under the control of the Surface Water Modelling Centre) as part of the development of a general model of all the major rivers of Bangladesh. This uses existing river level and flow data, with the nearest gauging station being at Bahadurabad Ghat (river hydrographs for the last 5 years are shown in Figure 3.2.9). The aim of FAP 25 is to develop the model to allow predicted simulations to be made under different embanked conditions. It is at present essentially a one dimensional model and requires interfacing with the awaited digital topographic data of both the mainland and the Char land before more idea can be gained of the depth, extent and duration of flooding. In the meantime the FAP 16 National Char lands Study has obtained field information as to the approximate percentage peak flood water coverage for each Mauza for the years 1988, 1990 and 1991. The FAP 16 Mauza summary data gives indicators of the extent of flooding for a "normal" year (1990), a high normal year (1991) and an extremely high year (1988). This simple classification is based upon interpretation of the river hydrograph for Bahadurabad Ghat over the last 20 years. The detailed analysis of this data awaits the integration of the FAP 16 information into a database and digital mapping system. Pending this the following table indicates the overall situation for the total FAP 3.1 Char study reach of the Jamuna.

Year of Flood	Mean Days Duration of the Annual Peak Flood	Estimated Area Inundated at Annual Peak Flood
1988	24	79%
1990	14	53%
1991	12	46%
Source: FAP 16 National Char Lands Study, Mauza Summary Data 1992		

It is interesting to note that although the peak flood level at Bahadurabad Ghat in 1991 was considerably higher than that during 1990, the flooded area and its duration was less. This can be explained by the fact that although the peak level was high it was not sustained for very long in comparison with a lower but longer duration peak flood in 1990. The FAP 16 data also records 315 deaths in the area directly due to the 1988 flooding and a further subsequent 55 attributed to it. This total figure amounts to 1 in 2122 of the unprotected study area population and is likely to be much higher in the Island Char areas.

The river water levels follow a yearly seasonal cycle, although the timing and rate of rise and fall of these can vary greatly from year to year. A crucial factor is the date of commencement of river level rise as a result of snow melt in the upper catchment. This appears to determine how rapidly the water level rises, a later start producing a quicker rise. The peak water levels appear determined by the pattern of monsoonal rainfall in the catchment and how these are phased with snow melt run-off. The timing and duration of peak flooding has different implications for economic activity, (specifically agricultural land use), in the Island Chars, Attached Chars and Set-back land areas. This is related to land level, channel development and human access. The dynamics of low flow river channels over the last 20 years can be seen in Figures 3.2.10 and 3.1.11.

A major hydrological consideration is how any proposed embanking of the main river channel will effect water levels, both in terms of their peaks but also the increase in Char land inundation occasions when previously there were none. This is dependant upon the results of hydraulic modelling work for the main river being carried out by FAP 25.

The FAP 25 work is important for providing comparative with and without project simulations for the analysis of the impacts of embankment construction. The preliminary analysis has included model simulations under flood conditions, with and without the FAP embankment, the existing embankments and the Jamuna Bridge. This has yet to be extended to include different flow conditions. The preliminary results are given in the externalities Section 2.5.2 of this report and shown in Figure 3.2.12.

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No similar work is being carried out on the Old Brahmaputra, although study of the August 1987 image shows this to be required. The area suffers from being at the interface of two regional studies and, as recommended by FAP 3, urgently requires a special study to look at it as a single unit. Again this is commented upon in Section 2.5.3 of this report.

2.2.4 Mainland Area Internal Hydrology

The internal hydraulic system and how this has been modelled is shown in Figure 3.2.12. This also shows the location of present water control units (principally embanked roads and railways) and the location of existing flood control embankments. The network can be briefly described as follows:

The river flooding from the Jamuna enters the study area from both the main Jamuna in the west and also from the Old Brahmaputra river channel system in the north and east. The trigger point for flow down the Old Brahmaputra is dependent upon the bed level of the river inlet at the northern end of the study area which changes and is rising due to sedimentation. This has now got to the point where downstream users at Jamalpur complain of insufficient dry season flow. During flood situations a significant proportion of the Old Brahmaputra flow is diverted through the Jhenai river system across the south eastern part of the study area on the north west side of the railway line which acts as a major influence on the drainage system. The only major flow of water out of the study area and into the next downstream sub-region occurs under the Bausi railway bridge. The flow through this is concentrated at major flood times and even then is considerably smaller than the flow continuing through the study area to the north-western side of the railway embankment. In addition, the Chatal river takes off from the Jamuna left bank at Maijbari (although an embankment has recently been constructed across this in an attempt to prevent flood flow from the Jamuna) and flows south eastward until it meets the Jhenai some 6 km upstream of Bausi bridge. At this point it divides, with the western branch flowing south westwards to rejoin the Jhenai 6 km downstream of Bausi bridge having picked up additional flow from an off-take channel from the Jamuna left bank 6 km downstream of Madarganj. This combined channel rejoins the Jamuna just downstream of the fertilizer plant intake at the extreme south of the study area, 6 km downstream of Sarishabari.

In addition there is the local rainfall run-off system, some parts of which drain into isolated pools, although the number and extent of these varies depending upon the degree and timing of river flooding and the intensity, timing and location of rainfall. The distribution of water bodies has been mapped from SPOT imagery dated February 1989 and November 1990 (see Figures 3.2.7 and 3.2.8) and attempts have been made to differentiate these according to reflectance response to the lowest visible waveband sensor. This could well indicate those pools which are fed only by rainwater flooding (linked to turbidity and/or the concentration of suspended sediment) or be an indication of depth. Further work with more time series imagery (particularly that taken soon after heavy rainfall during a time of little river flooding) would provide significantly more useful information on this subject which has considerable implications for the study of the fisheries situation in the project area. As a broad generalisation, under "normal" flood conditions some 40% of the run-off through the study area originates as rainfall (this represents 50% of total rainfall in the area) and the remaining 60% is river flood flow from outside the area (ie from the Jamuna) which even in the very extreme high flood of 1988 represented only some 1-2% of total Jamuna flow. This flooding covered over 75% of the study area and resulted from an increase in river level at Bahadurabad of only one metre above a "normal" flood.

The flooding and drainage pattern is significantly affected by the existence of man made structures, particularly the railway and road networks which are on embankments of varying heights incorporating hydraulic structures of differing types (bridges, culverts etc). In addition there is a relatively long history of construction of flood embankments in the area and these are kept in varying degrees of repair and are at times deliberately breached by local people to solve drainage problems. These existing structures form the basis for a water and land management system for the area.

There are significant backwater effects in the flood network within the study area, which can be characterised as a highly complex riverine floodplain system, rather than a river catchment.

There are external hydrological issues which have differing effects on and implications for the flood and drainage pattern in the study area. These include the cumulative influence of any upstream water development or control interventions both within Bangladesh (specifically any flood embankments and drainage works on the Jamuna and in the North West regional study area) and also in the rest of the upstream catchment outside the country. These are commented upon in Section 2.5.5 of this report. Added to this are the effects of seismic activity and upstream river capture, which have been a major influence on river morphology in the past, along with longer term considerations of climate change. The course of the Brahmaputra underwent a relatively sudden westward change soon after 1776 (the date of the Rennells map, reproduced in Figure 3.2.13, which shows the Brahmaputra in its easterly course and the Teesta in its old southerly course to the Ganges) and 1830 to form the Jamuna. This was linked to a sudden change over six days in the course of Teesta caused by very heavy rainfall run-off in 1787 and by capture in the upstream Tibet catchment, possibly linked to seismic activity (Ref: Rangpur Government District Gazetteers 1977). The dynamic nature of river movement is shown in Figure 3.2.14 which comprises a base map derived from compiling Gazetteer maps dated between 1907 and 1937 overlaid with the 1992 river position.

In addition there are reported to be probable backwater effects from the proposed construction of the Jamuna Bridge which may be felt up to 50 km upstream of the bridge. The location of this is shown in Figure 3.1.1 and extends to the southern half of the Jamuna adjacent to the study area. This could have secondary backwater impacts in impeding drainage off the study area. Consultations have been held with members of the EIA team for the Jamuna Bridge Study and this has been considered in the analysis of external impacts in Section 2.5 of this report.

Additionally there are possible downstream impacts that could be caused as a result of any controlled flooding intervention. Specifically for the study area these include the nature of changed discharge patterns through Bausi Bridge and also possible concentration effects along the Old Brahmaputra both along its left bank and downstream of the present Jhenai off-take. This again is considered in the external impacts Section 2.5.

2.2.5 River Morphology

Analysis for the last 20 years using interpretation of the time series Landsat imagery is given as Section 1.4 in the main report of this feasibility study. A map of different main Jamuna bank alignments is shown in black and white in Figure 3.2.15 and in colour as Figure 1.2 in the main report.

In a historical context, Rennells map dated 1776 but not published till 1794 (Figure 3.2.13) shows the situation before the Jamuna came into existence when the main channel was the present Old Brahmaputra. It also shows the Teesta flowing southwards into the Ganges, not to the Brahmaputra/Jamuna system. It is known that the Teesta changed its course suddenly over a six day period in August 1787 (Ref: Rangpur Government District Gazetteers) as a result of sudden high run-off. It must therefore be concluded that the change in the course of the Brahmaputra occurred after 1776 and probably around 1787. It has also been postulated that the cause of the change in the course of the Brahmaputra was a combination of the change in the course of the Teesta and river capture in Tibet which changed the velocity of the flow. In addition there was seismic activity in 1762 and 1787 which changed land levels in the area. The presently used 1":1 mile Upazila maps (also known as Police Station Maps) of the area are on map bases first surveyed in 1907 and subsequently updated. These show the then river location on them. The Gazetteer maps use similar bases at 1": 4 miles dated anything from 1907 to 1937. These have been compiled to give an indication of likely river bank and Island Char locations for this period and is shown in Figure 3.2.14. From different series of 1:50 000 maps made in the 1960's it is also possible to plot the changing course of the Jamuna. However the most detailed data exits from 1973 onwards using time series dry season Landsat satellite imagery. A map showing bank alignment from all these sources has been digitally compiled by FAP 19 and is given in Figure 3.2.15.

Analysis and interpretation of Char land allowing its classification by location, size, age, stability and if cultivated/inhabited or not was carried out as part of the Char Study and is given in Section 2 of Annex 9 of this report. The conclusion is that the main river system is very dynamic indeed with major short and long term changes caused by river capture and drainage patterns which are all effected by seismic activity.

2.2.6 Sedimentation and Erosion - General

The erosion and accretion pattern along the main river bank edge of the Jamuna over the last 20 years is shown in black and white in Figure 3.2.16 and in colour as Figure 1.2 in the main report. This work was carried out as part of the FAP 1 (Brahmaputra Right Embankment) study by FAP 19 using digital time series satellite imagery analysis for two scenes dated 1973 and 1992. Other sources used for this work include the 1960's 1:50 000 maps, dry season Landsat imagery for 9 occasions over the last 20 years, SPOT satellite imagery since 1988 and air photography of 1963 and 1990. A map showing the incremental bank edge erosion changes in approximately three yearly stages is given in Figure 3.2.17. The colour version of this appears as Figure 2.4 in the Char Study, Annex 9. More river morphology work is presently under study by FAP 1 and FAP 21/22, the results of which are awaited.

In addition classification work of the accretion and erosion of islands has been carried as part of the JPPS Char land study and also the FAP 16 National Char Land study using FAP 19's image analysis facilities. This has produced distribution mapping of the age of Char land over the last 20 years using digital superimposition techniques. This is given in Figure 3.2.18, the colour original being Figure 2.8 in the Char Study report now attached as Annex 9 of this report. Using this data, a classification of Char land types has been carried out, with criteria of location, age, stability and land utilisation. This is shown in Figure 3.2.19 and gives two major types of Char land, Attached Chars and Island Chars. The definition of Attached Char land is that during low flow conditions it is not necessary to cross a main river channel to reach it but the land would be expected to be inundated during the peak flood of a "normal" year. The Island Chars require a main river channel to be crossed even in a low flow condition. Thus the classification is valid only for the date of the imagery and river channel conditions of that time.

Within the JPPS reach of the Jamuna there is significant erosion and sedimentation along the left bank, with changes in the alignment of the river bank ranging from plus and minus 5 km over the last thirty years. This is shown in Figure 2.6 of the Char Study Report (Annex 9) for the whole reach of the river. This process occurs in both the flood and dry seasons. During the dry season the river appears to meander, producing serious main bank erosion with alternate accretions. During the wet season "normal" peak flows most Island Chars and the majority of the Attached Char lands are usually inundated. At present there is severe erosion south of Madarganj, Bahadurabad and at Maijbari. There are accretions of Attached Char lands at the Old Brahmaputra off-take, north of Madarganj and west of Sarishabari. The erosion risk in the northern part by Bahadurabad, Belgachha and the Chatal intake has very serious implications for the security of any Jamuna embankment. In addition the recently accreted land is considered to have unstable foundation conditions. Both of these factors have considerably influenced the location criteria for the proposed flood embankment. Jamuna erosion is understood to be the most significant cause of the creation of landlessness amongst local people. There are also large islands within the Jamuna river which are cultivated and settled to varying degrees, more details of which are in Annex 9.

It would seem likely that in the near future the main river channel next to Madarganj and its extension southwards to Jagannathganj and Bhuapur will close up resulting in three large Island Chars to become Attached Chars and putting the main river into one channel next to the western side. This could have profound implications, both positive and negative, for a large part of the area:

- Catastrophic bank erosion in the dry season should decline significantly south of Madarganj, but the Ghat at Madarganj will become inoperative.

- The process water inlet for the Jamuna Fertilizer factory is likely to have insufficient supply for a considerable part of the year. The nearest source of main river water will be over 12 km distance as the crow flies. In addition the jetty is likely to become inoperative.

- Jagannathganj Ghat is likely to become inoperative for major passenger ferries.

- To the south of the study area, the Island Char land as far south as Bhuapur will be attached to the mainland and river navigation to Bhuapur is likely to be very difficult.

- The river will be concentrated into one main low season flow channel and this is likely to increase bank erosion on the west bank for a considerable length of the river throughout Bogra and Sirajganj Zilas. This is likely to put the Brahmaputra right embankment under more serious threat.

2.2.7 Erosion - Satellite Image Interpretation

Detailed analysis carried out by FAP 19 (ISPAN/GIS) for FAP 1 (the Brahmaputra Right Embankment Study) has segmented the main river long section into short reaches and using time series satellite imagery has measured the average annual movement of the main bank lines. This is expressed as diagrams in the Char study, Figure 2.6 for the left bank and Figure 2.7 for the right bank. The reach of the river within the FAP 3.1 study area is indicated and from this it can be clearly seen that the right bank has eroded westwards along its total length at an average rate of up to 150 m a year over the last twenty years. The exception is two small areas immediately downstream of hardened protection points built for major settlements at Sirajganj and Kazipur. The situation on the left bank is very different having been subject to alternate erosion and accretion with up to 300 m average annual accretion in some places and 250 m erosion in others.

In summary it can be seen that the low flow river channel locations and movement are very dynamic, with newer formed channels in northern locations on the left bank, the eastern edge of the large northern Island Char and the right bank south of Pulchari Ghat and particularly south of the Attached Char land area.

2.2.8 Sedimentation - Satellite Image Interpretation

The nature of sedimentation patterns in the main Jamuna requires detailed hydrographic survey work which is under the work programme of the newly mobilised FAP 24. In the absence of this so far, work has concentrated upon using time series low flow satellite imagery of the last 20 years for mapping patterns and looking at trends. A factor which is likely to be raised in relation to embanking of the main river is the likelihood of significant increases in sedimentation as a result of confining the river where as previously the sediment was deposited over a wider unprotected area. The fear is that any increase in bed sedimentation would mean that the embankments would need regular raising to maintain their security. Whilst this has been a serious problem for some much smaller confined rivers in Bangladesh (the Gumpti for instance) the situation on the Jamuna is very different. The immense width of the river and the relatively small differences in height needed to protect land to different return periods would seem to indicate that other factors such as sudden river channel location change are likely to be more important. In any case, study of classified satellite image seems to indicate that the quantity of silt deposited on the mainland, even downstream of major breaches (that on the right embankment for instance) is very small and highly confined when compared to the total amount of sedimentation in the river bed. Where it is far more important is in low lying Island Chars and in the internal river system on the mainland.

Sedimentation deposition change has significant implications for waterborne transport. There are already serious navigation problems on the Jamuna due to the low level of dry season flows and the development of shoals linked to the present size and draught of craft. This also effects the railway system in the project area and nationally as the long distance network timetable is fitted to boat train connecting services across the Jamuna between Bahadurabad Ghat and Phulchhari Ghat. This is made worse by the fact that the Ghats have had to be moved many times in the recent past due to erosion. Whilst their present locations are on stable banks and they lie opposite each other they suffer from being divided by one of the largest and most stable Island Chars in the middle reach of the Jamuna.

In addition there are problems with internal navigation in the study area due to low river flows and sedimentation at the mouth of the Old Brahmaputra and Jhenai rivers and the recent shutting off of the Chatal intake. This has rendered dry season internal navigation by cargo boats impossible between January and the start of significant river flood water rise. The implications of this are dealt with in Section 2.4.13 of this report. There are serious issues of navigability for the movement of goods and also insufficient water supply for the Jamuna Fertilizer factory as a result of its location on the Jhenai not on the main Jamuna. This is likely to get significantly worse irrespective of any project intervention. The degree to which sedimentation patterns at any inlets (particularly of the Jhenai) will change as a result of the building of control structures will need to be studied. From a management point of view it is obviously better to try and make these self clearing but from a fisheries management perspective it is better that the flow is not too fast.

Suspended and bed-load sediment is deposited on Char land and to a very lesser extent in the mainland as silt during times of flooding. This appears to act as a natural, self sustainable fertilization mechanism, although the degree of usefulness of this has yet to be ascertained. A study of this at the national level is being undertaken by FAP 16 and the results of this are awaited. This will include chemical analysis of the sediment and the agricultural implications of its deposition. Any usefulness of sedimentation deposition needs to be off-set against the possible negative effects that concentrated deposition of large volumes of silt can cause by smothering land and clogging the drainage system. However this could also be used as a resource both for agricultural use and as a building material. With the introduction of flood control and drainage improvements silt deposition is likely to decrease in the protected area and may require the substitute use of artificial fertilizers with their associated negative effects on water quality, to retain soil fertility levels. This has been a particularly serious problem in other large river systems in the world as a result of building upstream dams. It also has secondary socio-economic implications to the farming system at household and national level if substitute artificial fertilizers have to be purchased by the farmers (often imported into the country) where as previously the useful silt was a "free good". This will need study once the results of the FAP 16 soil fertility work are available.

The process of sediment deposition is the major one responsible for the emergence of Char land, although it is greatly assisted by dune formation due to aeolian action, particularly in the low flow dry season period, of continuous northerly winds. Waterborne deposition normally occurs during seasonal peak flood times, exposing newly deposited land as the water levels fall progressively during the start of the dry season from November onwards. Whilst this is a major stage in the formation of new land for human use it can also be a serious hinderance where sand carpeting occurs on the top of existing Char land. This can temporarily render formerly cultivable land unsuitable for such purposes due to the high infiltration rate of the soil and its lack of retention properties. This can be improved naturally by the addition of organic matter to the soil by the process of Catkin grass colonisation. Trials carried out by SCI at Bhuapur using Catkin grass (Spontaneous Sucrossa) for stabilisation of sand deposits at the mouths of braided channels in the Attached Char lands have slowed down the rate of water flow causing significant deposition and rapid channel infill. This has stabilised the land still further and allows a larger area to be cultivated once natural vegetation has quickly become established.

2.2.9 Groundwater

The situation with regard to groundwater is outlined in detail in Annex 1 of this report and summarised here. The availability of groundwater in the JPPS area is highly favourable for the development of dry season irrigated agriculture and also as use for domestic water supply. Groundwater extraction uses three differing types of technology. Very shallow treadle pumps (see Orr, Islam and Barnes) are widely used for small scale irrigation at the farm plot level and easily extract from 6m depth. Shallow hand pumps are used for domestic supply at household and settlement level. Shallow tubewells powered by small diesel pumps are in widespread use for irrigation and are normally put in by individual farmers with access to sufficient capital. In general they use them to irrigate their own land and then sell any surplus water to neighbouring farmers. Temporary informal earth channels are constructed to distribute the water. There is some evidence (Orr, Islam and Barnes) that these may displace treadle pumps in some places by a combination of locally pulling down the water table and also offering water for sale at a price deemed by the land holder to be worth paying in comparison to the labour requirement of manual pumping. There are also deep tubewells in the study area which have been provided as part of aid programmes in the last 15 or so years. These use bigger diesel powered pumps set at much deeper levels. They provide greater discharges of water to larger areas and require more formalised concrete canal systems to distribute the water. They are often co-operatively managed, sometimes under the control of larger and/or more influential farmers who have the resources to keep them running. There have been major problems in making these sustainable, both in engineering terms (difficulties with spare parts and maintenance), social terms (they command a large area and require a considerable number of people to work in co-operation and economic terms (the cost of operation is greater than using presently available free family labour or even wage paid hired people). Deep tubewells can also locally draw down the water table and put it out of the reach of close by treadle and low lift pumps. Many in the study area are not used apparently due to a combination of the above factors, at best they are irrelevant to the area as groundwater is so good, at worst they can actually be detrimental. The area under irrigation has increased considerably in the last few years and looks likely to continue to do so, irrespective of any flood control or drainage intervention.

A major effect of constructing flood protection embankments will be to reduce groundwater recharge brought about by river flooding. A greater proportion of recharge would thus rely upon local rainfall infiltration. The degree of effect has been modelled and is variable depending upon site specific conditions. Data collection and analysis by FAP 3 for the Jamalpur Upazila indicates that controlled flooding as envisaged under Option B would reduce recharge only slightly whereas, on average, full flood protection as envisaged in the now discounted Option D would cause a reduction of up to 20% from present figures. These figures are for a worst case situation assuming the widespread expansion of irrigated agriculture in the study area. Given the very conservative nature of the recharge calculation methodology, changes in groundwater levels are not considered to be a constraint. Calculations based on observed well performance show that groundwater levels are likely to remain high enough to allow the present area of irrigation to be expanded over the study area utilising the present types of extraction technology. Even with improved drainage provision to overcome surface drainage congestion there would appear to be no problem.

The likely impact of controlled flooding on groundwater quality brought about by the likely increased use of fertilisers and pesticides cannot be estimated at present. The situation needs to be monitored through a programme of water sampling and testing. This is discussed in Section 2.2.10.

2.2.10 Freshwater Ecology and Water Quality

The issue of water quality needs to be seen in the wider context of freshwater ecology. Unfortunately the Terms of Reference for the study did not do this and no ecologist directly worked on the main study nor the extension period. Assistance was kindly provided by the expatriate ecologist on FAP 2, particularly in the interpretation of water quality analysis results. The Guidelines for Ecological Impact Assessment (Annex 5 of the GPA latest edition, May 1992) were put in place too late to justify a case for including these in the study. As such the work which could be construed as freshwater ecology has been limited to water sampling and wetland flora and fauna compilation work. The water quality work is written up below.

There appears to have been very little systematically collected data concerning water quality in the study area prior to the study. Dry season 1991/2 and wet season 1992 (although it was an abnormally dry wet season) water samples were selected from representative locations and have been collected in the field and analyzed. The locations are shown in Figure 3.2.20 and a summary table of the chemical analysis in Table 3.2.1 for the dry season and 3.2.2 for the wet season. In addition the minimum water quality standards for Bangladesh are indicated in Table 3.2.3. It was not possible to do analysis for agro-chemical residuals as no facilities were available at the time. It has subsequently come to light that the Atomic Energy Laboratory is able to do this, but the cost is quite high and would in any case have been beyond the budget of the study.

The aim of the programme was to initially collect dry season samples from along the main Jamuna, off-takes of the main surface flow into the mainland area and outfalls back into the Jamuna. In addition attempts were made to include samples from Beels that appeared to be fed only from rain water and also those fed by internal rivers that were likely to have been filled with a mixture of rain and main river flood water. Both deep groundwater and shallow groundwater samples were taken, along with the outfall water of the sugar factory at Dewanganj and the fertilizer factory south of Sarishabari. This was achieved for the dry season conditions which give the most useful results as these are times when concentrations are likely to be highest. The programme was repeated during the wet season with the aim of seeing the degree to which flooding dilutes these causing water chemistry to be more uniform. However the 1992 wet season was abnormally dry and should not be considered a typical year. A long term on-going sampling programme is needed and it is questionable if the project study is an appropriate institutional structure to do this. It would be far better placed under the care of a local government authority and/or the Department of the Environment. However if this is not possible then provision and resources need to be made to do this from the proposed project.

Interpretation of the results of the dry season sampling has indicated the following broad patterns.

- Levels of Sodium Chloride are all low according to accepted use standards. The main Jamuna river water has the lowest levels of Sodium Chloride, dry season levels of which increase as you move further down the Old Brahmaputra and through the internal river system and river fed areas of standing water. They are also low in shallow tubewell water but higher in deep tubewell water. The highest value was found in the sugar factory outfall but this is not particularly great and is probably linked to the level of the deep tubewell source water.

- Levels of Calcium Carbonate were lowest in rain fed ponds, fairly low and similar through out the river system and shallow tubewells. They were higher in deep tubewells and highest in the sugar factory outfall were lime is used as a flocculant in the processing.

- Nitrate levels were generally low with the exception of the fertilizer factory outlet where they were very high indeed. This was also the case with phosphate levels although these were also high in a shallow tubewell. Sulphate levels were also high in the fertilizer factory outfall and low elsewhere, although significantly higher downstream of the factory than upstream of it.

- Potassium levels were highest in a stagnant pond and the fertilizer factory outfall.

- Iron levels were high in some standing and stagnant water (up to 16.6ppm) and in the tubewell water source for the sugar factory process water (8.2ppm). The allowable drinking water absolute maximum is normally fixed to be 5.0ppm with a stated Bangladesh standard value of 0.3 to 1.0. Limits for fisheries and irrigation have not as yet been standardised for the country. This problem can be seen in deep tubewell water once it has been exposed to the air and allowed to oxidise. This is most marked in the dry season and there are iron stains on most of the deep tubewell concrete canals. They were however highest in the sugar factory outfall but this also had very high levels in its tubewell water source.

- Attempts were made to try and see how low iodine levels were and if there was not much variation. This showed levels to be low with little difference through out the area, although the sensitivity and accuracy of the testing has to be questionable.

- Silica levels were found to be high in the river and groundwater system and lowest in the rainfall fed pond. There is reportedly a link between silica and algal growth. High silica levels encourage green algae which use up nitrogen and retard the development of blue-green algae, some of which are toxic and have proved to be serious problems in open waters in warm climates. There is also no plankton in the main Jamuna river due to the high levels of sediment.

- The pH levels of over 8.2 indicate active photosynthesis, those below this level being either stagnant, polluted or deep groundwater.

- The levels of dissolved oxygen were low in shallow tubewell water, when normally a high figure would be expected from pumped water. Free Carbon Dioxide levels were abnormally high in the sugar factory outfall, although the source water was relatively high to start with.

- The validity of the organic results was considered to be highly suspect, being very high. It is likely that the samples could not be got to the laboratory quickly enough nor in a completely sealed and undisturbed state. Only by using a suitably equipped laboratory nearer the site will this be possible. At present there appear to be no facilities to do this and it is a major constraint to the identification and analysis of urban effluent discharge, particularly from the four towns on the left bank of the Old Brahmaputra.

By comparing the wet season results with those above the following conclusions can be drawn:

Calcium carbonate levels have levelled off at a generally lower level across the study area and the highest levels in the sugar factory have been curtailed as the operation is shut down for the wet season. Nitrate levels at the fertilizer factory outlet remain high although not at the previous peak. This is despite the fact that the plant commissioning period is over. The location of the outfall appears to be a big problem as it lies on a small side channel to the main river which is closing up and there is insufficient water to ensure dispersion. Nitrate levels in other locations are generally slightly higher than during the dry season with the exception of the Old Brahmaputra at Jamalpur where it is significantly higher. Phosphate levels are very high in the sugar factory supply and outlet as well as a previously stagnant ditch. They are also generally higher throughout the study area although this may be due to the testing procedures being improved. Iodine levels are generally low but it is difficult to sensibly identify spatial differences as the comparative accuracy of these low counts is suspect. Levels of silica are the same or lower in the main Jamuna and higher in the newly flooded areas. Potassium levels are high in the sugar factory and fertilizer factory and higher than the dry season figures for the rest of the study area. This could possibly be the result of improved analysis. Zinc levels are higher throughout the area than in the dry season and highest in the Old Brahmaputra near Jamalpur and the dry season drainage ditch. Sulphate levels in areas where they existed in the dry season were found to be lower, however those places where none was previously recorded had recordable levels, possibly because testing methods may have improved. The recorded levels of iron have levelled off across the study area, the dry season peaks having fallen and the lower levels risen. Sodium chloride levels are even lower than in the dry season, but are slightly higher in the dry season ditch, the Chatal and the fertilizer factory. The organic level results are still to be treated with caution, but do show significantly lower levels than the dry season, possibly demonstrating a significant flushing effect and dispersion.

In summary another set of dry and wet season samples will be needed before any sensible trends can be seen. The fact that the 1992 wet season was abnormally dry means that these results are probably a typical, even so some dilution effects of flooding can be identified.

Subsequent interviews with people living and fishing around the fertilizer factory outfall have indicated that there is a serious problem with water quality and some ammonia air pollution. Interviews with the factory management and site observations during its commissioning stage indicated that a high technology feed-back effluent quality processing plant exists, linked to the water re-cycling plant. However it may be that there are difficulties in managing such a high technology plant. There have been significant deaths of fish and although at first this was thought to be an extreme case at low water flow when effluent is concentrated and unable to disperse it has continued into the wet season. It was at first also thought to reflect teething problems with the factory as it was being commissioned and test run, however it has continued. It also seems that the outlet is badly located on a side river to the Jamuna, fed only in the flood season from the Old Brahmaputra and will not allow for dispersion. This also effects the quality of inlet process water to the plant and will only get worse as the channel is suffering from increased sedimentation, irrespective of any FCD intervention, which itself could make the situation worse still depending upon the water management criteria used.

The degree and problem of urban effluent discharge, particularly from the four main nucleated settlements on the left bank of the Old Brahmaputra remains still remains difficult to assess. Without a suitably equipped laboratory close at hand to carry out organic analysis further sampling it is unlikely to be of much help.

The systematic collection of water quality data at national level needs to be carried out in a centralised and controlled manner, not on an ad-hoc basis. Project studies are not a suitable institutional framework for the systematic collection of this data. It is important that this is done as soon as possible, as changes in water quality can be important early indicators of significant natural environmental change. It has possible implications for the study of likely nutrient levels, nitrate build up (possibly linked to length of time of standing water and fertilizer use), algal growth (including toxic algae), herbicide and pesticide residual levels and hence domestic water quality and human health. Suitable laboratory facilities need establishing as a matter of urgency.

From site reconnaissance work it is notable that there is widespread occurrence of water weed, particularly water hyacinth. In many countries this is considered a major problem and constitutes a serious nuisance. This situation is normally made worse by the introduction of all year round standing water where previously the yearly cycle was broken by drying out or through the action of moving water. As such it is often considered a major negative impact of water development programmes. However in the context of the intensity of resource use in Bangladesh and particularly the project area, this is utilised as a resource. Despite its poor nutritional value it is harvested and apparently sold as fodder. Whilst there are better quality alternatives, the general lack of fodder availability (particularly for draught animals) in the study area forces it to be used rather than wasted. If large areas were to be drained and put under all year irrigated cropping then this source would decline. What matters is if the residues of the irrigated crops that replace it are at least equivalent as a fodder source to the lost hyacinth.

Cutting of the hyacinth removes a potential source of high levels of vegetative matter in open water bodies that can become a water quality problem. As presently managed it is a form of nutrient recycling which along with other such measures such as the management of fish stocks could go a long way to preventing or reducing any water quality problems. It could also have wider uses as a raw material for paper and furniture manufacture.

There is increasing but sporadic use of artificial fertilizers in the study area, mainly urea and TSP with little use of MP. This appears to be linked to the uptake and expansion of irrigated high yielding rice varieties. As farming is in the hands of private farmers there will be little control mechanisms to change the use of fertilizer should there be pollution problems. The mechanism that could be used is price control but this would appear socially undesirable. In addition the largest fertilizer plant in Bangladesh is located at the southern tip of the project area. This has recently been commissioned within the last year and produces large quantities of urea from piped natural gas using a reputedly high level "clean" technology ammonia process. This requires the extraction of quite large quantities of water from a tributary of the Jamuna and discharges treated and diluted waste water back into the river, although the rate of water use is significantly reduced by recycling. Samples of this have been taken and the analysis is commented upon above. There is also some release of ammonia into the atmosphere this was thought to be a temporary state of affairs as problems were sorted out during the commissioning phase of the plant, however it has persisted.

There is at present hardly any use of chemical weed control herbicides in the area (weeds are again harvested as a valuable fodder resource) as the majority of these have to be imported into the country and are prohibitively expensive for local farmers. There is some limited but increasing use of chemical pesticides for control of insects particularly in areas of HYV rice cultivation. The likely increase in their future use in conjunction with high yielding varieties will need consideration, especially in the light of known susceptibility of HYV varieties to such attack. In addition there is a serious problem with pest attack on grain storage which could be the future subject of a pesticide use programme. From an environmental point of view it is preferable to promote efforts for more secure grain storage containers rather than extend pesticide use.

There is a large sugar mill at Dewanganj which discharges wastes into large open areas next to the factory and close to a major residential area. Water samples have been taken from the outfall and the results are commented upon above. These ponds leak very badly into the open water system and are a serious health hazard as well as constituting an unpleasant smell. If well managed and secured they could be used as a source of organic fertilizer. The management of the factory is aware of the problem but requires guidance and assistance as to how to go about this. At present the disposal of these wastes should be a cause of concern from both a groundwater quality perspective and a human health risk, both in terms of possible disease vector breeding grounds and also direct human contact. There is reportedly a concentration of malaria cases in the area (4262 suspected recorded cases in 1991 of which 414 were confirmed) which may be related to this standing water, although checks in the area also indicate that the prevalence of water for jute wretting may be a contributory factor.

2.3 The Natural Environment - Terrestrial

2.3.1 Agro-Ecological Zones

There is a mapped classification of agro-ecological zones of the study area based upon the work of FAO in 1988 and this is shown in Figure 3.2.21. This links topography with the length and depth of flooding as well as soil and land use systems. These are very complex interactions and the mapping may be rather simplistic but it provides a valuable basis for spatial analysis. This delineation identified three major zone types running north to south through the study area linked to historical river deposition patterns. Although the date of this work is given as 1988 it utilised the 1963 air photography of the area. A slightly modified and updated version of this has been prepared by the study team using the November 1990 SPOT satellite imagery and is shown as Land Systems in Figure 3.2.22 of this report. This updates the FAO work due to the results of river movement, erosion and deposition, specifically the recently flooded area south of Madarganj. It also revises some of the boundaries as they are easier to delineate on the enhanced SPOT image than air photography, particularly the complex river flood systems from the Old Brahmaputra in the southern part of the study area. It must be remembered that like so much land resources mapping, many of these are transition boundaries rather than hard and sudden changes. Mapping of land types is shown in Drawing No 18 in the Album accompanying this report.

2.3.2 Soil

The assessment of soils and their potential has been tackled as part of the agricultural studies and is written up in Annex 5 of this report. Soil type distribution is closely related to the agro-ecological mapping mentioned above. From the point of view of induced environmental change the major issues to consider are the present soil chemistry and possible changes due to the expansion of irrigation with higher groundwater application rates and a reduction in river water flooding. This requires consideration of water chemistry and evaporation rates along with infiltration, drainage and leaching. There could be major changes leading to possible increases in salinity and changes in soil structure and water holding. Allied to this is the use of agro-chemicals and possible erosion and degradation of the soil. However the present evidence is that there is a very low salinity risk indeed as the level of salts in the groundwater is extremely low. This is linked to high annual groundwater replenishment rates and the geology of the catchment. Added to this is the fact that the dry season (when irrigation is at its highest) is the coolest time of the year when evaporation and any salt concentration rates are very low.

The biggest soil problem at the moment is waterlogging of the lowland soils. Improved drainage and the reduction in flooding from the main rivers will help to reduce this problem. Conversely more of the less frequently flooded higher land soils are likely to brought under all year irrigated agriculture. This could pose longer term problems if previously dryer soils were to be permanently saturated, possibly leading to anaerobic conditions which may change the chemical composition of the soil. This could prohibit the supply of oxygen to plant roots. There are also high levels of soluble iron in the groundwater which oxidises on contact with the air. This could possibly increase to toxic levels. Research work at the national level is needed on these subjects and is presently under study by FAP 16.

Of perhaps greater concern must be the effect of the likely increased use of agro-chemicals associated with the extension of irrigated HYV rice cultivation. The use of artificial fertilizers is likely to increase due to greater ease of supply from the nearby factory and the dependency of HYV's on these for their enhanced performance. There may also be a reduction in the use of natural organic fertilizers as fodder becomes less available and livestock numbers fall as arable agriculture intensifies still further. However the availability of rice husk residues for fertilizer may increase although this use is likely to be of lower priority than for domestic fuel. The oft mooted natural fertilization of the land from silt deposited during flooding is likely to decrease as a result of controlled flooding. However there would seem to be contradictory factors in the benefits of silt for soil fertility. This is again under study by FAP 16. The residuals from all agro-chemicals can pollute groundwater and hence domestic water supply and get into the food chain causing long term natural environment and human health problems. The high horizontal seepage of the loamy soils in the study area is likely to promote the concentration of nitrates in adjoining depressions and ponds. This will have water quality considerations for domestic water supply use, flora and fauna.

Study of these possible impacts requires a suitable long term comparative monitoring programme, the basis for which at a national level is presently being done by FAP 16. There are already vast amounts of soil chemistry data collected by SRDI for the area at Upazila level. Unfortunately whilst the locations of the samples can be mapped for most of the study area the data is at the moment only available for Melandah (1985) and Madarganj (1990). This is shown in Figure 3.2.23 and Table 3.2.4 with rating of the analytical values of soil nutrient components in Table 3.2.5.

2.3.3 Ecology

The perception and definition of ecology as seen in the Flood Action Plan was only first addressed in the May 1992 version of the GPA which gives the procedures for ecological assessment. The resources and staffing for the study had already been fixed by then, and what little extra were available were concentrated on the higher priority and more immediate issues of the Char lands (particularly as this appeared to question the whole philosophy and viability of the proposed intervention), fisheries, human health and nutrition. The study is thus recognisably weak on ecology, but the specific issues of water quality, flora and fauna that were specified in the Terms of Reference have been tackled within the constraints of the resources made available. The wider issues of the understanding of the complex inter-relationships of the biophysical system have not been addressed and until a commitment is made to provide the resources to do this is a systematic and sustainable manner it is not possible to do so.

The main issue as regards ecology are the way in which induced environmental change will effect the number and distribution of species, both in terms of location and time. This has implications for human use of these resources (flora and fauna) and particularly their contribution to economic livelihoods. The desirability of conserving and maintaining bio-diversity to allow species continuation by ensuring the sustainable preservation of habitats also needs to be borne in mind, especially when dealing with rare or threatened species. These are matters for national policy priorities and require clear criteria that can be applied to the study area. These do not exist at the moment.

A programme was instigated to collect the incidence of differing flora and fauna in the study area utilising a check list approach. Master lists were drawn up using the work of FAP 2 (North West Regional Study Interim report Annex 9), and reference has been made to the FAP 3 Ecological assessment report (BCEOM, North Central Regional Study Supporting Report V, Ecological Assessment). Flora and wildlife lists are given in Appendix C along with a list of medicinal plants and their uses. Ideally these should record the past status of species, the present situation and the future likely state (both those that are predicted to thrive and those that will be threatened as a result of project interventions) with and with out the project. However this has proved impossible to do, due to the lack of data, and the level of understanding and awareness of local officials due to the low priority attached to these subjects in the past in Bangladesh. There is a large body of local knowledge on these matters but it requires a major programme of interviewing work and public consultation to extract this. The work of the Asian Wetlands Bureau carried out for the North East Regional Study (FAP 6) has yet to be received by the project, but it could contain information that may be relevant to the study. Discussions with ornithologists having knowledge in the area have also taken place. A major problem in the process is the lack of useful hydrological modelling output data which will give indications of likely habitat change under intervention conditions. Without this it is impossible to make any meaningful judgements.

The arguments for the preservation and conservation of flora and fauna are now well documented and are contained in the World Conservation Strategy of the IUCN (Ref IUCN 1980). These have been embodied into the National Conservation Strategy of Bangladesh (First Draft, Ministry of Environment and Forest, Government of Bangladesh July 1991) which has recently been discussed by Cabinet. Like similar documents this is in essence a statement of intent and now requires to be acted upon, specifically the definition of national priorities, the drawing up of a consolidated body of environmental legislation and an enforcement system to turn the strategy into an operational reality. This is in the process of being done as part of NEMAP.

It must be appreciated that due to the extremely high human population densities in the study area that the status of very many species of flora and fauna is already threatened or have become extinct. This trend is likely to continue irrespective of any project development.

2.3.4 Flora

The list of flora in the area is given in Appendix C as Table 3.C.1. This gives the Bangla, English and botanical name, its type, habitat and use along with the past and present incidence. The major issue will be the likely degree and nature of change in wetland habitats as a result of the control of river flooding and the possible decrease in run-off as a consequence of improved drainage. There appear to be differing flora systems linked to the locations of rainwater fed pools or beels when compared to those fed by river flooding systems. There are no gazetted forestry or grazing reserves in the study area and it is characterised by extremely high levels of land utilisation for rice cultivation which militate against this. Natural vegetation has all but disappeared although there is widespread use of vegetative matter for building construction and stall-fed fodder. There is extensive use made of various naturally occurring plant species for medicinal use. Enquiries have been tactfully made amongst traditional doctors and healers to ascertain the types, quantities and locations of these source plants, if there is a risk to their future as a result of the project and if suitable replacement sources exist. Their use has also been investigated to see how important they are and if suitable alternatives exist. The medicinal plant data is given in Table 3.C.3 and indicates the scientific and Bangla name, along with the active chemical ingredients and their use. This work has been assisted by medical specialists at FAP 16. The crucial issue is how the distribution of these will be effected by the project intervention and if there are sufficient alternative sources available elsewhere.

2.3.5 Fauna

The area is very poorly endowed with mammals, anything of any size has been hunted, either for food, sport or as a nuisance or has been displaced by habitat change due to the intensity of human settlement and cultivation. A list of wildlife species is given in Table 3.C.2 and indicates the English, Bangla and scientific names, by species group, their habitats and past and present incidence. There are no gazetted Wildlife or National Parks in the study area. Discussion with the ecologist on FAP 2 has highlighted the possible importance of ground fauna and insects as part of the food chain and their possible place in biological pest control. This will require further investigation at a later stage. Reptile life linked to water will be affected and mention has been made in the literature of the problems of snakes during flood times when they retreat and concentrate, along with humans, onto higher land

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during times of flooding. It has been claimed that during the 1988 floods more people died on the main land in the north of the country as a result of snake bites than from drowning. Conversely it is acknowledged that snakes are a major predator of pests, particularly rats, the incidence of which is already growing and known to be a particular problem in the sugar cane growing areas around Dewanganj. It has been estimated nationally that crop storage losses due to pests are considerably higher than the losses from flood destruction (MPO report). The north of Bangladesh and particularly the upper reach of the Jamuna and Brahmaputra area is known as a habitat and stop-over point for migratory water birds to and from Siberia. How important it is in comparison to other similar sites in the north of the country is still unknown, but studies are in hand for this by FAP 6 and a wetlands inventory by FAP 16. Only a national assessment will give the type of data required to allow a prioritisation for conservation policies to be drawn up. It is likely that there will be quite serious impacts to water bird species if the number, size and distribution of areas of open water were to fall and if the present numbers and varieties of fish species in them were to change. However there are known to be better sites for these in other parts of the country to the north and north east of the study area.

The changes in fish species in terms of human use are discussed in Annex 2. This is one of the most serious negative impacts of any flood control and drainage proposals. There has been very little research carried out on the over 200 species of fish found in the country. From the fisheries impact analysis it would seem that severe fish losses should be expected under Option B, both in terms of species used for human consumption and others which form the present, although rapidly contracting level of bio-diversity. There appears to be little use of wild animal products in the study area due to their relative scarcity.

2.3.6 Seismic Activity

This subject is often regarded as an induced impact for some water resources developments, particularly large man made lakes. In the context of this project it is a constraint that needs to be considered for project formulation and design. There is a known history of seismic activity in the area which is characterised by relatively rare but sudden and intense events. There were major earthquakes with epicentres in the Assam hills in 1762, 1787, 10th January 1869, 14th July 1885, 12th July 1897, 3rd July 1930 and the 15th August 1950. (Ref Government Gazetteers, Haroun Er Rashid 1991 and FAP 16 work on the Surma-Kushiyara Project). These events caused widespread damage and destruction to the few substantial stone built buildings in the region (UNESCO 1984). However as most of the population were then living in bamboo houses there were very few human casualties. The implications if similar events were to happen now with the greater numbers of concrete built buildings are serious. Seismic activity is thought to be a major, if indirect, reason for the sudden and rapid changes in the course of the Brahmaputra at the northern end of the study area. Due to the extremely flat nature of the terrain the whole of the lowland Bangladesh drainage system is particularly susceptible to the secondary effects of earthquakes and the project area is no exception. In addition concern has been raised as to the resulting likely effects of relative changes in sea level. Whilst these are likely to have more serious implications for Bangladesh than most other countries, the project area is too far north to affected. The recorded seismic activity was further studied by the embankment/materials engineer along with its implications for embankment design, location, orientation and stability. Of particular concern is the risk of liquefaction and catastrophic failure and the degree to which this can be reduced by appropriate design. Contemporary accounts of the 1897 event (Rangpur District Gazetteer) indicate that liquefaction was a major problem with catastrophic results in riverine areas. Of particular concern must be the possible combination of an earthquake and high river levels. It should be noted that nearly all of the earthquakes happened during times of high river levels and the implications for embankment failure are very serious indeed although it is difficult to address this issue in a satisfactory manner without detailed studies. The recommendations of FAP 3 Report V, Chapter 5 (Risk and Hazard Analysis) are endorsed. The embankments act as dams for which there are stringent international standards, especially where significant loss of life can be expected as a result of failure. A proper safety analysis of hazards should be a minimum requirement for any embankment scheme. In addition fall back systems are required which reduce the consequences of catastrophic failure due to seismic activity, water management using compartmentalisation is one of these. As part of the environmental management and planning process this needs to be considered in greater detail and the need for and nature of emergency disaster planning ascertained.

2.4 The Human Environment

2.4.1 Introduction

Assessment of the human environment centres upon the type and use of the natural environment by man, specifically in this case the economic use of land and water. The intensity and inter-related nature of resource use in Bangladesh must rate as some of the highest in the World, especially for rural areas. This makes systematic analysis difficult but yet of even greater importance. It also means that any change in the environment is likely to have serious negative consequences for somebody. Whilst changes that are perceived as "natural" ones can be attributable to "acts of God" (even though they may be man induced) those that are obviously man made or induced have blame attached to them and are subject to scrutiny and are more likely to become the subject of politicisation.

2.4.2 Household Socio-Economic Livelihood

Of prime concern are the effects that induced changes have on livelihood levels and sustainability, specifically differences to the levels of risk and hazard. This needs to be seen in both spatial differentiation terms and also how this effects people of various socio-economic levels and groups. In the context of this project the present risk and likely losses due to flooding are linked to location, socio-economic levels and stratification as well as occupation. A major concern are particularly vulnerable groups such as those households having no agricultural land (41% of all study area households, defined as those having less than 0.02 ha), the 38% of households who catch fish and women headed households (1.8% of all households). These are considered as particularly important special issues and a major factor linking all three will be the likely changes in the availability of wage paid labour for these people. The priorities, attitudes and perceptions of different households have been taken into consideration, particularly with regard to flood risk aversion strategies, as part of the detailed socio-economic questionnaire work. Attempts are being made to link this to people's willingness and commitment to contribute to any proposed project, however this requires a very specific and detailed approach. This has been proposed for the detailed design phase of the study the staffing of which has been drawn up with a large non-engineering component. Annex 6 of this report contains the Social Impact Assessment and only a brief summary is given here. In addition the Char Study report (Annex 9) contains the results and interpretation of the socio-economic data collected for that area. From frame survey of 5 000 households on the mainland, some 530 households in 19 villages were sampled for detailed socio-economic survey. These were selected in locations to give coverage across all the agro-ecological zones. In the Char lands some 500 households were interviewed in detail from 63 villages scattered across the area but with an emphasis in the Island Chars. The location of the sampled villages is given in Figure 3.2.24.

2.4.3 Population, Settlement and Land Tenure

The present situation with regard to population in the study area has been tackled by specific sociology and socio-economic studies which are described in Annex 6 of this report. The most recent national census for the area was carried out by BBS in 1991 but the results are not as yet released. The one previous to this was in 1981 and is now considered to be badly outdated for present planning work. Using a sample village listing and census technique the population for the mainland study area and the Char lands, split by Char type, has been estimated. These estimates are given in Table 3.2.6. From the surveys the average household sizes were found to be 5.12 people for the mainland, but with great variability correlated to land holding area, and 6.1 for Island Char land. The population density distribution for 1981 is given in Figure 3.2.25 and whilst this data is badly out of date it clearly shows the spatial variability across the study area.

From an induced change perspective the major variables are settlement distribution, location and density and the past and future trends of this along with the availability and location of agricultural land. Information on the past settlement history of the area is hard to come by, but a significant source are the Government Gazetteers for the area, one dated 1917 and the other 1978. The 1794 Rennells map indicates a large number of evenly distributed settlements at that time, including the area now occupied by the Jamuna river. The administration delineation of the area is based upon that set up using the 1907 1":1 mile map. Field investigations have shown that these boundaries are rigidly adhered to and people have a strong sense of territorial attachment or belonging. A map down to Union level is given as Figure 3.2.26. The recent settlement process in the study area seems to have been over land from the south and east and not by river. As a result there are strong connections eastward and the river is a relative barrier. The exception is the those parts of the study area which in 1908 were on the west bank but due to river movement are now on the east. This is the case for the Attached Char land north of Madarganj. This is still administered from the west bank and its inhabitants consider themselves part of or from it. The situation on the Char lands is different due to the dynamic nature of the area and is commented upon in Annex 9, the Char Study.

Land tenure is a critical variable in Bangladesh as land is a very highly prized asset and the major key to economic survival and autonomy in rural areas. The mainland project area contains some of most densely populated rural areas in Bangladesh if not the World, with average densities in 1981 of well over 1000 people per km^2 in seven of the Unions and an estimated present overall density of 970 people per km^2 people. The distribution of population in terms of concentration in towns, minor towns, villages and hamlets can be characterised as having a few larger nucleated urban settlements mainly on the eastern side of the railway line on the western bank of the Old Brahmaputra (see Figure 3.1.2). There are a few smaller nucleated settlements but a considerable number of villages (administered as Mauzas or village revenue districts). Added to this is a generally extremely high density of scattered rural settlement at both hamlet (sub Mauza villages and Paras, equivalent to Wards) and down to the level of individual households. The percentage of landless households, defined as those households with less than 0.02 ha (i.e. that generally sufficient for a small homestead), is around 50% for the mainland area, increasing to over 66% for the Attached Char and Set-back land (mainly due to erosion displacees) and lowest on the Island Chars at 37%. A further 11% on the mainland are regarded as being in a marginal position with between 0.02 ha and 0.2 ha of land. The equivalent figure for the unprotected land is 10%. The variation in this over the mainland study area indicates that the landless are evenly spread over the mainland, where as the large farmers are concentrated in agro-ecological Zone 8, the medium level land. There appear to be significantly fewer women headed households in Zone 9, the highest level and most agriculturally productive land. Full time fishing households are concentrated in Zone 8 where most of the Beels are

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located. It must be stressed that all of this data is based on sample household surveys and present unavailability of the 1991 census data is a serious constraint to planning in the study area. As soon as it becomes available it needs to be analyzed, compared and reconciled with the sample data.

Due to the high population density and intensity of use, land is valued very highly. As a result there is a system of statutory cadastre (the Mauza or revenue mapping) which is in theory kept reasonably updated to cope with sub-divisions at death, adjudication and transfers. It includes systematic mapping and registration, although it is cumbersome to use. Enquiries were made at the relevant office in Madarganj to see this data. This has highlighted the system for land allocation in re-emergent Char land. The present situation under law is that when land is lost to the river the requirement to pay land tax is wavered but the rights to the land default to the state. This becomes Khas land but the former owner has the first option on it should it re-appear within 20 years of its loss. However in order to continue to retain their legal right to the land it appears that people will continue to pay land tax and avoid the risk of forfeiture to the state and possible difficulties in reclaiming this at the time it re-appears.

There is a significant land displacement problem caused by recent (1991) river erosion south of Madarganj which has resulted in a serious dispossessed refugee and squatter problem along the road embankments of the area. In the past dry season many of these people have moved onto newly emergent Char land west of Madarganj but are likely to have been displaced by the recent (July 1992) rise in the river level. There is also a similar erosion and displacement problem in Islampur Upazila west of Belgachha. In addition there is a spontaneous settlement around the new fertilizer plant north of Jagannathganj. This is a result of in-migration for seeking work and associated activities for the construction of the plant. The degree to which it is likely to remain is difficult to predict, but the job opportunities for its residents after the construction programme is finished must be quite limited.

The issues of land acquisition, displacement, compensation and disruption caused by the proposed location and construction of embankments have been broadly addressed by FAP 15. Their recommendations were that a major revision in the procedures for land acquisition are required to make the process more efficient both in terms of speed and giving equitable settlement of claims. These issues will need to be dealt with in detail at the detailed design phase of the study once more definite proposals are known. In the meantime strenuous efforts have been made to minimise any requirement for land acquisition by drawing up social criteria for the location, design, construction and maintenance of embankments. They have been located so as to try and protect as many flood prone fixed assets as possible, principally major settlements and land. In addition they are following existing roads and/or embankments as far as is possible and where not, will then be located at major field boundaries to minimise the land take. However this must be seen in the light of minimum height and width requirements needed for the construction of durable stable structures determined by material availability and the maximum steepness of slope that can be safely considered. The role of embankments as refuges during flood risk times has also been considered as part of the flood proofing strategy for the area. In addition consideration will be given to provision of a berm on the protected side of the embankment face that can be utilised by displaced people who presently occupy the crest and even the "wet" side of embankments, causing access problems. Other direct construction impacts such as the location and extraction of materials, possible pollution and the need for reinstatement etc will also need be addressed at the Detailed Design phase. Central to this is the degree and nature of likely in-migration that will occur during any construction period. The guiding philosophy is to maximise the positive impacts (employment opportunities for example) by appropriate design and construction technology and minimise the negative ones by careful planning.

2.4.4 Common Resource Rights

The use of common resource rights (or "free goods") is of considerable importance to a large proportion of the population, particularly the landless and poorer sections of society. However the availability of these is in decline as human population levels increase, farming methods become more intensive and areas of common land fall into private hands. This includes capture fisheries which contribute the main animal protein component of the diets the these households. The degree of dependence on fish for animal protein is presently under study at the national level by FAP 16. The implications of flood embankment construction along the Jamuna on common good capture fisheries in the project area are considered in Annex 2 of this report. Without a targeted fisheries mitigation and management programme the losses are likely to be high under Option B with significant nutritional consequences.

Common resource rights also include the grazing and collection of fodder from publicly owned land, the picking of fruits and gathering of vegetative matter, all of which have a multitude of household uses. The flora inventory has shown that medicinal plant use is significant in the area and these are listed in Table 3.C.3 in Appendix C. The incidence of collection of such "free goods" is a function of the degree of access to land that is allowed by owners. This is generally a function of the intensity of cultivation, specifically the degree to which irrigated rice farming is being expanded. As cropping intensifies and is likely to be accelerated still further as a result of water and land management then these important sources of livelihood sustenance will become scarcer.

2.4.5 Agricultural Land Use

Agricultural aspects are written up in Annex 5 of this report. In order to consider the implications of induced change as a result of project interventions, attempts were made to utilise the FAP 3 land use mapping using digital classification techniques on the February 1990 SPOT satellite imagery. This has proved unsuccessful due to the complex seasonal nature of cropping, the small units of cultivation and resulting miss or cross classification. A more simplistic classification using Landsat imagery of 8th March 1992 has been used at FAP 19. This has classified land cover or utilisation into four broad categories:

- water at the time of the image
- sand at the time of the image
- land that is cultivated or vegetated at the time of the image
- other land that has been recently cultivated (ie probably at some time in the previous 12 months)

The plot of this is shown in colour in Figure 3.2.27. A land use map is shown in Drawing No 18 in the Album. A perhaps more useful approach is to consider a broad conceptual pattern utilising the generalised cropping pattern diagram given in Figure 3.2.28 in conjunction with the Land Systems Map given as Figure 3.2.22. This links the cropping pattern in spatial terms to changes in flood depth and duration through out the year and across the study area. The major variables here are topography and drainage and how these effect sowing dates and cropping intensity, specifically the degree, location and rate of increase in irrigated third crop HYV rice cultivation. This has significant socio-economic implications for labour demand, benefit distribution and equity. These effects have been well documented for Bangladesh in the work of Hossain, Mahabub 1989.

In broad terms, the present situation in the mainland study area is that there is a significant and increasing grain surplus (mainly rice) being produced which is being exported out of the area principally to urban markets. Present cropping intensities are said to be 191% and are expected to increase to 195% as a result of the planned intervention. This grain production amounted to over 263,000 metric tonnes in 1991. The major benefits of this accrue to those who own agricultural land (at the most 55% of the population) or lend money to farmers. There is an increase in the seasonal demand for labour which generates some cash income to some landless people, however evidence from the work of FAP 12 indicates that the often claimed increases in employment opportunities for landless people as a result of increased cropping may be very limited due to the abundance of labour already available within the households of landowning families. The 50% of households who do not own cultivable land appear to not have the resources to purchase significant quantities of the grain surplus even though they are already the most in need of it. The calorie intake status of households by land ownership is shown in Annex 6, Tables 6.C.28 and 6.C.29 and commented upon in Sections 2.6.1 and 2.6.2 of that Annex. This indicates that the 44% of the households had below the WHO threshold limit of 2122 calories per day of which 28% were in the landless category. Evidence from the FAP 12 summary report indicates that this situation is likely to continue and exacerbate irrespective of any water and land control programme, which itself is likely to increase the equity gap still further. This is an issue which overrides all analysis of project benefits and losses. It is a question of priorities and definition of sustainable development both in economic, social and environmental terms. It requires specifically targeted programmes and policies to tackle these issues.

2.4.6 Fishing

As stated above this is tackled in detail in Annex 2 of this report but a data summary is given in Table 3.3.1, with one column showing the present situation. It is considered a very major issue for the development of any water and land development programme. Although the level of fish capture has been recently increasing in the project area (possibly as a result of increased recruitment due to the damage caused to some of the flood embankments as a result of and since the 1988 floods) it is thought this has now reached its peak and is entering into decline as the internal river system becomes dryer and over-fishing occurs. As a result there have been major difficulties in predicting without project trends as the figures for the last 6 years for the study area were very different for those at the national level. These are shown by fishing system/habitat in Table 3.2.7 below

Table 3.2.7 Average Annual Jamalpur Fisheries Production % Trends 1985-1991

	MAIN RIVERS	INTERNAL RIVERS	FLOOD LANDS	BEEL	POND	TOTAL
JAMALPUR	+16.49	-21.75	+11.52	NA	+18	+14
BANGLADESH	-26.71	NA	-1.05	+0.61	+3	-1.5
Source: FRSS data						

In the absence of any other data, the impact analysis used the overall national trend figures of -1.5% per annum for calculation of the comparative with and without project situation for all systems except ponds where +4% was used.

The fisheries issues centre around the priority that is to be given to the expansion of arable agriculture (principally rice cultivation) against the loss of common resource capture fisheries and the degree to which any mitigation programme (fish farming or cultivation for instance) can address likely losses. There is a constraint to mitigation in that those people most dependent upon directly caught and consumed "common good" fish resources (defined as "occasional" fishing households) for a large proportion of the animal protein in their diet are concentrated among the landless and poor and do not have the resources (specifically access to land and other inputs) to partake in this type of programme. They are in any case worse placed and least likely to benefit from this inevitably commercial approach. It will need very specific targeted programmes to tackle this issue. The exception to this would be the main river fisheries which would be least effected by project interventions. However these are already in a state of decline due to overfishing. An alternative method of protein production which is appropriate to the situation of these people is required to mitigate against the likely losses to their nutrition. This could include livestock and poultry production but will require very careful consideration. A study on the nutritional consequences of fisheries decline is presently under way at FAP 16 and is due to report soon. A short reconnaissance nutritional study was carried out in the extension stage of the Feasibility Study of FAP 3.1 but needs to be followed up with a systematic programme of appropriate data collection. The Terms of Reference for this are in Appendix D. A mitigation study for fisheries management and development was also carried out at this time and is written up in Annex 2.

2.4.7 Forestry and Bio-mass Fuel

The situation in the project area has already been reached where there is a severe depletion in fuelwood sources and widespread use is being made of rice straw and animal dung for domestic fuel. This competes with demands for animal fodder and reduces the amount of dung available for use as organic fertilizer on the land, resulting in possible chemical degradation of the soil which may be addressed by the increased use of artificial fertilizers, with resulting increased risks for domestic groundwater quality. In addition, the problems with availability of draft animals outlined in Section 2.4.8 below and the uptake of power tillers are likely to exacerbate this still further. There is also significant use of materials for building construction which compete with these other demands.

The major fuelwood use in the area is of a commercial nature for the firing of bricks and pottery manufacture. Relatively large quantities of wood are purchased for cash and brought into the area, reportedly from the Madhupur tract, for these purposes. There are significant brick making operations in the area, linked to the location of suitable clay sources. In addition there is a large commercial artisan pottery operation south of Islampur which is located by sources of particularly suitable clays. This is all fired in wood fuelled traditional kilns and some is secondary fired for glazing. There could be fears as to the continued sustainability of this operation bearing in mind the scarcity and increased price of fuelwood.

There has been past mention of the possible benefits of using embankments as locations for community forestry programmes and particularly their value as shade and resources for settlements that have grown up on them (see the work of FAP 13). Whilst in the past it had been considered that in a narrow engineering technical point of view this would be undesirable (due to the nature of embankment materials and risks of tree root damage leading to leakage and failure) this has to be weighed against the potential benefits. It will require careful species selection in terms of rooting type and also flood tolerance. It will also need to minimise the land take on the "dry" side although any berms could be a good opportunity for planting. Species also need to be considered for their shade and fruit value and planting programmes would be best carried out as part of an integrated programme of multi-purpose use for embankments.

There is however likely to significant beneficial aspects for embankment stability by allowing grass cover. This could be a significant source of fodder material and perhaps grazing although BWDB have expressed concern as to the possible erosion effects of large stock on the embankments, especially during times of rainfall. Again this needs careful consideration and management particularly in the selection of appropriate species, although there is considerable experience in using Vetiver grass for such work in other parts of the world.

2.4.8 Livestock

A major area of concern with regard to impacts on livestock is the situation of draught animals, specifically their numbers and present condition and the likely increased demand for their services as a result of increased cropping intensity. In 1991 there were estimated to be 195 000 cattle in the mainland study area, a mean of about 2/ha of total land. In addition there are 87 000 buffaloes, a mean density of 0.1/ha. The estimated total straw production in the study area has been calculated as 260 000t. Further details can be found in Annex 5.

At present there is some, if limited open grazing on common access land and of crop residues in fallow fields. The opportunities for this are likely to decrease still further with the intensification of agriculture. This is also likely to cause significant changes in the type and availability of fodder for stall feeding. The wetter areas which presently produce harvested fodder hyacinth are likely to be dryer and under crops for a longer part of the year resulting in less being available. Whilst hyacinth is of poor quality, the important issue is the degree to which this will be replaced by irrigated crop residuals. Whilst these are of superior nutritional value to hyacinth, they are likely to be short stalk HYV varieties which provide far smaller volumes and are of lower nutritional value than traditional varieties. There is also competition with their use for fuel and building materials. As mentioned above there is some scope for the production of fodder on embankments but this is small in area and accessible to only a few people. Due to the risk of erosion animal grazing on the embankments has not been favoured by the BWBD in the past. The level of draught animal health is also poor and there is a shortfall in the number of trained animal teams available, particularly for land preparation. This could well be a serious constraint to the intensification of agriculture. It already appears that the use of power tillers is increasing, particularly in the north end of the study area and whilst in terms of the reduction in employment opportunities and narrow environmental and energy use this may be considered undesirable, it may be the inevitable and pragmatic solution at household level to the lack of draught animals. The need for increased protein production has been stated above as a replacement for lost common good fisheries resources. There would seem to be possibilities for increasing small stock and particularly poultry.

2.4.9 Off-Farm Activities and Wage Paid Employment

There is a significant level of wage paid labour (69% of households) and share cropping in the agricultural system, constituting a mean of 65% of all household cash income in the mainland study area. This is linked to the high level of landlessness and the labour intensive nature of rice farming with very peaked seasonal demands for labour. Non agricultural wage paid labour is the main occupation of 14% of households with a further 7% in service employment and 2% in transportation. Most artisanal work is specialised and carried out as a full time occupation and not in association with farming. Occupations include brick making with its associated activities, paddy husking, fishing, along with waterborne and road transport provision including maintenance. There are complex patterns of movement to and for work and these include significant daily travel. There is likely to be increased seasonal demand for labour due to the extension of HYV rice cropping, but the amount and location relative to supply and sustainability of these opportunities is uncertain. The work of FAP 12 indicates that due to the abundance of labour in land owning households the likely increase in work available to the landless is quite limited.

2.4.10 Industry

There is some rural industry in the study area including the previously mentioned sugar mill and fertilizer factory. In addition there are numerous rice mills of varying scales of operation and size. There is likely to be a significant increase in the demand for their services as a result of extended rice cultivation. However as agricultural production lies in the hands of private farmers, it is difficult to quantify and plan for. The issue is if private entrepreneurs will be able to provide the required capacity to satisfy this. There have been serious impediments to rural industrialisation in the past, notably the lack of capital formation for such activities after the flight of capital as a result of partition. The sorry state of the jute industry in the area (the jute mill at Sarishabari is very run down) is an illustration of this. There is apparently little present incentive for farmers to grow jute due to the low prices being offered. The sugar mill is presently said to be running at well beyond design full capacity producing some 14,000 tons of cane sugar per annum. Cane is grown by small holders on an out-grower basis. This is a notoriously difficult type of operation to manage from an industrial point of view but often has significant benefits in terms of income distribution to a large number of previously subsistence farmers. There are major constraints to enlarging this operation, one being the poor transport infrastructure in the area to bring cut cane quickly into the mill to minimise yield loss.

The fertilizer plant has recently been commissioned. Such high technology plants are characterised by their very high construction costs (much of it in hard currency) and the fact that they employ relatively few people and high skilled specialised ones at that, very few of whom are likely to have come from the local area. It would seem that the main employment opportunities will be associated secondary service functions along with handling and distribution activities. As mentioned above, there are serious problems with process water supply and waterborne navigation for transport of the finished product due to siltation and river channel movement, irrespective of any project option. There are also serious problems of outfall water quality resulting in the killing of fish, made worse by the siltation problem which will not allow dilution of the effluent. There is also an ammonia airborne pollution problem which is bad enough to be a visible hazard to humans. During site visits these were at first thought to be teething problems during commissioning and would be dealt within time using the high technology feed-back quality control systems that have been installed. However they have persisted and it can only be assumed that there are problems in managing the operation.

2.4.11 Drinking Water

Some mention of the present situation with regard to domestic water supply has already been made, particularly in the context of possible problems over groundwater quality as a result of increasing agro-chemical use. At present there is only use of open standing water during times of flooding when access to hand pumped ground water supplies becomes difficult. However the likely effects of flood control and improved drainage will be to reduce the amount of surface water available and will force yet more people to use groundwater sources and from a health point of view this is highly desirable. The likely impacts on groundwater recharge have already been mentioned and are considered to be a very minor issue. One of the most serious contributory factors to flood induced mortality is the forced use of polluted river flood water for drinking when normal safer sources are inaccessible or become polluted. Flood control and flood proofing measures, including the provision of handpumped wells and the stocking of emergency treatment chemicals at flood refuges, should go a long way to overcoming this. Conversely there is a risk that some of those pools which were previously flushed clear of concentrated dry season contaminants by river flow will no longer be so, although as the percentage of run-off due to rainfall is so high this may not be a serious problem. The only real way to tackle this issue is a major health education programme to advise people of the dangers of drinking surface water during flood times. This needs to go hand in hand with both a ground water supply programme (this could perhaps be linked to the expansion of pumped irrigated water abstraction) and particularly the provision of sealed sanitation facilities. The reduction of flooding should allow easier provision of pit latrines but they will still need to be reasonably well sealed to prevent groundwater pollution.

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2.4.12 Human Health and Nutrition

The major human health considerations in the study area are waterborne diseases, nutrition and mental health. Information on epidemiology has been collected from existing sources for 1991 from the District Civil Surgeon, Jamalpur and is shown in Table 3.2.8. Some of this is incomplete and in any case only records those who have come into health centres and hospitals for treatment. It thus greatly under records the situation and distorts it according to ease of access to these facilities. It has been verified for instance that in Dewanganj the death figure from the return was 27 but the total death figure recorded was reported to be 54, a 50% level of under reporting. Overall it must be appreciated that in the mainland deaths from drowning due to flooding are negligible but were significant in Char lands during the 1988 floods where over 300 people were reportedly drowned in the large accreted Island Char west of Madarganj. However these are minor in the national context when compared to cyclone flooding. Nutritional data has been collected as part of the detailed socio-economic surveys and with reference to the data of the Bangladesh Institute of Nutrition and BBS data. These results are shown in Annex 6 as Tables 6.C.28 and 6.C.29.

A brief reconnaissance health and nutrition study was undertaken to verify the existing data listed above and investigate specific issues of note, particularly those of relevance to the proposed interventions. The aim was to draw up a work programme for future studies in the Detailed Design phase and these are shown in Appendix D.

Many of the main diseases are linked to the incidence of standing water and particularly when this remains all year round. The proposals to control flooding and provide drainage are likely to improve the situation but conversely the expansion of irrigated rice farming may well lead to an increase all year habitats to disease vectors, depending upon the detailed nature of the irrigation and drainage regime. The increase in waterborne diseases as a result of the introduction of irrigation is well documented (Ref: Tiffen/WHO 1991 and Birley/WHO 1991). The situation with regard to domestic water supply availability and chemical quality have already been discussed above and have implications for human health.

The main diseases are diarrhoea and dysentery which is known to include undiagnosed cholera. However the hospitals and clinics do not have the necessary laboratory facilities to separately identify this from general diarrhoeal diseases. These are responsible for a significant number of deaths. The provision of safe all year drinking water, sanitation and a health education programme are the major ways to combat these.

Malaria is also presently a problem in the area although it is presently confined to Plasmodium Vivax vector which is not severe. It is rarely fatal though it can be debilitating and when combined with other illness can be a significant factor in mortality. It has in the past been transmitted through a relatively fragile mosquito species Anopheles philippinenis. However FAP 16's studies indicate that since November 1991 malaria transmission is now occurring via the far more common species Anopheles aconitus which is more robust and this should be cause for concern. Malaria, being mosquito borne is dependent upon suitable habitats, specifically all year standing water. The existence of water hyacinth provides enhanced habitats for Anopheles mosquitos. Malaria is likely to increase under irrigation (ref WHO/Birley and WHO/Tiffen) and this could be made worse still by the use of agricultural pesticides which kill off the main mosquito predators which act as varying degrees of biological control. A main source would also appear to be urban ponds and tanks, although the recorded concentration of malaria cases in urban areas may be a consequence of better and more accessible health facilities where as in the remoter rural areas these go unrecorded. It is presently difficult to predict likely patterns of change as a result of the project, but it should be born in mind when locating drains and borrow pits. It requires the results of a major study such as that being carried out by FAP 16 to give a perspective on this and some conclusive results.

There is a concentration of leishmaniasis (also known as Kala-azar) at Madarganj. This is a serious disease spread by sand flies formerly thought to be in association with rodents. However it is now doubted and the existence of damp organic matter is now though to be an important factor and there appears to be a correlation with homesteads having stalled cattle and being located in areas where water has drainage trapped behind embankments. After a period of low incidence it has shown a sudden upsurge in Bangladesh, particularly along the Jamuna river. Again a special study is presently under way by FAP 16 looking at this. The Japanese Encephalitis vector is transmitted via culex mosquitos from pigs and water birds and leads to mental disturbance in humans. This has been a problem historically in the area but is now not so and is likely to be a decreasing still further as a result of the rarity of pigs due to religious factors and the decrease in numbers of water birds due to habitat change and human population pressure. Filariasis is also carried via culex mosquitos but is mainly confined to urban areas and is less likely to be a problem in the project area.

There is widespread incidence of skin problems, particularly scabies, ringworm and fungal diseases. These appear linked to bathing in standing water, the high level of humidity for much of the year and the high concentration of population. There are also widespread parasite problems. Ulcers appear to be a very common problem, particularly amongst men and are a cause of death and a significantly quoted reason for suicide when the pain from them becomes unbearable. This could perhaps be attributed to worry and strain. Surprisingly there is a low incidence of jaundice which indicates that hepatitis is not the problem that one would have expected. Anaemia is a problem, particularly amongst women. Respiratory illness is significant, especially pneumonia, and is a cause of deaths. Recorded cases seem concentrated in the larger urban settlements with a significant number

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of deaths at Dewanganj. There are many cases on the Char lands which go unrecorded, linked to the general levels of dampness.

The existing situation with regard to nutrition levels in the project area is characterised by concentrations of unbalanced diets amongst lower socio-economic groups and women, particularly lack of protein and minerals. There is also significant lack of calorie intake for 44% of the population despite the area being a major producer and exporter of rice. A major source of protein for these people is fish although this is apparently starting to fall in some areas as total catch weights start to decline in places, reportedly due to over fishing. This is likely to increase much further as a result of the recommended Option B5 and the likely level of this is discussed in Annex 2 and in Sections 3.10.2 and 3.10.5 of this report. Further study of this needs to be carried out once the results of FAP 16's work are known. There is presently Vitamin A deficiency leading to blindness, particularly amongst communities alongside the Jamuna, adults and women. A past programme of distribution of Vitamin A capsules was apparently quite successful for children up to 6 years of age. Various proposals for creating more balanced diets include different protein types (e.g.poultry and small stock) and vegetables and this has been carried out by BRAC. However the low socio-economic level of the affected population make these difficult to implement and remain sustainable. It requires specifically targeted, welfare orientated approaches to tackle this problem along with nutritional education programmes. The incidence of famine in the area is related to post severe flood situations rather than drought. It occurs where food storage is inadequate, standing crops are lost and wage paid employment temporarily ceases. A major aim of the project is to address this issue by flood control and/or flood proofing measures including the consideration of emergency food reserves at household or village level. The Terms of Reference for follow up nutritional studies in the Detailed Design Phase are given in Appendix D.

There are reportedly relatively high levels of mental illness (e.g. clinical illness such as cretinism, which is a function of the goitre problem, and also the results of social pressures which menifest themselves in for instance relatively high suicide rates) generally in Bangladesh when compared to other developing countries, however field verification has shown that this does not appear to be a serious problem in the study area. The overall social pressures created by high population densities are likely to be a far more serious problem in urban areas. Despite the precarious economic existence of a large proportion of the population, people appear to take this in their stride, often in a fatalistic manner, considering it as being beyond their control. The levels of wife abandonment and destitution are low by national standards and only 1.8% of households in the mainland study area are female headed. However 74% of these are without agricultural land compared to a figure of 41% for the whole project area. The status of women across the study area is summarised in Table 6.2.22 in Annex 6 and shows some marked differentiation according to geographical area. The risk and anxiety prevalent in flood prone areas contributes to uncertainty and there would be expected to be trauma problems after flood events such as in 1988 when significant numbers of people were drowned on the Char lands. Unlike many moslem societies the "safety net" of the extended family system has either broken down to some extent or never been very strong in Bangladesh. Relatively small nuclear households are generally found rather than the large extended family households typical of the Middle East and the Maghreb.

There has recently been alarm expressed at the very high incidence of goitre (caused by thyroid problems, linked to iodine deficiency in the water supply and ground) in Bangladesh. This is now being recognised as a major source of direct mental health deterioration and is thought by some to be of epidemic proportions. It leads to cretinism and can become in-bred, compounding in the next generation. It is particularly a problem amongst mothers as they are generally less well fed and eat last in the household, plus they are deprived of iodine by breast feeding children. The Jamalpur District has been identified as one of the areas effected by this, linked perhaps to the lack of dissolved salts in the domestic water supply. There has been a Lipiodol vaccination campaign in the more accessible areas carried out by UNICEF between 1981 and 1989. Whilst this offers no cure for suffers it stems the risk of the next generation being effected. However there remains particularly high concentrations in Islampur Thana (10% overall) and Sarishabari (5%) and higher still on the Char lands. In some villages (particularly the attached Char land on the west bank and that at the northern end of the study area) as many as 80% of specific village populations have visible goitres including very young children. The project is unlikely to change this situation but there may be justification in including an "add-on" component to tackle this issue. Concern has been expressed at the high level of this problem and its implications for cutting the available active population and increasing the overall proportion of dependant people in the population. The situation can be resolved by provision of potassium iodised salt. This is relatively cheap but there are difficulties in motivation and distribution. There also appears to be a perceptual problem due to a lack of awareness of the issue and its links to mental illness.

Suicide rates are not especially high, (5 suicides out of a total of 54 deaths in 1991) especially by comparison to other parts of Bangladesh. The main reasons cited are incurable diseases, particularly ulcers amongst men, and emotional and family problems for women.

2.4.13 Access, Transport and Infrastructure

Present access to and through the project area is by boat, rail and road. A survey of main river waterborne transport has been carried out during the wet season of 1992 and is summarised in Table 3.2.9. This indicates the routes, destinations, lengths and seasonality of journeys taken along with the nature and size/weights of loads and commodities carried, and at what rates and fares. The size of craft is also recorded including length, carrying capacity, power and building and operational costs.

There is major all year waterborne traffic along the western side of the area along the Jamuna river. Many boats are large and motorised and provide commercial services for the movement of goods and passengers. Surprisingly the range of travel of all but the larger boats is relatively limited at up to 30 km radius but they provide links to all the Island Chars. There are problems of navigation due to changing flow patterns and shoals (these have been mentioned in discussion of sedimentation above), particularly during the dry season, along with poor visibility due to fog and sudden violent storms in the period before the monsoon breaks. There is use of waterborne traffic for both goods and people within the project area along the main watercourses. This varies according to water levels at different seasons and there are problems of sedimentation and lack of draught at certain times of the year. Due to the recent closing off of the Chatal intake and the silting up of the Jhenai inlet, major internal navigation is seasonal and during 1991/2 ceased by early January at the latest, more often by late October. There are also a considerable number of paddled craft used for fishing. There are specific issues concerning the movement of finished pottery, which is too fragile to go by road or rail. In addition, a significant proportion of the finished product from the fertiliser factory is moved by boat, although there is an already mentioned serious problem with this due to sedimentation and river channel closing at the wharf.

Any flood control and drainage programme will have major negative impacts on the navigation network which are notoriously hard to predict. Most boat owners and operators (many of the smaller passenger craft appear to be hired) are dependent upon this as their major source of cash income and their livelihoods are likely to be seriously jeopardised if flood control and drainage improvements were carried out. However as the whole internal navigation system is in decline at the moment this will just reinforce a present trend. Consideration could be given to preserving the water navigation network by the provision of opening structures or locks.

The present railway network serves the two eastern lengths of the project area and links to the cross Jamuna ferry system. As indicated in the sedimentation Section 2.28 above, it is indirectly affected by navigation on the Jamuna river. It is the major inter-city and town network for passengers and is robust to all but the most extreme flooding as it lies on extensive and well constructed embankments with substantial crossing structures. It was subject to some damage during the 1988 extreme floods and would benefit from projection from similar future events.

The present road system within the project area is poor and ill maintained. This is a constraint to the movement of goods by lorry but less of a problem for passenger traffic which is able to use motorbikes, bicycles and rickshaws and smaller boats. There are serious problems in the stability and construction of embankments and the sizing and foundation conditions of the major structures. All major bridges were destroyed in the 1988 flood and have not, as yet been rebuilt although work is in hand on some of the sites and there is a temporary Bailey bridge at one location. The network for motor vehicles is constrained by the need for ferries of sufficient size and capacity, although private entrepreneurs have recently stepped in to provide these. There are also seasonal causeways spontaneously built and maintained by local people in return for the payment of tolls. The taking up of possibilities for internal water management using the network of road embankments as a basis would result in the establishment of an integrated and robust network of all weather roads which would considerably improve access to the area. Whilst there are likely to be institutional problems as to their maintenance, there is little doubt that this will be a major benefit of the project, particularly for the movement of lorry mounted goods.

2.4.14 Archaeology and Cultural Sites

Due to the fact that there is very little durable building material in the project area there are very few archaeological sites or even recent ruins. This is despite a long history of settlement of the area. A contributory factor may be that population pressure has destroyed what little there has been and as materials are highly valued, they are reused once a building falls into disuse and ruin. The climate is also rigorous and negates against the preservation of buildings. Enquiries have been made at various antiquities departments and museums to identify any significant sites in the study area such as temples and mosques. However study of the registers of historical buildings and the past work of UNESCO indicate that there are no such sites in the study area. The only major consideration is likely to be the existence of graveyards. By sensitive planning it will be possible to avoid disturbance and damage to any of these in the area and this is therefore not perceived to be a serious problem.

2.5 Externalities and Downstream Impacts

2.5.1 Introduction

The delineation of likely areas of external impact is defined by the present environmental situation and the nature of the likely intervention and how widely its influence will be felt. Thus the delineation of these areas requires some initial data collection and impact analysis to be carried out before this can be done. The initial uncertainty as to the nature of the likely interventions, particularly those in the external areas under study by FAP 3 and FAP 6, and the degree of impact of embanking, if any, has caused this work to be held back, despite the fact that it is likely to include the most serious negative impact.

The location of likely areas of external impact are shown in Figure 3.1.1. These include the adjacent Jamuna Char lands, which have been the subject of the special Char Study, the mainland area south of the study area, (Planning Unit 2 in the FAP 3 regional study, due to become FAP 3.2) and the Char lands and downstream area of the Old Brahmaputra. Identification and assessment of likely downstream impacts and hence the extent of the area to be looked at is difficult due to the present lack of hydrological information in an appropriate form to analyze the existing situation and give a prediction of likely future flood and drainage patterns under each option so that induced changes can be studied. The present methodology that is being developed rests upon using the MIKE 11 computer simulation model. According to FAP 25 and FAP 3 it is unlikely that the type of detailed output data which will allow analysis of downstream hydrological effects of proposed developments in the area for the Old Brahmaputra will be available. This will require a specially commissioned study and needs to be put in hand as a priority once development strategies are confirmed. The requirement for project impact analysis is for four dimensional mapped data on flooding extents, depths and changes over time under present and possible future alternative simulated conditions. At this stage there is coarse modelling being made for the main Brahmaputra/Jamuna river under different embanking scenarios. The initial modelling work that has been done of this area has allowed a comparison of with and without FAP 3.1 embankments to be made for a peak flood situation like 1988. The output of this is illustrated in Figure 3.2.12 and discussed in detail in Section 3.10.1 of this report dealing with impact analysis. The modelling work for the main river needs to be refined considerably to cover a complete range of flow conditions and be interfaced with a digital elevation model to give mapped outputs of flooding extent, depth, duration and timing so that the degree to which this is going to cause livelihood loss can be assessed. It is not possible or sensible at present to attempt the detailed type of analysis that is required at feasibility stage to predict the complex induced impacts that these hydrological changes in main rivers are likely to cause to both the natural and human environment and their interaction. Broad impacts and the number of people likely to be involved have been given.

2.5.2 Adjacent and Downstream Jamuna Char Lands

The present environmental situation in this area has been given in the FAP 3.1 Char Study report and data has been collected by the FAP 16 special study. The latest results from FAP 25 (Flood Hydrology Study Main Report, June 1992) have serious implications with regard to the likely concentration and backwater effects of flows down the Jamuna river as a result of construction of the Jamuna Bridge and FAP embankments. These issues are commented upon in the impact analysis Section 3 of this report. This has important and serious implications for the flood risk of the Char lands which lie outside the proposed embanked mainland area. This should be considered as a severe compounded negative impact of this and other projects. There is the possibility of mitigating for these losses by in-situ flood proofing and this has been considered and costed in broad terms in Section 4. The question of increased erosion and/or sedimentation risk needs to be considered but it would seem impossible to predict the nature and degree of this. There is also a serious social and political problem in that these negative impacts effect those people whose livelihoods are already the most precarious due to flooding and erosion. They are being asked to increase this risk still further to benefit those who presently have a much lower flood risk.

2.5.3 Adjacent and Downstream Old Brahmaputra Char Lands

The present situation along the Old Brahmaputra has not been studied, as it lies at the join of three regional or sub-regional studies and suitable hydrological analysis is lacking. Study of the 18th August 1987 image indicates that there are serious problems here in an unembanked situation and the effect of FAP 3.1 intervention has still to be assessed. It appears to be even more complex and contradictory than the Jamuna and warrants a special study in its own right. Embanking the right bank of the Old Brahmaputra will result in concentration of flow down the river, particularly if the inflow down the Jhenai off-take were to be restricted. This would pass more water downstream, particularly during flood times when it is already a problem. It is unlikely to help during dry season times when flows are presently inadequate for existing users and an increase would be useful. More importantly it may cause increased flood risks to land within the old flood plain (there are extensive Char lands between the braided channels) and also to land on the left bank if it were not subject to an embankment programme. Consultation with the North East Regional Study (FAP 6) has indicated that they have no plans for any major structural works in this area, both on the left bank of the main Brahmaputra and the Old Brahmaputra. What will be required from the hydraulic model is a set of hydrographs under present "typical" categorisation flow years and then synthesised versions for similar years under different option operational conditions. This needs to give the depth, duration and extents of flooding. This will require a specially commissioned study as a matter of priority.

2.5.4 Downstream Flow out of Bausi Bridge

Another concern is the likely nature of changes in flow patterns out of the study area southwards into the adjacent sub-region through Bausi Bridge due to different hydrological conditions. The modelling under FAP 3 needs to provide present hydrographs for typical flood years and synthesised versions of these under different project operational conditions. A control structure at Bausi Bridge will allow a managed flow to be passed downstream which, depending upon the operational criteria could prove beneficial in controlling damaging peak flows but may have differing and complex impacts, particularly on the natural environment.

2.5.5 Upstream Constraints

Consideration needs to be taken of future likely upstream interventions that would effect the project area. Discussions with FAP 6 indicate that they have no intention of proposing major infrastructural works on the left bank of the main Brahmaputra. There is already an embankment on the right bank of the main Brahmaputra/Jamuna downstream from the Teesta confluence which is under study by FAP 1. North of this there is an existing embankment to the next major confluence upstream. Thus the main potential issues lie outside the borders of Bangladesh and need to be considered at the international level and are regarded as outside the scope of this study.

3 IMPACT ASSESSMENT

3.1 Introduction

The environmental profile of the study area given in the previous section has highlighted those issues that appear to be important from a standpoint of resource use and management, particularly those likely to be impacted in any proposed land water development programme. As part of the process of considering environmental criteria in the drawing up and selection of Options for intervention, a matrix was constructed which allowed a comparison to be made between Options A to D and the without project Option. The results of this were given in the Interim Report of April 1992. The results of this analysis were used as one of the criteria to select a recommended option or strategy to be taken forward for more detailed study in the Final Feasibility Stage. During the feasibility stage the very limited resources allowed for the environmental component of the study were concentrated on carrying out more detailed fieldwork concerning the major identified negative impacts. This allowed quantification and valuation of these to take place.

3.2 Development Proposals and Options

The JPPS Interim Planing Report outlined the four development options that were considered for the area. These covered a wide range of intervention possibilities from non-structural flood proofing measures through varying degrees of controlled flooding to the complete exclusion of all river water by polderisation:

- Option A was for flood proofing provision for all of the mainland and east bank Attached Char land study area. This would have entailed an integrated strategy of raising the floor levels of individual houses and the provision of clustered communal flood refuges. This was based around similar projects already implemented by the NGO SCI/MCC to the south of the study area and along the lines of some of the findings of FAP 23. Some of the refuges could be for permanent settlement, particularly for homesteadless households and in addition use would be made of the proposed embankments for both permanent settlement and temporary refuge. The strategy is further developed in Section 4 of Annex 9. In addition there would be provision of a drainage provision programme to assist rainfall run-off in the congested centre part of the study area.

- Option B was for controlled flooding (i.e. allowing all normal flooding but preventing dangerous peak flooding) for the largest part of the study area possible. This would be achieved by constructing flood control embankments along the east bank of the Jamuna (using existing embankments where possible) and the west bank of the Old Brahmaputra. The proposed embankment alignments are shown in Figure 3.1.4 and the location of existing embankments in Figure 3.2.12. The embankments would have large openings in the places where there are presently river channels to and from the main rivers. Large gated water control structures would be built at these locations but designed to be run with the gates open to allow normal flooding. The gates would only be closed in dangerous peak flooding situations like 1987 and 1988. The parts of the study area, which due to engineering considerations could not be included in the controlled flooding area, would be flood proofed as for Option A. This would also include the multi-purpose use of the embankments as flood refuges and permanent places of secure residence, particularly for displaced, erosion victim and homesteadless households. In addition there would be drainage improvements to overcome present constrictions to the rainfall drainage network, particularly in the centre of the study area.

- Option C was for a similar programme of controlled flooding but on a smaller area (shown in Figure 3.1.5). This would thus have a much larger flood proofing component than Option B. The thinking behind this was to have a compromise between Options A and B, allowing the valuable agricultural land to be protected and the areas of more valuable floodland fisheries to be retained.

- Option D entailed the exclusion of all river flooding from the largest part of the study area as possible by building highly durable embankments in the same locations as Figure 3.1.4 but having no inlet water control structures, only drainage outlets. In addition there would be a flood proofing programme for the unprotected land on the left bank Attached and Set-back land, along with improved drainage for rain fed flooding the centre of the study area.

3.3 Comparative Assessment of Different Options

3.3.1 General

The Interim Report of April 1992 contained a preliminary Environmental Impact Analysis which included a comparative subjective matrix between all four options and also a without project situation. The aim was to provide sufficient information for a single option or mixed strategy to be selected for feasibility study. The matrix is shown in Figure 3.3.1.

The matrix lists all the likely environmental impact issues discussed in the Interim Planning Report, including those from both the natural and human environment and also a separate indication of four major external impacts. Care has been taken to avoid repeating or double counting particular issues by being very specific as to the nature of the impact being considered. For example, groundwater availability for domestic water supply is listed under the natural environment as is domestic water quality under freshwater ecology, whilst general drinking water availability is under human impacts along with overall drinking water quality. This reflects the differing sources for domestic water supply and also consideration of how this changes in peak flood conditions.

The matrix is in effect a ranking of impacts of 5 possibilities, assuming no mitigation programmes, based upon a steady state baseline position as of now. Scores are up to +5 for positive impacts and -5 for negative ones, with -6 being a severe negative impact which is likely to be irreversible. The interpretation of this for without project situation and for each Option is given below. This includes consideration of the internal impacts of the intervention, external impacts were insufficiently well understood at the time this work was done. The balance has subsequently been rectified and external impact comments for the recommended Options apply.

3.3.2 The Without Project Option

The present situation within the study area has been described in the project environmental profile in Section 2 of this report.

Specific points to note are the past rising trend of fish landings, both for "professional" capture and "common good" fisheries, however it is now considered that this is likely to have passed its peak and is in decline for all fishing habitats/systems with the exception of ponds and tanks. About 5% of all households are full time fishing households and these are relatively evenly spread across the whole study area. Approximately 45% of households fish occasionally and generally consume the catch themselves. They are concentrated more amongst the landless and also within the western part of the study area. It is thought that fish caught and directly consumed in this way forms up to 90% of the animal protein intake for the lower level socio-economic groups in the study area and particularly the landless. A major reason for the increase in fish caught in the last six years is thought to be due to the larger number of fish available rather than more people trying to catch them (this is demonstrated by the fact that the size of fish caught has not reduced significantly). It is thought that this situation, which is contrary to that in the wider regional context, can be credibly explained by the fact that the numerous breaches in the existing flood embankments created as a result of the 1987 and 1988 floods, and not subsequently repaired have allowed increased fish-fry recruitment rates. More details are given in Annex 2 and summarised in Table 3.3.1 with discussion in Section 3.10.2.

The major negative issues which are likely to persist and probably increase in the study area are the flooding of land and drainage problems from both rainfall and river flooding which cause soil waterlogging. This has some negative effects on the availability of wage paid labour, but evidence from FAP 12 indicates that the levels of increased agricultural labour demand for landless people are very limited as there is surplus labour available amongst households of landowning and occupying families. This is also reinforced by the observation that wage levels in such situations did not rise. Main river bank erosion causing severe land loss is a very serious problem on some stretches of the Jamuna river bank. The situation regarding the decline in fauna and its bio-diversity is bleak regardless of any intervention, due to the high human population levels and the intensity of land and resource use. Similarly the availability of fuelwood has already seriously declined and there is little that any option without a specific targeted programme will do to change this situation for either better or worse. There could be some scope for community forestry on existing embankments but this needs great caution and there are technical problems of finding suitable species that will not cause rooting damage to any embankment. The present road network is extremely poor, having suffered badly during the 1987 and 1988 floods, compounded by serious problems due to a lack of maintenance. Any intervention is likely to improve this situation to some degree.

In summary the present situation is under overall environmental strain but agricultural intensity has recently increased and is likely to continue to do so in the near future as a result of the further expansion of irrigated agriculture. There must be absolute limits to this expansion and intensification and flood risks are a constraint to this. However this does also mean that as the level of agricultural intensity is already so high, the remaining land area available for intensification is reduced and the possible benefits of water and drainage control are more limited than for an area less intensively farmed. The present general levels of economic livelihood risk, particularly to the landless, are high and will continue to be so due to a variety of factors including their precarious asset base and vulnerability to calamity, particularly erosion and flooding. It should also be pointed out that there has in the past been incidence of famine in the study area due to drought, although this is very rare indeed as indicated by the famine risk mapping carried out in 1974 by Currey.

3.3.3 Impacts of Option A

i) Major Positive Impacts

The prime advantages of Option A are that if well managed, it should prevent the loss of lives from drowning, malnutrition and waterborne diseases through provision of evacuation and refuge facilities along with clean drinking water and food during and after times of flood. It should also allow much quicker post flood rehabilitation as housing would not be so damaged and people would be able to mobilise themselves more quickly. In addition it is proposed to provide appropriate emergency supplies (seeds, secure drinking water supplies etc) which should help to reduce subsequent livelihood losses and risks. It should also prevent livestock losses and allow people to save many movable assets. Depending upon the nature and level of provision of refuges and evacuation routes, along with the degree of in-situ house raising, it could save many dwellings and fixed household assets. In areas where flood proofing is linked to use of existing embankments this could have some positive effects on the road communications system in the area. Spontaneous settlement on the tops of existing embankments is already common in the mainland study area, particularly on the western side adjacent to areas of major Jamuna bank erosion which has displaced significant numbers of people. Option A has a major advantage over all other options of having minimal detrimental effects on fish stocks and as a result does not reduce protein sources available to people, particularly the landless.

The proposed implementation policy is a "bottom-up" participatory approach which has already been well tried by the NGO's SCI and MCC close to the project area and found to be successful. This is written up in the Char Study Annex 9 Volume 1. It has proved to be a self sustaining strategy in both social and economic terms as well as creating a spirit of motivated self reliance. As a result cost recovery rates were found to be very high indeed and relied upon significant social pressure. It has also been used as a basis for an integrated rural development programme with major components for agricultural extension, including crop diversification (particularly into vegetables resulting in very positive effects on nutrition) and small scale irrigation using treadle pumps. River channel stabilisation programmes using Catkin grass (Sachoroma Spontaneous) and community woodlot programmes have also been incorporated into this approach. In terms of resource requirements for implementation Option A has a significant advantage of being highly suitable for a totally incremental development approach. It is also likely to be less socially divisive than any of the other options, as everybody gains to some degree, assuming that the total area of Char lands and unprotectable mainland are to be covered. There should also be fewer problems with land acquisition, as this can be sorted out amongst participants at the local level who have direct perceived benefits.

ii) Major Negative Impacts

Unlike all the other options, flood proofing has no major negative impacts. The major disadvantage is that it fails to secure flood losses to standing crops and the "knock on" impacts of these to the cropping calender and hence for wage paid labour and particularly agricultural production. The major constraint to its implementation is likely to be the availability and length of time to train suitable numbers of appropriate staff and the management of these. Whilst it has major social benefits these are difficult to quantify and value, especially in financial terms. These benefits are also likely to be of a long term nature.

iii) Summary

Option A tackles the issues of immediate loss of human life as well as direct livelihood and movable asset losses (including

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livestock) from flooding. It should also allow quicker post flood rehabilitation and reduce some medium term risks to economic livelihoods. Depending upon the nature of the flood proofing strategy, it could also save many dwellings. It does not have the serious disadvantages of major lost fish production and resulting economic livelihood and nutritional loss for the landless when compared to all the other options. It has already been successfully carried out close to the project area and is a self-sustaining approach which is very attractive in social and cost recovery terms. A major problem is that the benefits derived from it are far more difficult to quantify than other options and particularly hard, if not impossible to value in economic terms. Its major disadvantage compared to other options is that it fails to protect the existing cultivated land.

3.3.4 Impacts of Option B

i) Major Positive Impacts

Option B provides security from floods for the largest part of the project area that is considered technically feasible to protect. It protects lives, livestock, homes, farmland and fixed assets along with public and private infrastructure and communications for those areas within the embankment. Those areas outside the embankment would be subject to flood proofing and would experience all the positive aspects of Option A. Overall this will lead to increased benefits, but these will particularly accrue to those households who hold land. Land values are likely to rise, although this is likely to have both positive and negative effects. Agriculture is likely to continue to intensify and output increase, creating more opportunities for agricultural processing industries. Option B is also likely to increase the availability of wage-paid employment opportunities, both for the construction works their maintenance and as a result of the further intensification of agriculture. However, indications from other FCD projects and programmes (Ref:FAP 12) indicate that there is so much over supply in the labour market that employment opportunities tend to be taken up by labour from within land-occupying households rather than the landless. Construction work opportunities are likely to be relatively short term (and perhaps seasonal), and of questionable longer term sustainable benefit to the landless. In return, the maintenance of the infrastructure will provide long term work opportunities to the landless strata of the population These issues centre around equity, linked to land holding, and can only really be addressed by major land reform changes. They are constraints which overshadow all development policy options for Bangladesh. There are also possibilities for the development of permanent, secure flood proofed housing of a linear nature along existing and proposed embankments. However this has to be weighed against the increased land expropriation this will require.

The consideration of water management units or compartmentalisation should allow a far more flexible operation of the areas where drainage improvements are proposed. It could be managed in way that is to some degree autonomous for each water management unit and allow increased flexibility that could be more responsive to local conditions and wishes of farmers and fishermen. The proposed cross drainage rehabilitation to existing embankment boundaries will also greatly improve the road network, which will come under still increasing pressure as waterborne transport is disrupted and forced into decline. Increasing intensification of agricultural production demands more transportation of goods and services.

ii) Major Negative Impacts.

The major negative impact of Option B is that on fish availability, particularly for landless people, and this is likely to cause a significant decline in protein intake to those already most disadvantaged. It means that the equity gap between those who have land and the landless will be accelerated still further. Mitigation of these present "free good" fishery resources is difficult. It will necessitate a major change in fisheries management systems. An aquaculture training and extension programme is required and this could be difficult to make sustainable.

Option B, by confining the Jamuna river, will increase the depth and duration of floods in the set-back, attached and island chars within the Jamuna flood way. This will generally increase the cost of flood proofing required within this area rather than create the original need for such measures. Notwithstanding this, the construction of embankments may be expected to precipitate social conflicts within the immediate locality of the embankments which would require positive action being taken to address the concerns of those directly affected. The parallel development of a flood proofing programme in the unprotected areas is thus considered a necessary mitigation measure for Option B. Although not included within the FAP 3.1 scope of work, it may be expected that works of a similar nature but possibly lesser magnitude will be required in the lands left unprotected by the Old Brahmaputra right embankment.

Option B would have negative effects on water navigation, but these could be offset against improvements in the road transport network. However the beneficiaries are not necessarily likely to be those people whose livelihoods are jeopardised. There is also likely to be some risk of increased incidence of diarrhoeal diseases and malaria, as there will be more year-round standing water in irrigated rice fields and a decrease in the flood flushing of vector habitats. Thus the present breaking of their breeding cycle by river flood waters will be reduced. There will be some

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negative effects on flora and fauna (particularly aquatic bio-diversity) but these are relatively minor when compared to the "without project" situation where decline is expected irrespective of project interventions.

Without the adoption of an adequate water management system, Option B is likely to promote more social conflict in the determination of water and drainage management criteria. It will also be difficult to build and operate in an incremental manner.

iii) Summary

Overall Option B is likely to increase the short term general level of economic livelihood to many households, including some of those without agricultural land. However the equity gap is likely to increase quicker than in a without project situation, although this could vary greatly across the project area and between different occupational and socio-economic sub-groups. Agricultural production is likely to continue increasing, possibly at a steeper rate initially, and will most probably give the greatest benefits to the present landowners in the protected part of the study area. Major negative impacts are expected on fisheries and on flood security in the unprotected lands unless mitigation measures are taken.

3.3.5 Impacts of Option C

i) Major Positive Impacts

Option C provides full security from flooding for the part of the project area in which the intensity of cultivation is already highest and is the major economic activity. This is also the area in which there are the highest population densities and the highest concentrations of more valuable fixed assets. It will also fully protect the railway line and half of the road network. At the same time it gives the benefits of flood proofing to the remainder of the project area whilst preserving flood plain fish stocks in the part where they are likely to be the most important. In addition it will preserve waterborne transport in the western part of the project area. However the likely beneficiaries of this option will not be those whose livelihoods will be jeopardised. It will also allow an incremental approach to construction.

ii) Major Negative Impacts

What Option C fails to do is to secure from flooding the land in the western half of the study area which is, in general, most badly effected by it. In political terms it could be difficult to justify this proposal, both to landowners and wage paid agricultural workers in the western half of the project area. As such it could be the most socially divisive of all options, depending upon people's perceptions. The major reason for this is that the embanked area is smaller and less diverse then the non embanked area. There will still be significant losses to fisheries in the embanked area as the majority of the beel fishing is located there. The area of beels is likely to greatly decrease as river flooding is controlled and rainfall run-off drained, leading to the earlier field bunding and expansion of agriculture into the receding beel areas. This is likely to cause a decline in the availability of protein, particularly to households at the lower end of the socio-economic scale. Waterborne transport will be seriously affected in the embanked area and the benefits of cross drainage improvement to the road network will not be as effective or efficient, as more trans-shipping will be required with such a dual system. Option C will have similar, though marginally less severe, impact on flood security in the char lands as compared to Option B.

iii) Summary

In short, Option C is a compromise which embodies both the best and worst features of other options. At the minimum it should secure loss of life and movable assets from flooding over the whole area. It protects the most valuable agricultural land but does not fully exploit the advantages to agricultural production of Option B. However it does not have such severe disadvantages of lost protein intake, particularly to the area where it is probably the most important. It does have a logic but presenting this to the public is likely to be very difficult indeed, as could justifying it politically. It would require a similar approach to char land flood proofing as in Option B.

3.3.6 Impacts of Option D

i) Major Positive Impacts

Option D allows for the complete protection from river flooding to the largest area of land that can be feasibly embanked. It thus has all the advantages of Option B.

ii) Major Negative Impacts

Option D has greatly increased negative impacts over all the other options, created by the exclusion of virtually all river flood water. This exclusion, as opposed to a controlled flooding policy, will completely stop the recruitment of transversely spawning fish species and cause a severe curtailment in waterborne transport in the protected area. It will not allow for flexible operation that could take into consideration different conditions and people's wishes across the project area. It has even more serious negative impact on fisheries, nutrition of landless people and equity problems than Option B.

iii) Summary

In summary it can be said that due to the exclusion of virtually all river flooding, Option D offers the greatest benefits to agricultural production and the most severe negative impacts to fishing and hence nutrition of the occasional fishing households. As a result it widens the equity gap still further. In operational terms Option D is made redundant by Option B which could, if wished, be operated in the same way. Option D can not be built in an incremental manner, it is an "all or nothing" strategy.

3.3.7 Downstream Impacts

At the time that this comparative assessment was carried out there were no results of FAP 25's hydraulic modelling available. As soon as the preliminary version of these were released it became apparent that, contrary to previous information that have been given, the most serious negative impact of any embankment construction work appeared to be the increased flood risk to unprotected land. This has subsequently been followed up and the Char Study was aimed at tackling this issue.

3.4 The Recommended Option

As a result of the POE reactions to the JPPS Interim Planning Report, the development of a possible multiple development strategy, rather than a discrete option, was raised. It was decided to proceed with a more detailed examination of both Options A and B during the Final Feasibility Study Period. During the Extension period to this a recommended Option was put forward based upon Option B, controlled flooding and drainage improvement for the maximum area of land which can be protected together with a fisheries programme, with Option A (an integrated flood proofing programme) adopted for the land which can not be protected, including the adjacent Char lands.

As a result of the comments to the draft version of this report it has been decided that the unprotectable land should be treated as a separate but parallel project in its own right, irrespective of the development proposals for the mainland. The economic analysis and project proposals have now been amended to follow this policy decision but with only the incremental flood risk increase being included in the mainland economic analysis assuming a flood proofing programme is being implemented.

The specific nature of the flood proofing programme is, by necessity, open at the moment, pending detailed consultations with the beneficiaries. However it is envisaged that it will cover a range of possibilities and scales from individual house and homestead raising through to the provision of communal refuges, the size, spacing and locations to be decided with very close consultation with local people. In addition the multipurpose use of embankments will be a major element, both in terms of a place of temporary flood refuge but also as permeant flood proofed homestead sites, particularly for erosion displacees, homestead-less and landless households.

3.5 Impact Assessment Matrix for the Recommended Options

A second matrix is shown in Figure 3.3.2, it is similar to Figure 3.3.1 but omitting Options C and D and including a column indicating local (i.e. confined to those people resident on the mainland, the views of the Char land dwellers are indicated in the Char land report), peoples perceptions and priorities in addition to the existing column indicating those issues considered to be important from a purely detached "expert" technical viewpoint. None of these indicate Government or FPCO priorities or policy guidelines.

It should be emphasised that local peoples priorities are very strongly influenced by their perceptions of the short term benefits of FCD construction projects of which they already have experience and are well informed of. These include the opportunities for wage paid employment amongst lower strata people, along with security from flooding of agricultural land for land owners and also wage paid labourers. Few people, even those who stand to lose in the medium and longer term, (fishermen and boat operators for instance), appear to have any idea of, or place importance upon the possible negative impacts of FCD programmes and how these are likely to effect them. Whilst this is understandable in that many people are forced to live on a hand to mouth basis and only the short term matters, this must be treated with caution. There is a basic lack of understanding and concern of these longer term issues (nutritional effects of the decline in fish intake for instance) coupled with the ingrained response that any funding that is coming into the area must be good for everybody. This points to the need for a concerted community awareness and information programme for the area.

As before the matrix is in effect a ranking of impacts, assuming no mitigation programmes, based upon a steady state baseline position as of now, between the predicted without project situation, Option A and Option B. Scores are up to +5 for positive impacts and -5 for negative ones, -5 being a severe negative impact which is likely to be irreversible. This has allowed the major issues to be studied in more detail, quantified and valued. These centre around the increased flood risk to unprotected land and the losses to fisheries and the degree to which they can be mitigated for.

3.6 Public Reaction to the Recommended Strategy

Under the Option B scenario for the mainland only, there are likely to be serious objections from those outside it from two related perspectives:

- why is the mainland being flood protected when more serious flooding problems lie in the land which will remain unprotected?

- if the mainland is protected then there will be increased flood risks to the unprotected areas which already have a higher flood risk.

The proposal for Option B thus appears to be objected by many Char land dwellers and merely confirms their present feeling that central government not only does not take any notice of their position but is also prepared to sacrifice their livelihoods in favour of agricultural production on the mainland. Opinions have been expressed that Char land people will be prepared to deliberately breach embankments if they perceive that they are making flooding for them even worse than before. In the current absence of a national strategy as to how to bring security and social and economic development to those living within the charlands (and indeed the long term policy of whether or not and to what extent should public investment be made in such vulnerable areas), there are obvious social and humanitarian reasons for addressing their short and possible medium term needs. The success of the mainland project in part depends upon the cooperation of the char and particularly the setback dwellers. For these reasons it is strongly recommended that a programme of flood proofing in these vulnerable areas, very preferably undertaken in conjunction with income generating support activities, is embanked upon in parallel to the mainland project. Extreme care will be needed to reassure the Char land dwellers that their interests are being taken note of and they will at least be no worse off as a result of the mainland project and that they themselves will become targeted beneficiaries of the parallel programmes.

3.7 Spatial and Social Differentiation of Impacts

The next stage in the impact assessment procedure is to look at the detailed impacts for the selected Option or strategy, emphasising their spatial and social variability across the mainland and Char Study areas. This would divide the area into six or even eight major areas based upon the modified agro-ecological zones ("land systems" in effect) of high, medium and low land for the protected land plus the Island Char lands, Attached Char lands and unprotected main land (Set-Back land) between the existing and proposed embankments. This would be a priority if a credible EIA that will stand up to international scrutiny is required and the resources need to be made available in the Detailed Design phase to achieve this.

The other issue that requires considerable further work is the identification of the time scale of likely impacts related to the planning programme of the implementation strategy. It is too early in the planning stage and surrounded in uncertainty that it is considered unhelpful to attempt this at the present. It will need to await the Detailed Design stage.

3.8 Impact Quantification

Quantification of the major impacts has been carried out where possible, concentrating on the most important issues and particularly those that are negative and will require significant targeted mitigation measures. This has been done on an issue by issue basis, the FAP 3.1 Char Study having collected the relevant data for unprotected lands and Annex 2 of this report being the fisheries impact assessment and mitigation requirements. To be refined further, this work will require reconciliation with the BBS 1991 census data when this is released and very specific data collection in the following Detailed Design phase.

3.9 Impact Valuation

Valuation of impacts is fraught with problems, it is difficult to quantify many of the losses let alone place a value against them. The use of simplistic market cash valuation often omits to consider the real cost of impacts in needing to provide sustainable replacement livelihoods. The key issue is alternative replacement resource availability and use so that no body is worse off than they were before the project. For those items which can not be quantified then subjective and/or comparative assessment is required.

For the unprotected lands (this includes, unprotected main land, known as Set-Back land, as well as Attached and Island Char land - see Figure 3.2.19 for the locations of these), the costs of impacts are those of attempting to restore the people to, at worst, the level of flood risk they were experiencing in a pre-project situation. This would involve a large scale flood proofing programme. However, assuming a flood proofing programme would already be under implementation in the unprotectable land as part of the parallel programme in the unprotectable land then the costs of this apportionable to the FAP 3.1 mainland intervention programme would be the incremental cost of increasing the height of flood proofing by the mean rise in peak flood levels. Data to estimate the quantities and costs of such a strategy have been collected as part of the FAP 3.1 and FAP 16 Char land studies and are given in Annex 9. In addition data from FAP 25 has been used for assessing the increased flood risk. However more detailed figures are unlikely to be known until further studies have been carried out by these other FAP programmes during the Detailed Design stage of the project.

The fisheries assessment has indicated measures required in order to maintain the present level of fisheries production. However this does not address totally the nutritional loss of directly caught and consumed fish by occasional fishing households. The proposed fisheries mitigation programme, aimed primarily at providing replacement livelihoods for existing professional fisherman but with a targeted programme for presently occasional and particularly landless fishermen, includes the following components:

- management of the main river fisheries and remaining floodlands in the left bank Set-Back land

- stocking and management of the internal rivers

- beel and adjacent floodland fisheries stocking and management

- renovation, stocking and management of ponds and beels

The recently carried out nutritional reconnaissance survey needs to be expanded in the next phase of the study (the TOR for this are given in Appendix D) to include some primary data collection and to look at targeted replacement protein production possibilities with cost estimates for doing this.

3.10 Principal Negative Impacts of the Recommended Options

The principle negative impacts of Option A are nil and even the minor ones are negligible when compared to the without project situation. However its main draw-back is that it fails to secure agricultural land from flooding and as such does not address what many people on the mainland consider to be the principle issue with regard to flooding in the study area. In summary it is felt to have insufficient positive impacts to justify it, particularly in the eyes of local people.

The principle negative impacts of Option B are shown in the matrix (Figure 3.3.2). All issues with a rank of -3 and greater are discussed below in order of decreasing severity. Broad comments are also made as to mitigation possibilities. In addition Annex 6 contains the Social Impact Assessment. This should also be considered when carrying out an overall review of the project, although many of the issues are included in the EIA matrix under the more general heading of risk to economic livelihoods.

3.10.1 Increased Flood Risk to Unprotected Land

The latest published results of the hydrological modelling supporting study FAP 25, shown here in Figures 3.3.3 and 3.3.4 (taken from their Main Report of June 1992), indicate that under a peak flood condition similar to 1988, with the present embankments and FAP 3.1 embankment in place, the flood levels in the confined area between the existing and proposed embankments are likely to rise. The figure at Bahadurabad at the northern end of the project area is only 0.07 m, however the figure at Sirajganj is estimated to be 0.54 m. Dividing this proportionally to the length of the river gives a figure of 0.49 m at the southern end of the project area. A significant additional influence is likely to be the proposed Jamuna Multipurpose Bridge, the approach roads for which are already under construction. Discussion with members of the impact assessment team indicate that as a result of hydrological modelling work (using the same model as FAP 25) they expect, in similar peak flood conditions, a rise of 0.5 m at the bridge stretching back upstream for some 50 km (see Figure 3.1.1). This would mean an additional rise of 0.25 m at the southern end of the study area totalling 0.74 m. The figure adjacent to Madarganj where the Bridge impact is said to be nil would be 0.21 m. In addition there is reportedly (from FAP 18) a datum difference of 0.3 m from the left bank to the east bank. At present this has been discounted from consideration, but care will need to be exercise with this, especially when dealing with data sources with differing datums at the flood proofing detailed design stage. The increased peak flood risk levels are given in mapped form in Figure 3.2.12.

Considerable further modelling work is required to give the changed situation for other flow conditions. Of particular concern is the need to identify times in the past when specific Char land areas did not flood but will do so in the embanked situation. Ideally the model needs to be interfaced with the awaited DEM data to give mapped extents, depths, durations and timings of flooding. Only when this is done can accurate assessment of both homestead flooding and agricultural land inundation patterns be made. For the moment, the best analysis that can be done is to use an average figure for increased rise in peak flood conditions of +0.3m. This compares with a general figure of +3.0m being adopted for the costing of provision of house base raising and communal flood refuges in Section 4 of Annex 9. The present conclusion is that with the proviso of assuming a flood proofing programme is going to be adopted for the unprotectable area, irrespective of the mainland intervention, then the costs of the flood proofing that are attributable to the FAP 3.1 are 10% of the total programme cost then split between the left and right banks, 50% to FAP 3.1 and 50% to FAP1/2. Using this type of analysis the mean incremental effects of the Jamuna Bridge backwater become fairly insignificant at 0.06m or 2% of the flood proofing costs.

However it must be remembered that the changed flooding patterns of agricultural land in the unprotected area are likely to have more significant effects on household economic livelihoods than homestead flooding as it is impossible to directly mitigate for this, unlike flood proofing of homesteads. Diversification of economic activity to reduce flood risk through targeted income generation programmes would seem to offer the most appropriate way of tackling this problem and this has also been proposed in the Annex 9 (FAP 3.1 Char Study), Section 4.

From the FAP 3.1 and FAP 16 Char studies it is presently estimated that 602 000 people live in what will become unprotected land with an increased flood risk if only the mainland intervention were to be implemented. This is compared to 631 000 who will be within the mainland area protected by controlled flooding. The breakdown of these population numbers by location is given in Table 3.2.6.

In summary this means that without a flood proofing programme in the unprotectable land, those people already living with the greatest flood risk (although many actually state that erosion is an even bigger problem) are likely to have this increased marginally further in order to

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protect agricultural land on the mainland from which it is estimated increased agricultural production can be realised to economically justify the investment.

This underscores the difficulties associated with an investment justification process which is largely focussed on redily quantifiable economic grounds as compared to those projects whose benefits are far less easily measured in social and humanitarian terms. In humanitarian terms, priority should be given to those at greatest risk and international funding would necessarily have to take account of this. Of particular concern must be the "set-back" part of the mainland (i.e. on the "wet" side of the main Jamuna embankment) which would not expect to flood in a present normal year and where there are high population densities including many erosion displacees and other homestead-less and landless households. This highlights the necessity of carrying out the parallel flood proofing programme in the unprotectable land. The following analysis and costing of dis-benefits using mitigation costs assumes that this is going to happen.

Logically the costs of flood proofing the Char lands to mitigate for the increased flooding effect should be apportioned to those projects which caused the impacts. In the case of FAP 3.1 the cost of its apportioned part of the mitigation programme for unprotected land should be offset against the agricultural benefits attributable to controlled flooding. The total cost of the flood proofing programme is estimated to be Tk 1396 million ($US34.9m) compared to a mainland intervention cost of Tk1431million ($US35.8m). The apportionment of the incremental flood proofing costs attributable to FAP 3.1 has been calculated as Tk31.2m ($US0.78m) when taking into account the fixed costs of the programme.

It must be further emphasised that this assumes the flood proofing programme will be implemented irrespective of the mainland intervention. Some would argue that this is the type of targeted programme that the FAP should be doing as a priority. The social benefits of this are likely to be high but difficult to quantify let alone calculate in financial terms.

The issue of increased flood risk to the left bank of the Old Brahmaputra would appear to be a serious one, judging by the flood peak Landsat image shown in Figure 3.2.4. There is at present no output data from hydrological modelling to assess this nor a resource and population study of the area to quantify the impacts. This needs to be commissioned as a matter of urgency and will probably need to extend for some way downstream of Jamalpur town.

3.10.2 Losses to Fisheries

The present fisheries system in the mainland study area and the methodology for calculating losses under each option are given in Annex 2 of this report. They are shown in summary form in Table 3.3.1. For Option A the immediate post project floodplain fisheries losses without mitigation are in the order of 8% marginal and would seem acceptable. For Option B the equivalent figure is near 75% and would be very significant. However one of the difficult issues is prediction of the likely without project situation as the fisheries trends in the mainland study area over the last 6 years are very different from the national figures, particularly when these are dis-aggregated by fishing habitats and catch systems. The conclusion has been to use the overall national trend figure of -1.5% per annum for all fishing systems with the exception of pond production which is predicted to rise from its present low level by 4% per annum. These figures were initially predicted for 6 years after the construction period of the project but have now been refined and also considered the possibilities for mitigation. Mitigation of the fish resources of the area requires to address both the needs of professional fishing households and also the likely nutritional implications, particularly to occasional fishing households who catch "common good" fish for direct consumption.

The mitigation centres around a fisheries management and stocking programme for the area bearing in mind the different hydraulic regime that is likely to be in place as a result of controlled flooding. It is likely to be far more successful in mitigating the effects for professional fishermen, although specialist targeted programmes of riverine production aimed at occasional and landless groups would broaden this. Overall it is thought that if well managed the area could produce more commercial fish for sale than it does at present and in a without project situation. The capital costs of this programme will be in the order of Tk 28 million and require a major institutional commitment to the running costs, mainly in terms of the provision of skilled technical staff.

3.10.3 Permanent Disruption to Waterborne Navigation

There is likely to be a significant curtailment of waterborne navigation on the internal rivers in the study area. Whilst this is likely to cause serious livelihood loss to boatmen and associated activities (boat building, labour for unloading etc) it must be pointed out that this is already in significant decline due to the recent low flows in the Jhenai and Chatal systems during the dry season. This has been particularly acute in the last two years, probably linked to the construction of the embankment at the mouth of the Chatal which has stopped all flow and also the silting of the intake of the Old Brahmaputra and the Jhenai which has caused very low dry season flows and reduced the Jhenai to unconnected stretches of standing water. There is presently trade in goods during the wet season, certainly up until December to Bausi Bridge. In terms of mitigation, a replacement network of road links is required with transfer facilities to the main river navigation which should remain unaffected. This may entail extending the road embankments on the "wet" side of the main embankment across the "set-back" land. Provision of a replacement transport network could be achieved as part of the upgrading of the existing water management system that uses the existing road embankments. It is important that these improvements take into consideration the need to make the roads wide enough for commercial lorry traffic and also sugar cane tractors and trailers to pass.

Consideration for providing a navigation lock has been made, including designs and costings, however a policy decision has to be made as to if this is thought to be worthwhile, bearing in mind the fact that navigation is already in such decline. There are special issues linked to the carrying of the output from the fertilizer factory and the transport of finished pottery which commented upon in Section 2.4.13 of Annex 3. These will become increasing problems irrespective of any project intervention.

3.10.4 Decline in Flora and Fauna

Although the matrix ranking figures for flora and fauna decline in the area are high this is a result of a severe decline in habitat irrespective of a project intervention. The wildlife situation is already very poor and changed habitats, particularly the draining of beels, will make this still worse although the relative position when compared to a without project situation is not that great. The flora position is a little different in that there is still some reasonable diversity of habitat linked to the availability of water and their appears to be quite significant use of plants for medicinal uses. These have been inventoried to assess their usefulness and importance and how the supply of these is likely to be effected and if sufficient alternative sources will exist after project construction. The mapped output of the hydraulic modelling to determine the effect on habitats is required before this can be carried out. The estimated situation with flora is that there are likely to be greater losses than fauna as a result of project intervention, but the without project situation is not so bad, hence the end situation will not be so severe.

3.10.5 Nutritional Consequences

The nutritional consequences of the implementation of Option B have been commented upon in Section 2.4.12 of Annex 3 and also the Fisheries Annex 2. In addition there is the issue of how pulse production and avail- ability in the area is likely to change as irrigated rice cultivation is extended. It appears that these two factors could be highly significant and the reconnaissance nutritional study has identified the need for a follow up detailed study linked to the methodology being carried out by the FAP 16 Special Study. The nature of the issue is the degree to which various different groups of households depend upon fish intake for both animal and total protein intake,the nature of its source (directly caught and consumed,bought in markets and at what cost) and how this is likely to change as a result of implementation of Option B. Whilst the fisheries mitigation programme may provide some of these sources, other alternatives need to be identified that will provide economic and affordable replacement protein at the household level.The resources need to be made available during the Detail Design phase of the study to follow this up.This will allow an assessment of the

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degree of dependency upon common good fisheries resources and allow mitigation programmes of alternative protein provision to be investigated.

3.10.6 Possible Increase in Specific Waterborne Diseases

As with the nutritional issues there is insufficient knowledge as to the implications of project implementation on the likelihood of waterborne disease. Special studies are under way at FAP 16 to look at these, but until they report some conclusions there is little that can be sensibly said backed by statistical data. However summary data from the Jamalpur District Surgeon for 1991 indicate that there are already serious problems with waterborne diseases, particularly diarrhoeal ones and also malaria and an outbreak of Kala-azar at Maderganj. The confirmed malaria cases seem to be concentrated in the larger towns (414 cases in Dewanganj) and may be linked to mosquito habitats in all year standing water in urban ponds and tanks. There may however also be an urban bias in the reporting of cases. There has been significant evidence (Ref: WHO/Tiffen and WHO/Birley) that the expansion of irrigated agriculture which results in all year standing water in areas where previously it seasonally dried out can lead to the promotion of mosquito habitats, particularly in drains. In addition the curtailment of surface flooding can mean that there is an increase in stagnant water which was previously flowing and had creating a flushing effect. This increase in stagnant water could significantly promote the risk of waterborne diseases, particularly diarrhoea (which it appears includes Cholera but there are insufficient laboratory facilities to isolate it from diarrhoeal diseases) that are already a major problem in the area and a major cause of death. The most effective mitigation measure is the provision of all-year round safe drinking water and sanitation facilities, accompanied by a major health education programme. This would seem a priority for the area irrespective of any FCD intervention. This is also the case with the provision of iodised salt to tackle the presently very serious problem of goitre.

3.10.7 Decline in Fuelwood and Fodder Availability

There are already significant problems with the present supply of fodder and fuelwood in the study area. This will only get worse in a without project situation as the agricultural system intensifies. This process will be accelerated under Option B as common "free-good" fodder and fuel resources decline still further. There is a direct link between these issues in that there is widespread use of animal dung and also rice straw as fuel, the major use of wood being normally confined to large scale burning for pottery and brick firing. Some replacement provision of fuelwood could be carried out by the development of community forestry as part of a strategy of multi-purpose use of embankments. However great care will need to be taken in selecting appropriate local species that have the maximum utility (including shade and perhaps fruit production) and will not significantly damage the embankment. This will require a commitment by the implementing authority to this type of programme within a framework of integrated environmental management.

More detailed studies will be required in the immediate post construction phase.

The present shortage and poor quality of draught animals in the study area is cited as a constraint to the development of irrigated agriculture. However the intensification of resource use will only make the situation more difficult. There is already evidence in the northern part of the study area that small power tillers are being adopted by larger farmers and those with the necessary resources. Whilst in employment opportunity, energy and sustainability terms this my beg some questions, it would seem a rational and inevitable solution to the problem at household level if it can initially be supported in terms of spare parts and skills. The prevalence of small engines for both irrigation and boat power in the project area would seem to indicate that this can be made sustainable.

3.10.8 Soil Fertility Issues

Study of existing detailed SRDI data for the area has indicated that soil fertility issues are not considered to be a major issue in the area at the moment nor in the immediate future. There is no salinity problem (in fact there is a lack of salt in drinking water supplies which may be the link in the serious incidence of goitre in the area) and a review of the extensive archive of soil chemistry data has turned up no major problems although care may need to be taken with high levels of iron in deep tubewell water. This can be managed out of the system with suitable watering scheduling. However POE comments on a previous report (R2) raised the issue so it is being addressed in the Environmental Annex even though it scored a rating of only -2 on the matrix. The fear is that the spread of continuous mono-cropping is likely to deplete soil fertility in the medium term. This can be tacked by the use of large quantities of both artificial and organic fertilizers. However supplies of organic fertilizer are limited and declining as the use of draught animals becomes less attractive and more use is made of animal dung for fuel as fuel wood supplies dwindle. However in environmental terms the use of large quantities of fertilizer is considered undesirable in that it is likely to cause water quality problems associated with high nitrate levels. There is a chance that the high levels of rainfall may wash much of this out of the area but this depends upon the effectiveness of the drainage system, particularly in a controlled flooding situation. In addition there are apparently uncertain economic issues with regard to artificial fertilizer use, despite the existence of a production plant within the study area. Fears have been expressed that the extensive expansion of irrigation may cause waterlogging of soils in the dry season when previously they dried out. This could lead to anaerobic conditions which may change the chemical condition of the soil. This, along with the previously mentioned high soluble iron content in the groundwater, particularly from deep tubewells, point to the need for a baseline and longer term soil monitoring requirement for the area in addition to an initial assessment once the hydraulic modelling gives some idea of the water flow conditions in the with project situation.

3.11 Construction Impacts

It is too early in the planning stage of the project to give details of likely construction impacts. This will depend on the very specific nature of the construction programme, particularly the level of technology to be used, its timing and detailed location of sites. These need to be considered in the Detailed Design and Implementation stages of any project. The main issues to be considered include:

- The number of people likely to be employed, where they will come from, the length of time they will be employed for (i.e if continuously or only seasonally and also the total length of time envisaged for the construction programme) and if they will live at the site or travel in daily. Central to this is the level of construction technology and the hence the type and numbers of skilled or unskilled labour required. This will have a significant effect on the distance from which people are likely to travel and the likely development of temporary informal settlements at construction sites. The phasing of construction work, particularly the possibility of working in many sites simultaneously will be of great significance.

- The requirements for access to land, both for temporary works (e.g. borrow pits etc) and permanent structures. Of specific concern will be the phasing of this and hence the degree of losses to household food production or lost income which will need to be compensated for with a suitable structured and phased compensation assessment and payment programme. This has to cover for both temporary access to land and permanent acquisition including any immovable assets and improvements.

- Borrow pit land acquisition policy needs to be formulated that is flexible and allows for both the temporary acquisition of land and taking material over a large area followed by the return of the land to the owners with appropriated compensation payment, and also permanent acquisition of small areas of land for deep borrow pits which could subsequently be used for fish production.

- Requirements to conform to any existing employment and safety legislation. Special conditions of contract could also be attached which allow specific aims of the project (employment of women or landless people for instance) to be targeted. The minimisation of disturbance and nuisance also needs great consideration, particularly the temporary disruption to the transport network that is likely during construction programmes.

All these issues will be dealt with in depth at detail design stage, once the final proposed construction programme has been formulated.

3.12 Hazard and Risk Assessment

Chapter 5 of the FAP 3 Ecological Assessment Supporting Report gives a review of possible hazards and risks of FCD interventions in the region. These include natural phenomena and overall risk due to the philosophy of the design, implementation and management of the intervention. The risk of natural phenomena and the secondary implications of these need to be born in mind when considering engineering design. These include catastrophic failure caused by seismic activity (discussed in Section 2.3.6), flooding, sedimentation and erosion. This needs to consider the magnitude, frequency, duration and spacing of such events. There is simply not the data to do this at present.

In addition there are the risks to socio-economic livelihoods as a result of interventions. Levels of such risk are already high for many households in the area as they become more marginalised. Of concern is if this is likely to change for better or worse as a result of the project. Traditional farming systems are often based around risk minimisation strategies. The intensification of agriculture and particularly the uptake of irrigated farming using HYV's leads to specialisation and greater dependence on external factors. In addition there are major issues of the natural environment and the degree to which the intervention places further pressure on this and the extent to which this will produce irreversible impacts on it, leading to the continued decline in its status.

The proposed project intervention needs to be considered in terms of environmental sustainability in the widest possible context, covering ecological, social, economic and political criteria. It is not yet possible to do this in detail, however some broad issues have already been raised in the EIA. An underlying issue is the basis for assessment outlined in the GPA which emphasises the economic benefits to agricultural production rather than the social benefits of intervention which are likely to have significant economic ones in the longer term but these are difficult to predict and harder still to quantify let alone value, particularly in economic terms.

The economic justification for the intervention on the mainland is based upon the economic benefits of increasing estimated cropping intensities by 4%, and the extension of the use of high yield varieties instead of local ones. This is likely to significantly benefit those who own land and perhaps make some short term benefit to some of the landless people. However without a mitigation programme the people in the unprotected land will be worse off as a result of increased peak flood risks and these are people who already have the highest flood risk and thus are in greater need of assistance. As a result, the recommendations in this report stress the need for parallel development within the unprotected lands together with the mainland project. The minimum aim of the two programmes is that no people should be worse off. This is achievable for the mainland project only if the parallel one is also undertaken. This condition does not apply of course to the flood proofing programme which in itself does not precipitate a need for the mainland project.

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The whole question of the conditions of donor funding needs to be made clear, will it be grant aid or a loan and what control will be placed upon it? How could this money be best spent to achieve policy aims in the national, regional and local context? These beg very large issues well beyond the scope of this report.

4 MITIGATION MEASURES AND ENVIRONMENTAL MANAGEMENT PLANNING

4.1 Introduction

The previous chapter has identified likely impacts as a result of proposed project interventions, along with an indication of their possible degree of severity. The basis of the EIA is to identify impacts and to propose ways of minimising or avoiding those that are negative. This is to eventually be done by drawing up an Environmental Management Plan for the study area which is intrinsic to the development of the project. The basic philosophy is that no person is to be worse off as a result of the project and the costs of mitigation should be included in the economic analysis of the project. The previous section has given some indications of mitigation possibilities. These are elaborated below for the main impacts and quantities and mitigation costs given for the two most serious impacts, increased flood risk to unprotected land and losses to fisheries.

4.2 Flood Proofing Unprotected Land

From the FAP 3.1 and FAP 16 Char studies it is estimated that 602 000 people presently live in what will become unprotected land which it is proposed will be subject to a flood proofing programme. This is compared to the 631 000 people who will be within the mainland area protected by the proposed controlled flooding option. The proposed flood proofing programme (outlined in detail in Annex 9 Section 4) will more than mitigate the increased flood risk to homesteads created by the concentration effects of the main river, particularly in peak flow situations. Other elements of it will address, to some degree, the increased risk to agricultural activity by proposing programmes of income diversification but it must be recognised that this is not easy to achieve.

The philosophy proposed for the flood proofing programme is based upon the tried NGO approach of SCI/MCC and is given in detail in Section 4 of Annex 9, the Char Study report. It is a flexible and integrated range of sub-options including individual house and homestead raising, provision of clustered communal refuges and multi-purpose use of existing and proposed flood protection embankments for both permanent flood proofed residence and temporary refuge. The detailed planning of this requires a significant input of non-engineering technical assistance and close working with local people through NGO's to allow group formation and shape the nature of individual implementation strategies down to community and household levels. In addition an income generating programme would be instigated aimed at broadening the economic base of household livelihoods and reducing the dependency on agriculture which is already difficult and likely to be made harder still due to the increased flood risk to agricultural land. Irrespective of the requirements of mitigation there will be considerable social and economic benefits in embarking on such a programme although these are difficult to quantify and place an economic value against.

The total flood proofing programme on the unprotectable land is estimated to cost TK 1396 million (US$ 34.9m), with the proposed pilot phase being TK 118 million. The total amount is equal to Tk2140 per head of population compared to Tk2212 for the mainland controlled flooding programme.

From the perspective of EIA methodology it would be normal to apportion the incremental cost of the increased flood risk mitigation due to the mainland intervention to it. This is estimated to be Tk31.2million based upon the present hydrological modelling data and assuming the flood proofing programme is to be implemented irrespective of and in parallel with the mainland controlled flooding intervention. This figure has been used in the multi-criteria analysis.

It must again be stressed that there is a very strong case indeed for carrying out a flood proofing programme in the Char lands irrespective on any mainland intervention. The social benefits of this are likely to be high but difficult to quantify let alone calculate in financial terms.

The issue of increased flood risk to the left bank of the Old Brahmaputra would appear to be an actual one, judging by the flood peak Landsat image shown in Figure 3.2.4 and in colour in the main report. There is at present no output data from the hydrological modelling to assess this nor a resource and population study of the area to provide quantification. As a result the impacts of this can not be estimated nor a suitable mitigation programme be drawn-up and costed. This needs to be commissioned as a matter of urgency and will probably need to extend for some way downstream of Jamalpur town.

4.3 Fisheries Mitigation

Mitigation for fisheries will need significant commitment. It requires to address both the needs of professional fishing households and also the nutritional implications of fish loss, particularly to occasional fishing households who catch "common good" fish for direct consumption. Possibilities include rational management of Beels to formalise the inter-relationship between professional fishermen and rice farmers. Associated with this is the development of aquaculture, in internal rivers, Beels and ponds. Linked to this is the possibility of utilising the borrow pit requirements of construction as part of a fish pond development programme.

The detailed mitigation proposals are given in Annex 2 and centre around a fisheries management and stocking programme for the area bearing in mind the different hydraulic regime that is likely to be in place as a result of controlled flooding. It is likely to be far more successful in mitigating the effects for professional fishermen, although specialist targeted programmes of riverine production aimed at occasional and landless groups would broaden this. Overall it is thought that if well managed the area could produce more commercial fish for sale than it does at present and in a without project situation. The capital costs of this programme will be in the order of Tk 28 million and require a major institutional commitment to the running costs, mainly in terms of the provision of skilled technical assistance staff.

4.4 Improved Road Network

In terms of mitigation, a replacement network of road links is required with transfer facilities to the main river navigation which should remain unaffected. This may entail extending the road embankments on the "wet" side of the main embankment across the "set-back" land. Provision of a replacement transport network could be achieved as part of the upgrading of the structure on the existing compartmentalisation system that uses the existing road embankments. It is important that these improvements take into consideration the need to make the roads wide enough for commercial lorry traffic and also sugar cane tractors and trailers to pass.

4.5 Flora and Fauna Management

There seems little that can be done for protection of flora and fauna in the area bearing in mind the high human population in the area and its recent decline and low status. However the incidence of medicinal plants has been shown to be high and widespread. Follow-up work will be required at detailed design stage. This will indicate those plants which are likely to be threatened and if alternative sources exist and if not what measures can be taken for preservation.

4.6 Replacement Protein Sources

A reconnaissance input from a nutritionist has been carried out and an outline programme for further studies is given in Appendix D. Along with the fisheries mitigation programme, steps are needed to consider specifically how can any lost protein consumption be economically and affordable replaced at household level. This will include consideration of alternative sources, including poultry, small stock, vegetable and pulse production. This requires a community based approach and could be incorporated into the flood proofing programme for the unprotected areas. In the protected areas a special targeted programme will be needed. Central to this is health and nutrition education.

4.7 Waterborne Disease Prevention

The most effective mitigation measure is the provision of all-year round safe drinking water and sanitation facilities accompanied by a major health education programme. This would seem a priority for the area irrespective of any FCD intervention. This is also the case with the provision of iodised salt to tackle the presently very serious problem of goitre. Terms of Reference for a baseline health and nutrition study are included in Appendix D to be carried out in the next phase of the study and linked to the existing socio-economic survey database.

4.8 Fuelwood and Fodder Production

Some replacement provision of fuelwood could be carried out by the development of community forestry as part of a strategy of multi-purpose use of embankments. However great care will need to be taken in selecting appropriate species that have the maximum utility (including shade and perhaps fruit production) and will not damage the embankment.

The present shortage and poor quality of draught animals in the study area is cited as a constraint to the development of irrigated agriculture. However the intensification of resource use will only make the situation more difficult. There is already evidence in the northern part of the study area that small power tillers are being adopted by larger farmers and those with the necessary resources. Whilst in employment opportunity, energy and sustainability terms this my beg some questions, it would seem an inevitable and logical solution to the problem at household level if it can initially be supported in terms of spare parts and skills. The prevalence of small engines for both irrigation and boat power in the project area would seem to indicate that this can be made sustainable.

4.9 Soil Resource Management

The effects of flood control on soil structure need to be monitored to see the possible nature and degree of any change so that suitable and timely measures can be taken to avoid or minimise this. A suitable programme will need to be set up as part of the project overall environmental monitoring programme.

4.10 Construction Management

The construction programme needs to be designed in a sensitive manner to avoid negative impacts, both temporary and permanent ones. This requires close liaison between the non-engineering components of the study and the design and construction engineers. This is best done at detailed design phase but it is important that environmental considerations are borne in mind when planning the early basis of the construction programme. Central to this is the level of construction technology to be used.

5 FUTURE WORK PROGRAMME

5.1 Introduction

The planning of the future work programme for the environmental component of the study should focus on the mitigation works to be incorporated as an intrinsic part of the project. It will take into account the phasing of work implementation. The commitment and resources given to the non-engineering components of the work should not be underestimated. Terms of Reference for the detailed design phase of the study have been drawn up and the items for inclusion in the non-engineering supporting studies are given in Appendix D.

5.2 National FAP Data Collection Programmes

There is a basic lack of data on natural environmental issues with the result that these can not be considered in a sound technical manner in the EIA work for the FAP. These require long term national monitoring programmes (the short term and episodic nature of FAP 3.1 is a totally inappropriate vehicle for such work) and it needs to address the following issues:

- National water quality monitoring, including surface water, groundwater, industrial pollution (both rural and urban), agro-chemicals, including nitrate problems of fertilizer use along with herbicides and pesticides, particularly under conditions of all year round cultivation and dry season irrigated agriculture.

- The nutritional implications of present fish consumption and how this is likely to change under FCD interventions, considering production (species diversity change) and consumption patterns. This also needs to consider alternative affordable sources of protein intake, particularly for marginalised households.

- A baseline data collection exercise to monitor likely soil chemistry changes as a result of all year mono-cropping and dry season irrigated agriculture.

- A study and monitoring programme of the likely effects of all year standing water (due to irrigation) on the incidence and nature of waterborne disease, particularly diarrhoea and malaria.

Many of these programmes would be best carried out by a reinforced and assisted national Department of the Environment.

Specific recommendations for the JPPS environmental component are outlined in the following section on the future work programme for the Detailed Design phase.

5.3 The Detailed Design Phase

As part of the detailed design phase of the proposed project, it is recommended that there needs to be a significant amount of resources given to the non-engineering issues to ensure that wider environmental and social factors are considered during engineering design. This includes the institutional structure for project implementation and the nature and degree of public participation. A crucial issue is land acquisition policy and procedures. An indication of the issues that need to be included in the TOR for the supporting studies for the Detailed Design phase are included in Appendix D of this report.

The specific environmental items that need to be addressed include:

- A full, internationally credible EIA under World Bank Operational Directive 4.01 and the recently approved FAP Environmental Guidelines. To this end, it would be useful to improve the hydrology modelling of both the internal project area network and the main rivers (both the Jamuna and Old Brahmaputra) incorporating output from Digital Elevation Models (DEM's) that allow mapping to be produced that show time series extents, depths, durations and timings of floods under a full range of with and without project situations. This would allow a suitable data collection programme for detailed ecological assessment to be drawn up along the lines of Annex 5 in the latest version of the GPA. It would then be possible to do more detailed impact analysis that allows a comparative assessment of spatial and social variation of impacts among the six or eight sub-areas with in the implementation area.

- A special hydrological and environmental resource survey of the Old Brahmaputra is required as a matter of urgency.

- Baseline monitoring data collection of water quality will need to be continued along with the planning of an evaluation and monitoring programme for the whole project.

- The detailed nutrition and health baseline studies need to be instigated.

- Fisheries considerations in the detailed design of drainage networks will need to be addressed along with the details of the fisheries mitigation and management programme.

- Environmental considerations for design, particularly construction impacts, land acquisition policy and procedures including compensation.

In addition the following issues with wider environmental considerations need to be addressed and followed up:

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- the institutional framework for the implementation of the project, including construction, management, operation and maintenance.

- liaison with local people to form a participation strategy to obtain detailed planning data. This is particularly crucial to any flood proofing work which is likely to need a large component of "social engineering" in the form of group formation.

In order to comply with the requirements of the latest FAP Environmental Impact Assessment Guidelines there would need to be a full 12 month period of data collection on the natural environment. For the human environment the 1991 BBS data for the area would need to be made available to fully address the issues of spatial and social differentiation of both positive and negative impacts. However, the most important requirement is for mapped outputs of the hydrological modelling which show the with and without project conditions under a range of different flow conditions. This would be a pre-requisite for commencing a full EIA and requires FAP 25 and FAP 14 to have completed the relevent parts of their work at least 6 months before the FAP 3.1 EIA could be completed.

Tables

Table 3.2.1 Water Quality Analysis Results - Dry Season, February and April 1992.

CHEMICAL ANALYSIS																				MICRO BIOLOGICAL ANALYSIS		
Sl No	Smpl No	Name of the Spot	Date	Time	Dsolvd Oxygen ppm	Free CO_2 ppm	PH	Temp.	Description	$CaCo_3$ ppm	NO_3 ppm	PO_4 ppm	I ppm	Si ppm	K ppm	Zn ppm	SO_4 ppm	Fe ppm	Nacl ppm	Total No of Bacteria /100ml (Nutrient Soya Agor)	Faecal Coliform bacilli	Total no. of gram negative bacteria/100ml (Mackonkey)
1	1	Pulla Kandir Char	06-02-92	11:11	12	6	8.5	21°C	- Old Brahmaputra Jmuna confluence. - Sunny day. - Running water. - Water colour sightly greenis.	80	0	D	$0.88x10^{-4}$	11	4	N.T.	17	0.10	14.04	$5x10^{13}$ to $8x10^{13}$		Not Found
2	3	Dewanganj Sugar Mill	06-02-92	13:09	5	450	5.0	21.5°C	- Ditch water - Stagnant disposal - Sunny day - Water colour slightly brown.	400	0	8	$0.85x10^{-4}$	13	4	16	N.T	20.33	30.42	$5x10^{13}$ to $66x10^{13}$		$1x10^{9}$ to $3x10^{9}$
3	3.1	Sugar Mill (Pipe)	06-02-92	14:08	6	23	9.0	32°C	- Pipe water flow. - Sunny day.	160	0	0	$0.83x10^{-4}$	12	4	6	N.T	8.22	19.89	$10x10^{14}$ to $12x10^{14}$		$3x10^{9}$ to $7x10^{9}$
4	A	Sasaria bari	06-02-92	14:40	9	2	8.5	24°C	- Pond water - Fish culture - Sunny day - Water colour slightly greenis	38	0	0	$1.205x10^{-4}$	9	10	N.T.	17	4.15	26.91			
5	B	Bhangbari	06-02-92	16:15	5.7	6	7.5	24°C	- Ditch/Pond - Stagnant water - Sunny day.	54	0	D	$0.883x10^{-4}$	5	14	4	24	16.63	22.23			
6	7	Maijbari	06-02-92	17:10	5.8	2	9.5	21°C	- Jamuna river - Running water - Sunny day - Water colour slightly greenis	80	0	0	$0.87x10^{-4}$	8	4	N.T.	N.T	3.05	5.85			
7	F	Char Lotabar	07-02-92	11:25	7.8	3	8.5	22°C	- Ditch - Stagnant water -Slightly/Sunny day	8	0	0	$0.87x10^{-4}$	2	4	N.T.	N.T	0.83	11.70			
8	13	Jhalopara	07-02-92	15:15	8	11	8.5	21°C	- Cloudy weather - Few raindrops - Jharkata river	114	0	0	$0.883x10^{-4}$	8	3	N.T.	N.T	1.00	9.36			
9	J.T	Jamalpur Town (Hospital)	08-02-92	14:20	11	0	9.5	23°C	- Branch of Old Brahmaputra river - Sunny day - Stagnant water	40	D	1	$0.883x10^{-4}$	4	3	N.T.	N.T	0.03	28.08	T.Col-iform B		

10	5	Chatal River	17.04.92	9.05	6	1	9.0	28°C	- Chatal river - Sunny day - Greenish water - Oscillation of water	88.0	0.1	N.T	0.74×10^{-4}	17	4	N.T.	4	0.06	11	1.7×10^{5}	1.2×10^{6}	8.5×10^{4}	
11	4	Maderganj	17.04.92	10.00	6	0.0	9.0	28°C	- Jamuna river - Sunny day - Water terbidity - Slightly greenish colour	60.0	0.3	2	0.76×10^{-4}	8	4	N.T	4	0.30	12	4.2×10^{5}	1.7×10^{6}	5.7×10^{4}	
12	6	Tubewell	17.04.92	10.50	3	2.0	5.5	26°C	- Clear water	80.0	0.1	14.0	0.56×10^{-4}	19.2	3	N.T	4	0.80	9	2.8×10^{5}	0.7×10^{6}	9.8×10^{4}	
13	F.F	Fertilizer Factory	17.04.92	15.05	5	0.0	9.5	30°C	-Fertilizer factory disposal area -Jamuna sub-channel - W.L slightly raised in the river - Sunny day.	56.0	22.0	16.0	0.86×10^{-4}	6.0	11	N.T	58	0.08	12	1.4×10^{5}	1.0×10^{6}	7.4×10^{4}	
14	2	Jaganna-thganj	17.04.92	15.40	4	0.01	8.5	29°C	- Januna River - Sunny day	55.0	0.4	1.0	0.61×10^{-4}	7.5	3	N.T	11	0.20	9	10×10^{5}	2.2×10^{6}	38.6×10^{4}	
15	14	Down stream	17.04.92	17.25	6	0.0	8.7	31°C	- Lounajanj river downstream - Stragnant water - Water colour Slightly changed - No oscillation	76.0	0.2	3.0	0.66×10^{-4}	9.2	2	N.T	12	0.05	13	4.6×10^{5}	1.2×10^{6}	[illegible]$\times 10^{4}$	

Legend: CO_2 = Carbon di Oxide, NO_3 = Nitrate, PO_4 = Phosphate, I = Iodine, Zn = Zinc, Nacl = Sodium Chloride, $CaCo_3$ = Calcium bi Carbonate, Temp. = Temperature, N.T. = Not Traceable, Dsolvd = Disolved., Smpl = Sample.

Source: FAP-3.1 Field Survey, February - August 1992.

Table 3.2.2 Water Quality Analysis Results - Wet Season, August 1992.

CHEMICAL ANALYSIS																					MICRO BIOLOGICAL ANALYSIS		
Sl No	Smpl No	Name of the Spot	Date	Time	Dsolvd Oxygen mg/l	Free CO_2 ppm	PH	Temp.	Description	$CaCo_3$ ppm	NO_3 ppm	PO_4 ppm	I ppm	Si ppm	K ppm	Zn ppm	SO_4 ppm	Fe ppm	Nacl ppm	Total Count of Organism/ml: Bacteria	Coliform Bacteria	Faecal Coliform Bacteria
1.	1	Pulla Kandir Char	27.8.92	16.05	8.8	4	7.37	30.7°C	- Running water - Water colour sightly brownish - Sunny day.	12	0.60	9.10	0.18	6	10.92	2.07	3.84	1.02	6.61	$18.0x10^5$	$15.7x10^3$	$0.2x10^2$
2.	3	Dewanganj Sugar Mill	27.8.92	14.20	12.3	12	7.36	35.2°C	- Sunny day. - Stagnant water - Water colour sightly brownish.	20	6.57	56.50	1.12	12	67.80	2.39	3.51	0.32	25.23	$10.0x10^5$	$1.3x10^3$	$24.0x10^2$
3.	3.1	Sugar Mill (Pipe)	28.8.92	14.55	10.2	6	7.00	34.2°C	- Sunny day. - Stagnant water - Water colour sightly brownish.	16	4.22	30.21	0.42	10	62.40	1.20	2.31	0.30	18.20	$10.0x10^5$	$1.1x10^3$	$20.0x10^2$
4.	A	Sasariabari	28.8.92	07.40	8.0	8	7.23	28.4°C	- Stagnant water - Slight wave - Water colour brownish - Cloudy weather.	8	0.38	5.83	0.08	6	6.99	2.79	4.10	1.10	7.01	-	-	-
5.	B	Bhangbari	28.8.92	12.50	8.8	6	7.61	29.8°C	- Cloudy weather. - Mediumm wave - Brownish water colour.	8	1.46	5.02	1.32	5	6.02	3.18	4.68	1.11	6.61	-	-	-
6.	7	Maijbari	27.8.92	18.03	8.7	8	7.27	29.3°C	- Cloudy weather - Few raindrops - No wave - Water colour slightly greenis.	12	0.62	5.15	2.79	6	6.18	2.65	4.51	1.23	6.61	-	-	-
7.	F	Char Lotabar	27.8.92	07.45	2.0	15	7.41	29.5°C	- Pond water - Water colour slightly greenis - No wave.	12	2.47	16.53	1.35	8	19.84	6.93	10.10	1.62	24.82	-	-	-
8.	13	Jhalopara	27.8.92	07.10	8.5	10	7.73	28.5°C	- Slight wave - Water colour sightly brownish - Cloudy weather.	8	2.05	9.10	0.20	9	10.92	3.21	4.72	1.10	6.61	-	-	-
9.	J.T.	Jamalpur Town (near Hospital)	27.8.92	10.20	9.5	7	7.78	29.7°C	- Water colour sightly brownish - Medium wave - Running water - Cloudy weather.	8	15.50	5.42	1.35	7	6.50	5.33	7.84	2.24	7.45	-	-	-

10.	5	Chatal River	26.8.92	16.25	6.5	10	7.80	31.2°C	- Water colour blackish - Stagnant water - No wave.	16	0.69	6.64	0.08	14	7.97	2.05	3.04	0.78	16.53	$8.7x10^5$	$3.8x10^3$	$17.0x10^2$
11.	4	Maderganj	26.8.92	14.55	5.9	7	7.60	30.0°C	- Stagnant water - Used for jute stick sinking - Sunny weather.	12	1.63	13.42	0.15	3	16.10	2.81	4.13	1.10	10.75	$37.7x10^5$	$1.1x10^3$	$7.0x10^2$
12.	6	Tubewell	27.8.92	10.30	2.0	17	6.637	28.5°C	- Under ground water.	12	0.494	4.74	1.83	2.5	5.69	3.29	4.84	1.11	11.16	$22.4x10^5$	$42.0x10^3$	$8.0x10^2$
13.	F.F.	Fertilizer Factory	25.8.92	18.00	7.2	0	9.30	30.8°C	- Running water - Cloudy weather. - Moderate wave.	16	15.50	9.35	1.25	15	11.22	2.97	4.37	1.79	18.61	$25.0x10^5$	$3.3x10^3$	$4.0x10^2$
14.	2	Jagannathganj	25.8.92	18.30	12.2	2	7.08	29.1°C	- Jamuna River - Running water - Cloudy weather - No Sunshine.	8	0.42	6.10	1.35	5	7.32	3.26	4.79	1.10	7.45	$6.9x10^5$	$1.8x10^3$	$51.0x10^2$
15.	14	Down stream	29.8.92	10.10	10.0	6	7.06	28.8°C	- Louhajanj river, downstream - Heavy current due to sluice - Moderate wave - Sunny day.	12	0.484	6.23	1.78	7	7.48	3.34	4.90	1.11	7.01	$15.6x10^5$	$25.2x10^3$	$2.4x10^2$

Legend: CO_2 = Carbon di Oxide, NO_3 = Nitrate, PO_4 = Phosphate, I = Iodine, Zn = Zinc, Na = Sodium, SO_4 = Sulphate, $CaCO_3$ = Calcium bi Carbonate, Si = Silika, K = Potassium, Fe = Iron,

Temp. = Temperature, Dsolvd = Disolved, Smpl = Sample.

Source: FAP-3.1 Field Survey, August 1992.

Table 3.2.3: Minimum Water Quality Standards for Bangladesh.

Drinking Water Standards

Physical

• Turbidity	25 Units.
• Colour	30 Units.
• Threshold Order	Unobjectionable.

Chemical

Total Dissolved solids (TDS)	1500 ppm.
• Chloride	600 (max 1000 ppm).
• Iron	1.0 ppm (max 5 ppm).
• Manganese	0.5 ppm.
• Zinc	15 ppm.
• Copper	1.5 ppm.
• p^H	6.5 - 9
• Sulphate	400 ppm.
Total Harardness	250 - 450 ppm.
• Flouride	1 - 2 ppm.
• Nitrate	42 - 50 ppm.
• Phenolic substances	0.002 ppm.

Bacteriological

Same as international standard - In 90% of the samples examined throughout the year, coliform bacteria shall not be detected or the MPN index of coliform micro - organism shall be zero.

Toxic Substances

The maximum allowable concentration of toxic substance are as follow:

	Bangladesh Standard
Cyanide	0.2 ppm.
Hexavalent chromium	0.05 ppm.
Lead	0.05 ppm.

Discharge Standard for Industrial Effluents to Streams

	Proposed Bangladesh Standard		
Fertilizer Factory	T.S	BOD	Ammonia
	2000 ppm	50 ppm	7 ppm
Sugar Mills	S.S.	BOD	-
	100 ppm	90 ppm	-

Water Standard for Fisheries

- Dissolved Oxygen - a minimum concentration of 4 ppm
- p^H - Between 7.0 and 9.0
- Temperature - 20^0C - 32^0C through the year.
- Electrical conductivity at 25^0C tolerance limit for fish culture for inland surface water 800 x 10 ohms.
- Ammonia or its compounds - Maximum conc of 3 ppm.
- Carbon Dioxide - Maximum conc. of 2 ppm.

Source: MPO Technical Report No. 20
Environmental Assessment
April 1987.

Standard Values for Water Quality in Bangladesh for Various Uses

Parameter/ Determinants	Unit	Drinking Water	Fishery Water	Irrigation Water
Alkalinity	mg/l	NYS	70-100	NYS
Ammonia (NH_3)	mg/l	0.5	0.25	3
Carbon Dioxide (CO_2)	mg/l	NYS	6	NYS
Chloride (Cl)	mg/l	150-600	600	600
Dissolved Oxygen	mg/l	6	4-6	5
Hardness ($CaCO_3$)	mg/l	200-500	80-120	NYS
Iron (Fe)	mg/l	0.3-1	NYS	NYS
Nitrite (NO_2)	mg/l	<1	0.03	NYS
p^H		6.5-8.5	6.5-8.5	6.0-8.5
TDS	mg/l	1000	NYS	2000

NYS: Not yet standardized.
Source: Dept. Environment.

File: R6-323.

Recommended guideline values for some potentially harmful substances in drinking-water.

Substances	Guideline Value mg/l
Arsenic (as As)	0.05
Cadmium (as Cd)	0.005
Cyanide (as CN)	0.1
Lead (as Pb)	0.05
Mercury (total, as Hg)	0.001
Selenium (as Se)	0.01
Benzo [a] Pyrene	0.01

Source: Micropollutants in River Sediments WHO, Copenhagen, P-5, August 1980.

Table 3.2.4: Surface Soil Analytical Data, Melandah and Madarganj

Upazila: Melandah (1985)

Agro Ecological Regions	Site No.	PH	Org. Matter %	Milli equivalent/100 g m Soil			Microgramme (PPM)/millilitre Soil							
				Ca	Mg	K	Amon-N	P	S	Bo	Cu	Fe	Mn	Zn
AEZ-9	1	6.2	1.50	3.9	0.35	0.25	22	30	7	Trace	3.0	182	25	2
	2	5.4	1.30	3.4	1.20	0.87	23	35	13	Trace	2.5	192	25	2
	4	4.8	0.95	1.6	0.21	0.40	22	25	14	0.1	2.5	121	23	1
	6	5.3	0.80	1.8	0.28	0.32	23	25	10	Trace	2.0	125	23	1
	7	5.0	1.20	5.7	0.48	0.25	25	10	14	0.1	3.0	56	22	1
	32	6.0	0.95	1.5	0.28	0.35	25	185	7	Trace	2.0	148	48	2
	47	5.1	1.60	3.0	1.41	0.52	31	30	55	0.5	5.0	231	29	5
	59	6.2	1.50	0.6	1.32	0.27	30	40	13	Trace	2.5	161	23	2
	60	5.0	1.30	0.4	1.09	0.37	23	25	7	Trace	2.0	178	28	2
AEZ-8	10	6.0	0.90	5.7	1.05	0.45	23	14	16	Trace	2.0	214	24	2
	14	5.8	2.40	3.3	1.15	0.32	22	13	8	Trace	3.0	99	21	2
	15	5.4	1.50	2.7	0.21	0.35	20	15	6	Trace	3.0	101	25	2
	16	6.5	2.80	3.5	2.35	0.30	22	12	10	Trace	2.5	108	24	1
	24	5.8	0.80	1.2	1.47	0.57	21	20	10	Trace	2.5	156	9	2
	26	6.0	1.30	1.5	1.29	0.37	23	35	14	Trace	3.0	116	10	2
	36	6.0	1.40	1.3	0.84	0.42	25	18	11	Trace	2.5	137	-	2
	41	7.1	1.40	1.6	1.60	0.35	29	25	20	0.3	2.0	73	6	1
	42	7.2	1.50	1.8	0.27	0.35	23	25	23	0.2	1.5	51	6	1
	44	6.6	1.40	1.4	0.76	0.40	26	25	10	0.1	2.5	98	20	1

Source: SRDI Upazila Land and Soil Utilisation Guide.
Sample analysed by BARI.

Upazila: Madarganj (1990)

Agro Ecological Regions	Site No.	PH	Org. Matter %	Milli equivalent/100 g m Soil			Microgramme (PPM)/millilitre Soil							
				Ca	Mg	K	Amon-N	P	S	Bo	Cu	Fe	Mn	Zn
AEZ-8	6	4.9	0.71	2.35	1.23	0.20	38	12	5	0.25	3	103	7	3
	7	5.9	1.73	7.30	1.48	0.01	45	41	13	0.16	6	174	5	3
	20	6.5	1.37	9.40	3.83	0.22	38	8	20	2.00	6	18	22	6
	21	6.3	0.44	7.20	2.31	0.22	25	28	10	0.25	2	23	8	5
	22	6.7	0.50	4.00	1.95	0.10	5	2	50	0.18	3	10	7	2
	28	6.3	0.51	3.90	2.03	0.07	10	2	100	0.18	6	171	69	3
	29	6.0	1.21	5.30	2.62	0.16	5	2	200	0.17	7	79	41	4
	35	7.0	0.90	11.60	2.09	0.09	10	16	25	0.20	6	15	8	2
	36	7.3	0.07	6.80	0.43	0.10	5	7	25	0.15	3	36	6	3
	44	6.9	0.42	4.15	2.17	0.14	7	93	Trace	0.25	2.8	83	29	3
	48	6.4	2.19	10.70	3.09	0.12	10	9	50	0.16	6	20	42	4
	53	6.2	0.62	5.10	2.35	0.30	29	6	23	1.00	3.0	35	6	3
	57	5.3	2.26	9.20	2.56	0.10	13	7	63	0.13	7.0	112	48	3
	60	7.0	0.96	8.70	2.84	0.01	15	3	6	0.16	5	32	27	3
AEZ-7	5	5.5	1.10	6.20	2.11	0.06	15	10	38	0.20	7.0	192	48	5
	32	6.7	0.09	1.80	0.83	0.17	25	2	5	Trace	0.3	6	2	5
	34	7.3	0.60	5.10	2.57	0.13	10	6	38	0.27	7	23	33	3
	37	6.5	0.67	4.45	1.13	0.35	63	5	65	0.25	1.8	18	5	4
	42	7.2	0.40	3.35	1.26	0.22	63	10	15	0.25	1.6	22	5	4
	43	7.0	0.10	7.30	0.32	0.08	10	3	25	0.17	2.0	27	5	4
	56	7.2	0.53	9.90	0.66	0.15	5	11	25	0.16	6.0	78	16	3

Source: SRDI Upazila Land and Soil Utilisation Guide.
Sample analysed by BARI.

Table 3.2.5: **Rating of Analytical Values of Nutrient Components**

Nutrient Components	Low	Medium	High
Ammonium Nitrogen (N) PPM/millietre Soil	< 76	76-150	151-300
Phosphorus (P) PPM/millietre Soil	< 13	13-25	26-75
Sulpher (S) PPM/millietre Soil	< 13	13-25	26-75
Boron (Bo) PPM/millietre Soil	< 0.21	0.21-0.50	0.51-4.0
Copper (Cu) PPM/millietre Soil	< 1.1	1.1-3.0	3.1-10
Iron (Fe) PPM/millietre Soil	< 21	21-40	41-200
Manganese (Mn) PPM/millietre Soil	< 5.1	5.1-10	11.50
Zinc (Zn) PPM/millietre Soil	< 2.1	2.1-4.0	4.1-18
Calcium (Ca) Milliequivalent/100 millietre Soil	< 2.1	2.1-4.0	4.1-18
Magnesium (Mg) Milliequivalent/100 millietre Soil	< 0.81	0.81-2.0	2.1-9
Potassium (K) Milliequivalent/100 millietre Soil	< 0.21	0.21-0.40	0.41-1.8
Calcium - Magnesium ratio	< 1.3	1.3-1.7	1.8-3.1
Magnesium - Potassium ratio	< 1.7	1.7-2.0	2.1-7.0

Source: SRDI Upazila Land and Soil Utilisation Guide.

Table 3.2.6 FAP-3.1 Mainland and Char Land Areas and Population Estimates, 1992.

Land Type	Land Area (ha)	Human Population Estimate 1992	Remarks
Set Back West	12,682		
Attached West	11,600	175,130	
Sub Total West Bank	24,282	175,130	FAP-1/2 Area
Main River Channels	20,801	0	
Island Chars	38,744	118,060	As at 8th March 1992
Attached East	17,342		As at 8th March 1992
Set-Back East	12,869	309,413	
Sub Total FAP-3.1 Char Land Study	114,038	602,603	Includes river channels.
Total Char Land Implementation	93,237	602,603	Not including river channel
Protected Mainland Implementation Area	65,800	631,023	Not including river channels
FAP-3.1 Mainland Study	96,011	940,436	
Total FAP-3.1 Mainland and Char Land Study Areas	179,838	1,233,626	Includes river channels

Source: FAP-3.1 Sample survey Estimates 1992 and Classified Landsat Imagery of 8th March 1992.

Table 3.2.7 Average Annual Fisheries Production Trends Over the Last Six Years

	Main Rivers	Other Rivers	Floodland	Beels	Ponds	Total
Jamalpur	+16.49%	-21.75%	+11.52%	NA	+18%	+14%
Bangladesh	-26.71%	NA	-1.05%	+0.61%	+3%	- 1.5%

Source: FRSS data
Note: NA - not available

Table 3.2.8 Jamalpur District 1991 Epidemiological Report.

NAME OF UPAZILA	WATERY DIARRHOEA		DYSENTERY				ACCUTE RESPIRATORY ILLNESS				JAUNDICE		MEASLES		TETANUS				DIPHTHERIA		WHOPING-COUGH		POLIO		MALARIA		KALA-AZAR		OTHERS		TOTAL	
			BLOOD		OTHERS		PNEUMONIA		OTHERS						NEO-NATAL		OTHERS															
C	C	D	C	D	C	D	C	0	C	D	C	D	C	D	C	D	C	0	C	0	C	0	C	D	S	V	C	D	C	D	C	0
JAMALPUR SADAR	1702	19	2050	-	10505	-	963	-	5782	-	4	-	2												4491	11	-	-	36182	-	57201	19
SARISHABARI	2900	8	102	-	8225	-	-	-	-	-	1	-	4	-	-	-	2	-	-	-	-	-	-	-	583	-	-	-	48	-	11282	4
MADERGANJ	927	3	550	-	557	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	59	-	1	-	2115	3
MELANDAH	686	11	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	687	11
ISLAMPUR	1749	15	1456	5	500	11	4	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	3348	14	-	-	2	-	3727	31
DEWANGANJ	1013	2	2989	2	11048	3	101	9	8909	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4262	414	-	-	-	-	24474	27
GENERAL HOSPITAL JAMALPUR	743	8	532	1	4068	-	84	15	605	3	-	-	-	-	8	6	34	7	1	-	-	-	-	-	-	-	-	-	-	-	6075	40
TOTAL	9720	66	7680	8	34903	14	1152	24	15296	14	7	-	7	-	8	6	36	7	1	-	-	-	-	-	12693	439	59	-	36233	-	105561	135

\- NONE RECORDED
C = NUMBER OF CASES
D = NUMBER OF DEATHS
S = SUSPECTED CASES
V = CONFIRMED CASES

SOURCE: JAMALPUR CIVIL SURGEON.

Table 3.2.9: Waterborne Navigation Survey Results.

Route Origin	River Navigability: Main Rivers	River Navigability: Internal Rivers	Destination	Length of Journey	Load Type and Carrying Cost: Passenger	Fare per Person	Commodities	Rate Quantity	Goods	Rate	Length of Boat (meter)	Loading Capacity: No. of Passenger	Loading Capacity: Cargo Weight (Kg.)	Power/ Draught	Boat Costs (Tk): Building	Repairing /month	Running	Source of Fund	Boat Builders Social Status (%): Hindus	Muslims
Pulla Kandi	-	Old Brahmaputra (All season)	Shanandabari	3 hr.	Passenger	Tk. 10	Wheat	Tk. 10 per bag	Mixed	-	15 - 20	40 - 50	150 - 250		25000 - 30,000	150	125 - 150	Self	12	88
							Nut	Tk. 10 per bag	Mixed	-	15 - 20	40 - 50	150 - 250		25000 - 30,000	150	125 - 150	Self	12	88
							Cement	Tk. 5 per bag	Mixed	-	15 - 20	40 - 50	150 - 250	Power	25000 - 30,000	150	125 - 150	Self	12	88
							Brick	Tk. 80-100 per 1000	Mixed	-	15 - 20	40 - 50	150 - 250	(diesel)	25000 - 30,000	150	125 - 150	Self	12	88
							Rice	Tk. 10 per bag	Mixed	-	15 - 20	40 - 50	150 - 250		25000 - 30,000	150	125 - 150	Self	12	88
							Rod	Tk. lumpsum	Mixed	-	15 - 20	40 - 50	150 - 250		25000 - 30,000	150	125 - 150	Self	12	88
Shanandabari	-	Old Brahmaputra (All season)	Pullakandi	2.5 - 3 hr.	Passenger	Tk. 10	-	-	Vegetable	Tk. 10 per bag	15 - 20	40 - 50	-	-	-	-	-	-	15	85
Shanandabari	All season	June - October	Narayanganj	3 days			Jute	Tk. 25 per mnd	Vegetable	-	15 - 20	-	250 - 350 mds	Power	35,000 - 40,000	250	300 - 400	Self	10	90
							Glass Scrap	Tk. 25 per mnd	Vegetable	-	15 - 20									
Shanandabari	All season		Chittagong	4-6 days			Cow	Tk. 5000 13 pairs	Mixed	-	15 - 20	-	225 - 350	Power	35,000 - 40,000	150-300	500-1000	Self	8	92
							Kalai	Tk. 40 per bag	-	-	15 - 20	-	225 - 350	Power	35,000 - 40,000	150-300	500-1000	Self	10	90
Shanandabari	All season		Bhairab	4-5 days			Wheat	Tk. 40 per bag	-	-	15 - 20	-	225 - 350	Power	35,000 - 40,000	150-300	500-1000	Self	10	90
							Mastard	Tk. 40 per bag	-	-	15 - 20	-	225 - 350	Power	35,000 - 40,000	150-300	500-1000	Self	10	90
Shanandabari	All season		Sylhet	6-7 days			Onion	Tk. 40 per bag	-	-	15 - 20	-	225 - 350	Power	35,000 - 40,000	150-300	500-1000	Self	10	90
							Garlic	Tk. 40 per bag	-	-	15 - 20	-	225 - 350	Power	35,000 - 40,000	150-300	500-1000	Self	10	90
Shanandabari	All season	-	Phulchari	3 hrs.	Passenger	Tk. 10	Bamboo	Tk. 500-600 per bam	-	-	8 - 11	35 - 45	80 - 150	Power	25,000 - 30,000	100-150	100 - 150	Self	10	90
		-	Jamalpur	3 hrs.			Vegetable	Tk. 15 per bag	-	-	11 - 14	-	80 - 150	Power	20,000 - 25,000	100	80 - 100	Self	10	90
Narajanganj	All season	-	Shanandabari	3-4 days			Salt	Tk. 15 per bag	-	-	11 - 14	-	80 - 150	Power	20,000 - 25,000	100-150	300 - 350	Self	10	90
							Fertilizer	Tk. 20 per bag		-										
Pulla Kandi	All season	-	Kamarjani	3 hrs.	Passenger	Tk. 20	-	-	-	-	8 - 11	35 - 45	80 - 150	Power	20,000 - 25,000	100-150	100 - 150	Self	15	85
Sarishabari	All season	-	Guthail	3-4 hrs.	Passenger	Tk. 8-10	Fertilizer	Tk. 8-9 per bag	-	-	9 - 12	5 - 10	120 - 150	Power	20,000 - 30,000	200 - 250	150 - 190	Self	15	85
Guthail	All season	-	Char Projapat	1.5 hrs.	Passenger	Tk. 2	-	-	Mixed	Tk. 2 per bag	9 - 12	5 - 10	120 - 150	Power	20,000 - 30,000	200 - 250	150 - 190	Self	15	85
			Char Monna	1.5-2 hrs.	Passenger	Tk. 5	-	-	Mixed	Tk. 5 per bag	9 - 12	5 - 10	120 - 150	Power	20,000 - 30,000	200 - 250	150 - 190	Self	15	85
Madarganj	All season	-	Shariakandi	2-2.5 hrs.	Passenger	Tk. 10-12	Paddy	Tk. 5 per bag	Mixed	Tk. 5 per bag	9 - 11	20 - 25	80 - 100	Power	18,000 - 25,000	200 - 300	200 - 250	Self	10	90
							Jute	Tk. 5 per bag	Mixed											
							Mastered	Tk. 5 per bag	Mixed											
	All season	-	Naryanganj	4-5 days	-	-	Jute	Tk. 20-25 per bag	-	-	11 - 14	-	200 - 300	Power	35,000 - 45,000	300 - 350	350 - 400	Self	8	92
	-	June - Sept	Kalihati	8-10 hrs.	-	-	Jute	Tk. 7-8 per bag	-	-	9 - 12	-	150 - 200	Power	30,000 - 35,000	200 - 250	400 - 500	Self	15	85
	-	June - Sept	Bhuapur	8-10 hrs.	-	-	Jute	Tk. 7-8 per bag	Mixed	Tk. 7-8 per bag	9 - 12	-	150 - 200	Power	30,000 - 35,000	200 - 250	400 - 500	Self	15	85
			Sarishabari	2 hrs.	-	-	Jute	Tk. 7-8 per bag	Mixed	Tk. 7-8 per bag	9 - 12	-	150 - 200	Power	30,000 - 35,000	200 - 250	400 - 500	Self	15	85
							Paddy	Tk. 7-8 per bag	Mixed	Tk. 7-8 per bag	9 - 12	-	150 - 200	Power	30,000 - 35,000	200 - 250	400 - 500	Self	15	85
Shariakandi	All season	-	Madarganj	3 hrs.	-	-	Chille	Tk. 8-10 per bag	Mixed	Tk. 6-8 per bag	9 - 12	-	150 - 200	Power	30,000 - 35,000	200 - 250	400 - 500	Self	10	90
							Molases	Tk. 8-10 per bag	Mixed	Tk. 6-8 per bag	9 - 12	-	150 - 200	Power	30,000 - 35,000	200 - 250	400 - 500	Self	10	90
Jagannathganj	All season	-	Kamarjani	3 hrs.	-	-	Fertilizer	Tk. 20 per bag	-	-	10 - 15	-	175 - 200	Power	30,000 - 35,000	200 - 250	400 - 500	Self	10	90
	All season	-	Chandanbaisl	3 hrs.	Passenger	Tk. 10	Egg	Tk. 30 per 1000	Mixed	Tk. 20 per Kg	10 - 15	25 - 30	80 - 150	Power	35,000 - 45,000	200 - 250	300 - 350	Self	15	85
							Jute	Tk. 25 per 40 kg	Mixed											
	All season	-	Meghai	1-1.5 hrs.	Passenger	Tk. 15-20	-	-	Vegetable & other	Tk. 15-25 per bag	12 - 18	30 - 35	125 - 175	Power	25,000 - 35,000	250-300	130 - 170	Self	15	85
	All season	-	Sirajganj	2-2.5 hrs	Passenger	Tk. 20	-	-	Vegetable & other	Tk. 15-25 per bag	12 - 18	30 - 35	100 - 150	Power	25,000 - 35,000	150-200	100 - 150	Self	15	85
	All season	-	Jakerchar	1 hrs.	Passenger	Tk. 5	-	-	Mixed	Tk. 5-10 per bag	12 - 18	30 - 35	50 - 100	Power	25,000 - 35,000	150-200	50 - 60	Self	15	85
	All season	-	Banglabazar	1.5 hrs.	Passenger	Tk. 10	-	-	Mixed	Tk. 5-10 per bag	12 - 18	30 - 35	80 - 150	Power	20,000 - 25,000	150-200	80 - 100	Self	12	88
	All season	-	Char Nalsand	1 hrs.	Passenger	Tk. 2	-	-	Mixed	Tk. 5-10 per bag	12 - 18	40 - 80	80 - 150	Power	20,000 - 25,000	150-200	70 - 75	Self	15	85
Sirajganj	All season	-	Jagannathganj	2-2.5 hrs	Passenger	Tk. 20	Molases Diesel	Tk. 10 per 40 Kg	Mixed	Tk. 20-25 per bag	12 - 18	30 - 50	100 - 175	Power	25,000 - 35,000	250-300	130 - 180	Self	15	85
Sarishabari	All season	June - Oct	Chandanbarisha	3.5 hrs	Passenger	Tk. 30	Fertilizer	Tk. 10 per bag	-	-	12 - 18	-	80 - 100	Power	35,000 - 45,000	250-300	200 - 250	Self	10	90
	All season	June - Oct	Meghai	2.5 hrs.	Passenger	Tk. 30	-	-	Mixed	Tk. 25 per bag	12 - 18	-	300	Power	35,000 - 45,000	250-300	200 - 250	Self	10	90
	All season	June - Oct	Maijbari	2.5 hrs.	Passenger	Tk. 15-20	-	-	-	-	12 - 18	-	250 - 300	Power	35,000 - 45,000	250-300	150 - 200	Self	15	85
Phulchari	All season	June - Oct	Sarishabari	3-4 hrs.	-	-	Jute	Tk. 14 per bag	-	-	12 - 18	-	250 - 300	Power	35,000 - 45,000	300 500	250 - 350	Self	10	90

Source: FAP-3.1 Field Survey 1992. Note: 1 bag = 80 Kg (appx).

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Table 3.3.1

Summary of Estimated Fisheries Impacts with no Mitigation

AREA	NOW	WITH OUT	OPTION A	OPTION B	OPTION C	OPTION D
FLOODLAND TONS	900 (17%)	860	-54 =846	-549 =351	-297 =603	-864 =36
% Change	/////	-1.5% PA	-6%	-61%	-33%	-96%
BEELS TONS	1100 (21%)	1051	-99 =1001	-836 =264	-704 =396	-1067 =33
% Change	/////	-1.5% PA	-8%	-75%	-63%	-97%
RIVERINE TONS	508 (10%)	485	-26 =484	-352 =158	-173 =278	-495 =15
% Change	/////	-1.5% PA	-5%	-68%	-34%	-97%
SUB-TOTAL TONS	2508 (48%)	+2396	-168 =2342	-1717 =793	-1159 =1351	-2428 =84
SUB TOTAL % Change	/////	-1.5% PA	-8%	-69%	-47%	-97%
SUB-TOTAL TAKA (m)	254	-4 = 250	-8 =245 (-3%)	-83=171 (-31%)	-55=199 (-22%)	-112= 142 (-44%)
PONDS	1313 (25%)	+4.5% PA = 1498	+4.5% PA = 1498	0% = 1313	0% = 1313	-1.5% PA = 1254
MAIN RIVERS	1379 (27%)	-1.5% PA = 1317	-1.5% PA = 1317	-1.5% PA = 1317	-1.5% PA = 1317	-1.5% PA = 1317
GRAND TOTAL TONS	5200	5211	5157	3423	3981	2655

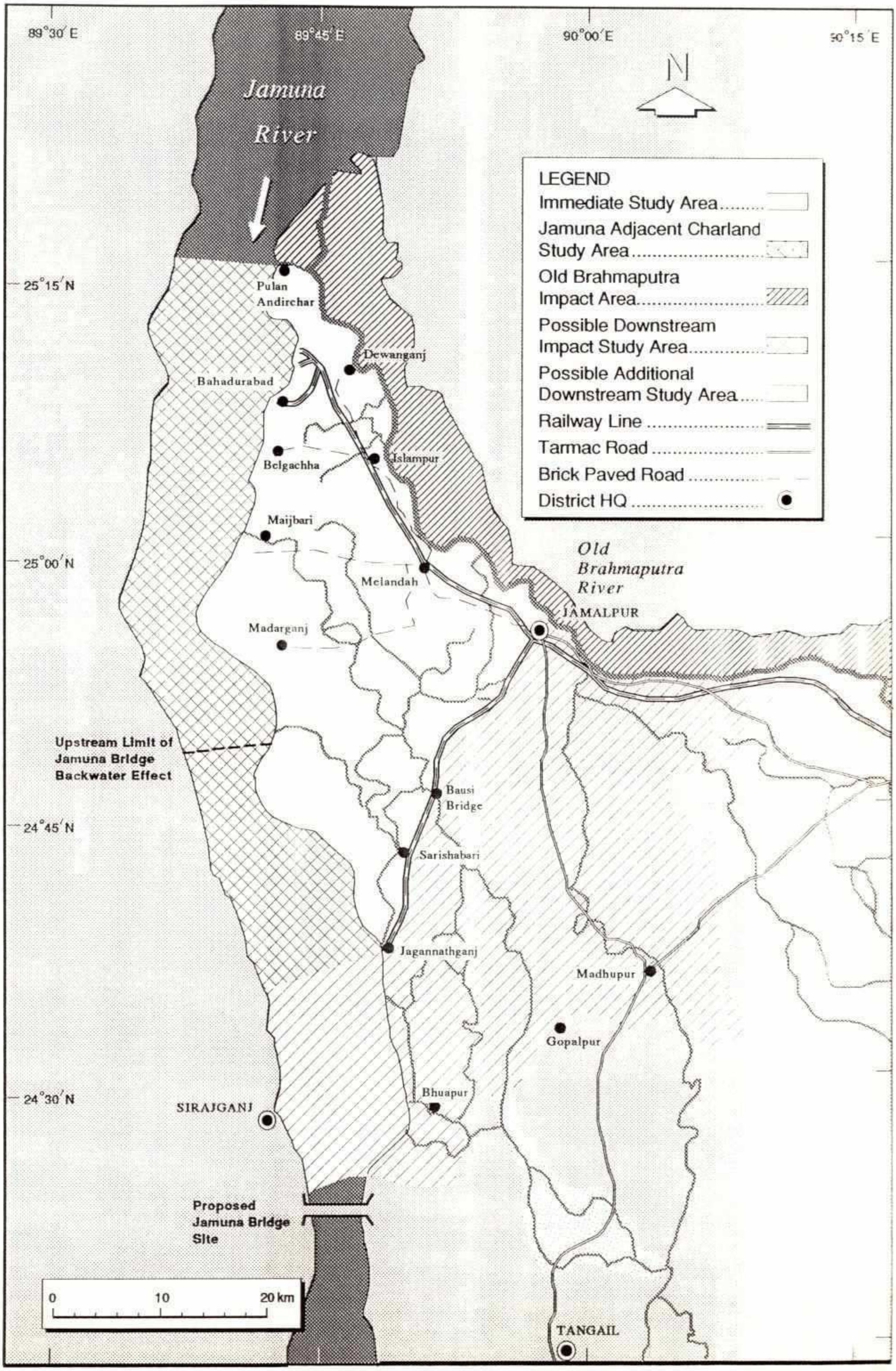
Source: JPPS Data Collection and Analysis 1991-1992

Notes:
- -Estimates are for Year 3 from now assuming imminent construction of the project and completion within the three year period.
- Main Rivers figure is 25% of FRSS main river figure assumed to be landed in the project area by people living there.
- Cash valuations are based on market prices and consider different species mix and hence values for different systems.

Figures

120 Figure 3.1.1

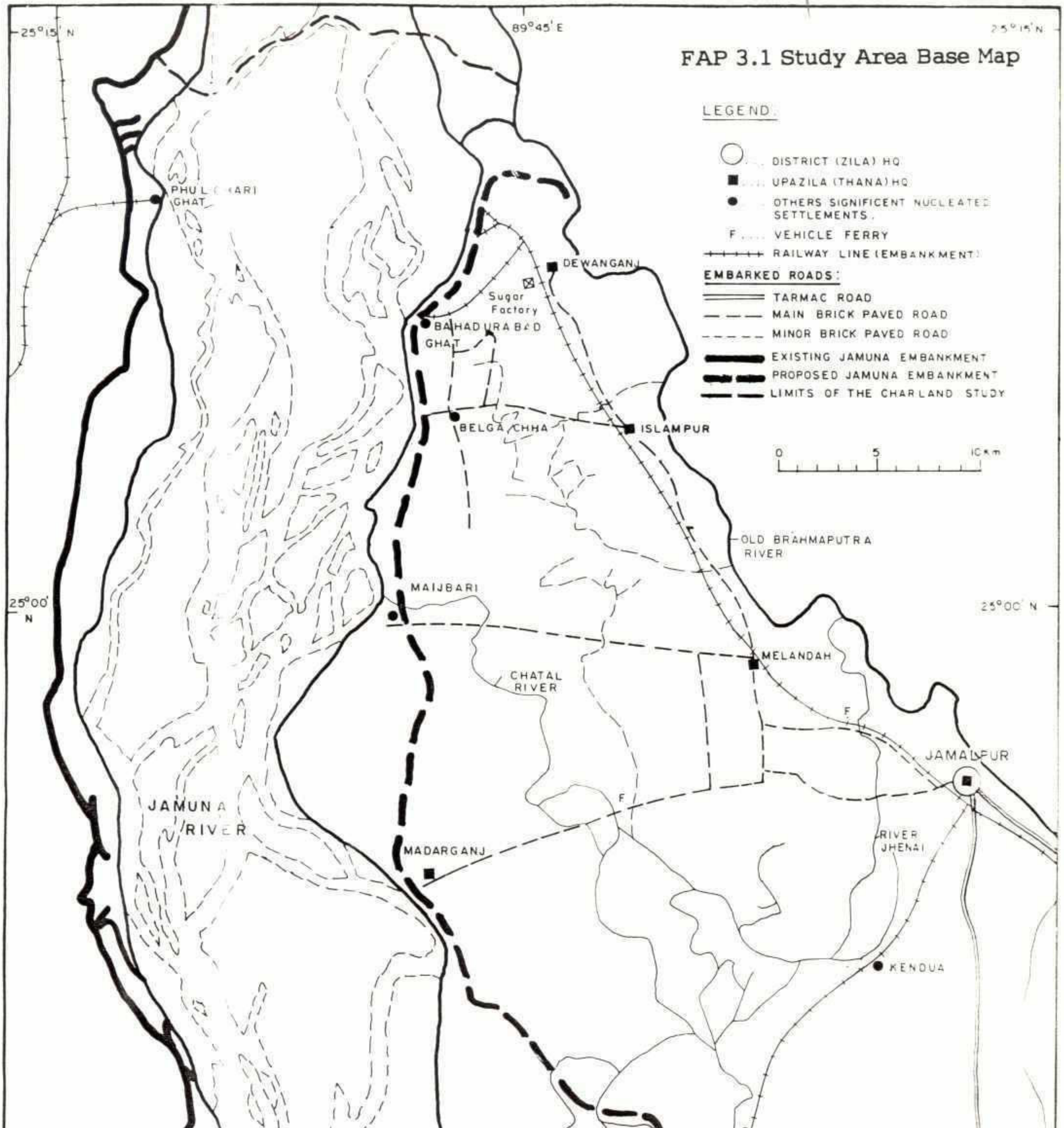
FAP 3.1 Regional Context



base-2..gem

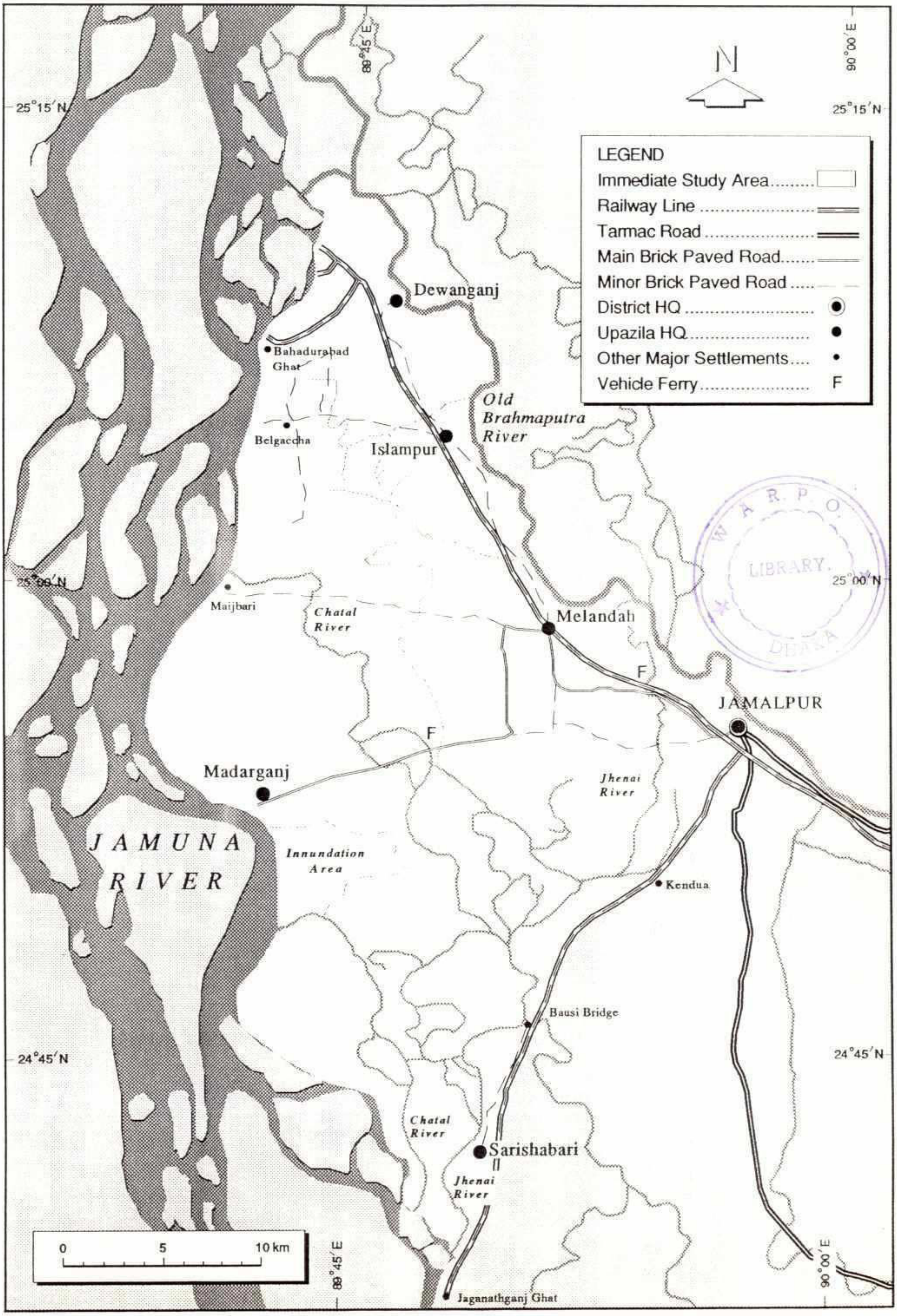
Base Map Source: FAP 3 Interim Report, updated with SPOT Imagery of 20th November 199[illegible]

Figure 3.1.2



Base Source: SPOT Satellite Image of 20th November 1990, Updated with Landsat TM Imagery of 8th March 1992

FAP 3.1 Study Area - November 1990



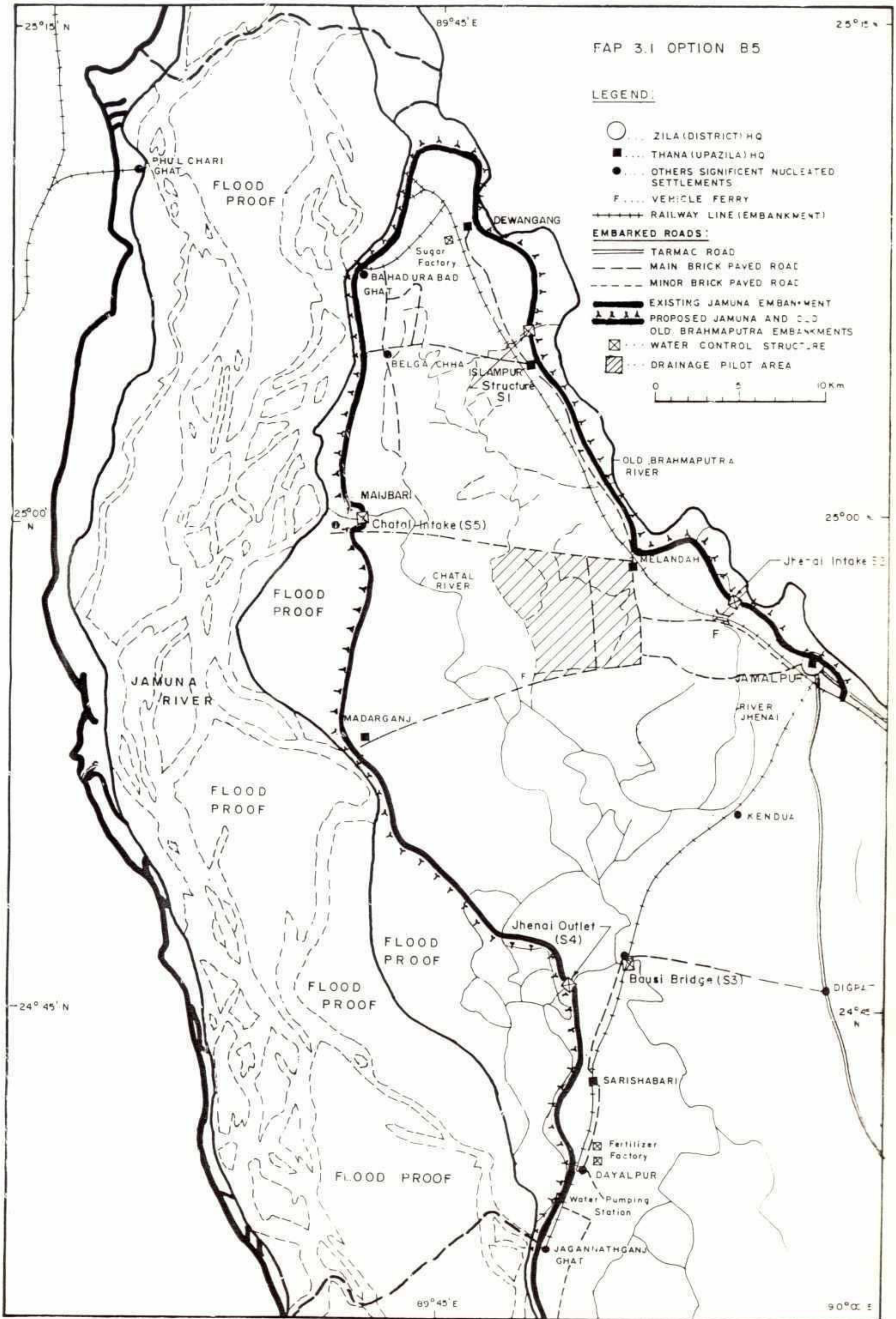
base-1..gem

Base Map Source: SPOT Imagery of 20th November 1990

123

Figure 3.1.4

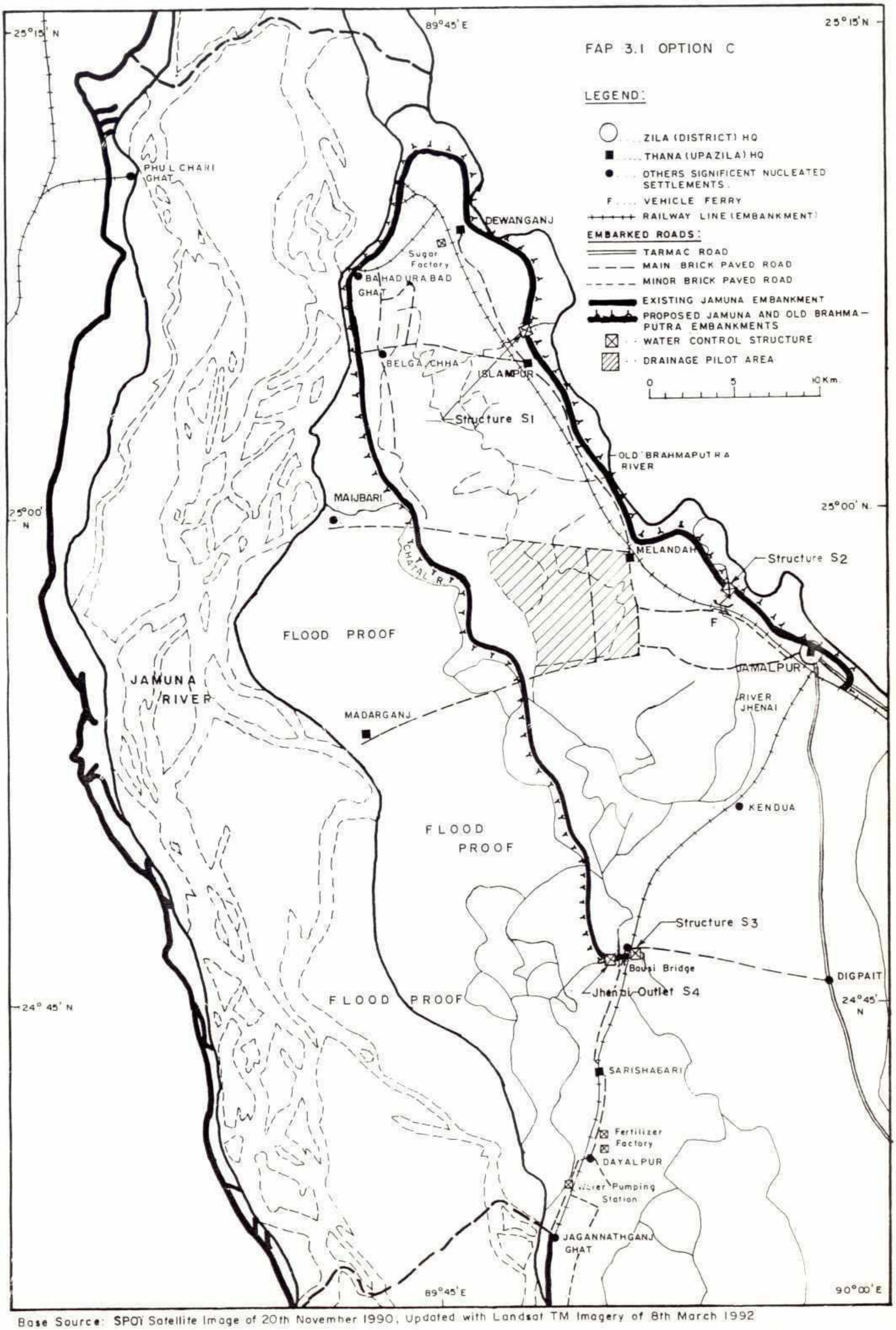
General Layout - Option B5/D



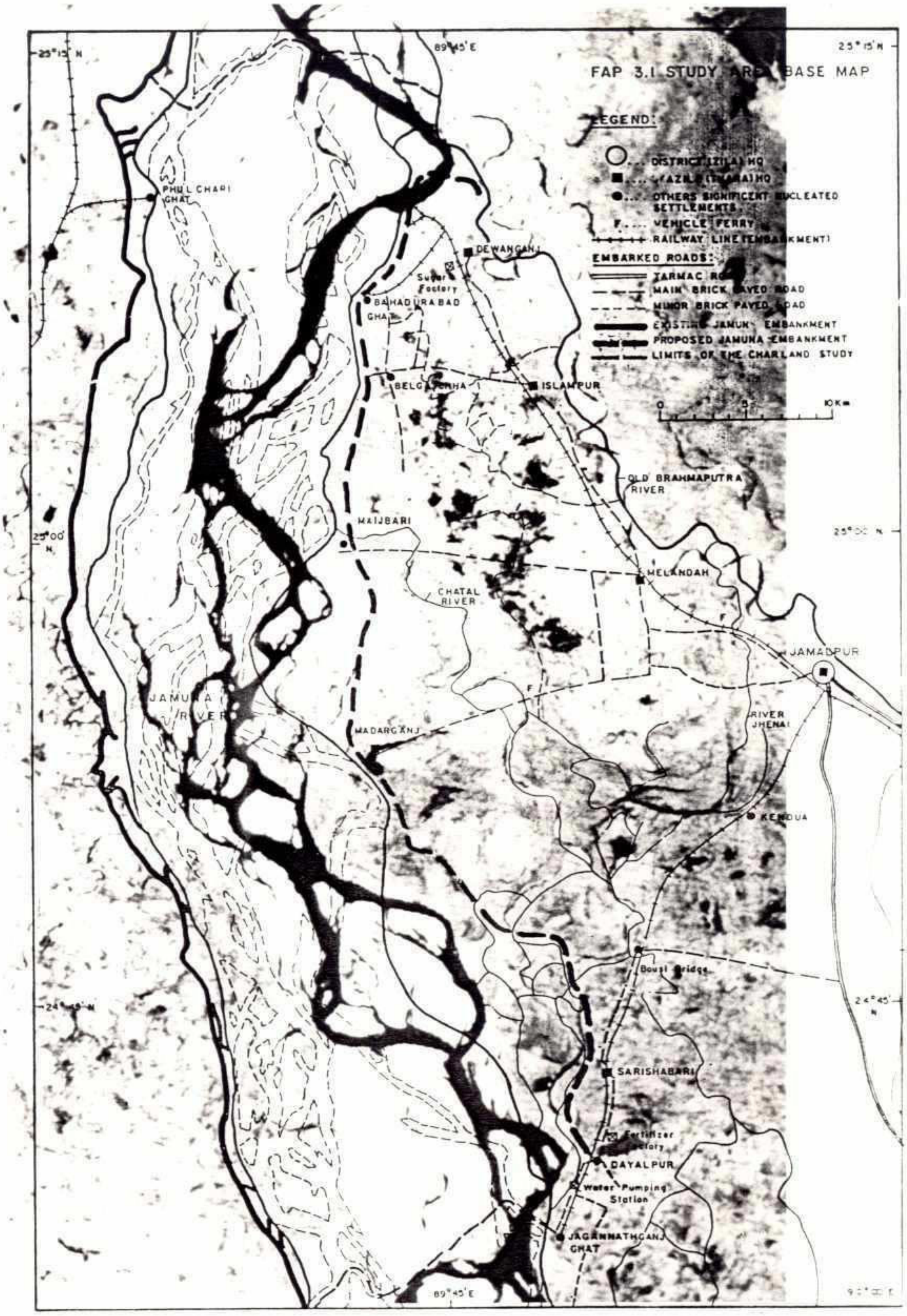
Base Source: SPOT Satellite Image of 20th November 1990, Updated with Landsat TM Imagery of 8th March 1992

Figure 3.1.5

General Layout - Option C



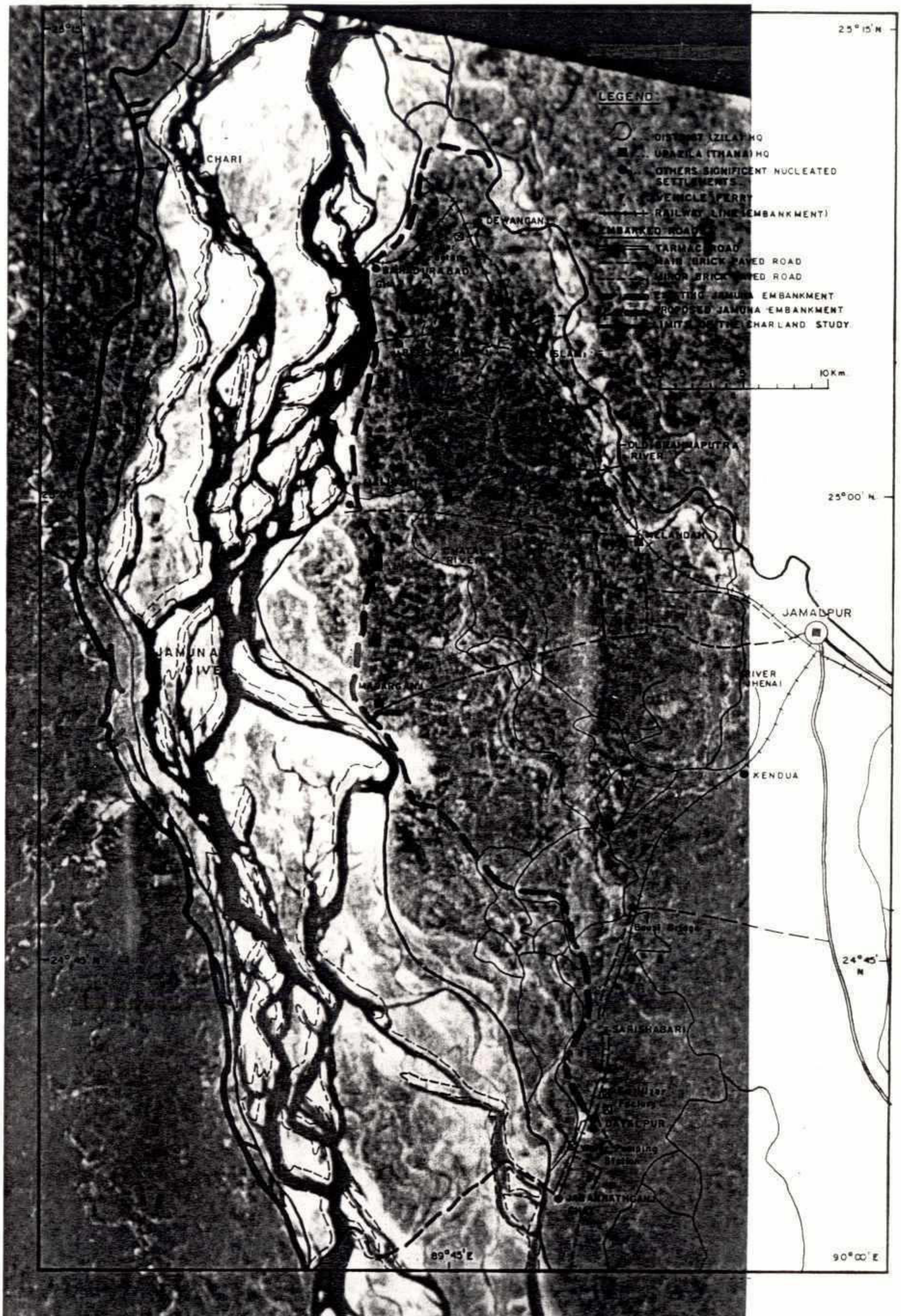
Base Source: SPOT Satellite Image of 20th Novemher 1990, Updated with Landsat TM Imagery of 8th March 1992



Landsat Image 21st February 1973

126

Figure 3.2.2



Landsat Image 8th March 1992

Figure 7.2

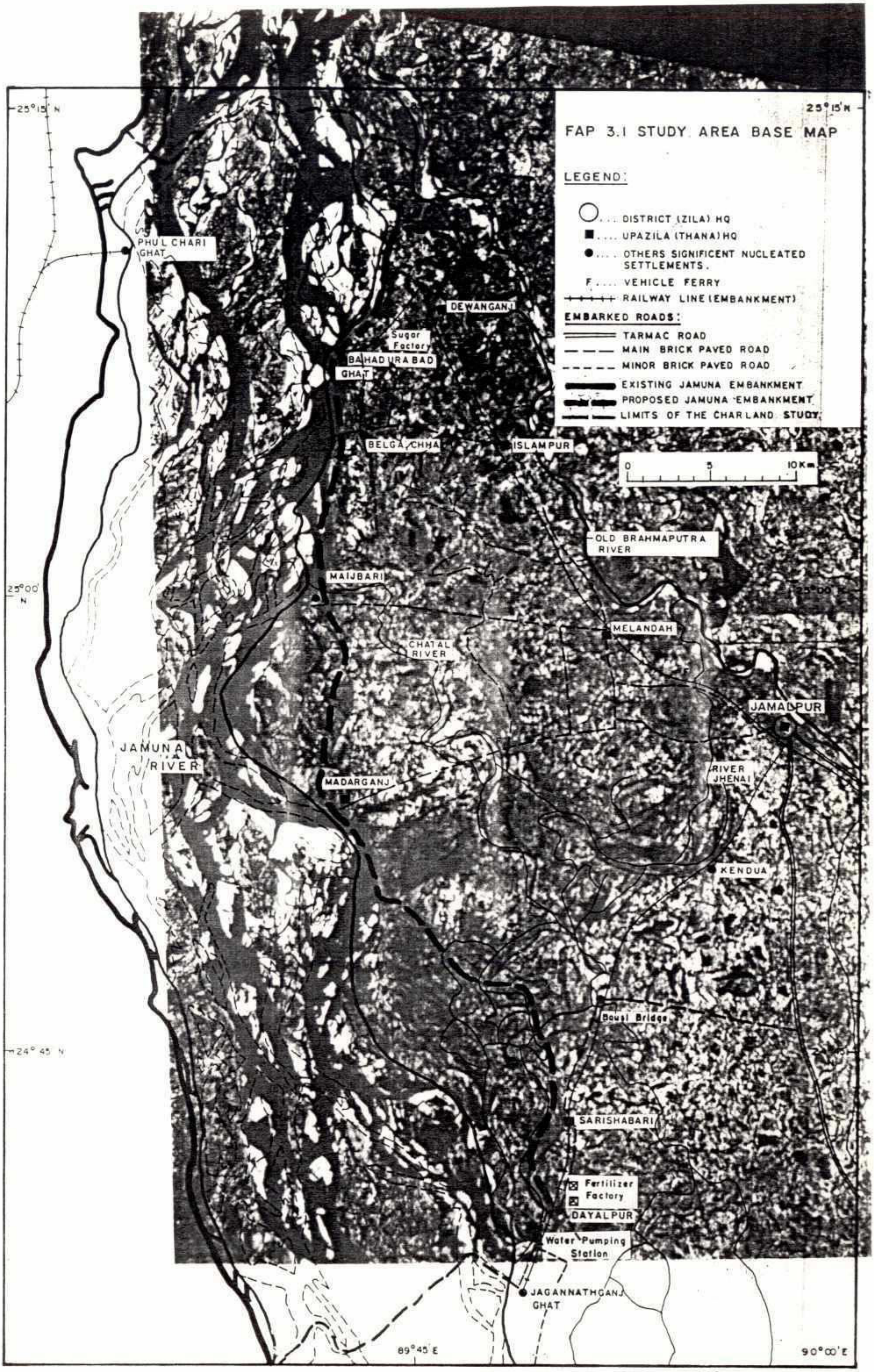

FAP 3.1 STUDY AREA BASE MAP
LEGEND:
DISTRICT (ZILA) HQ
UPAZILA (THANA) HQ
OTHERS SIGNIFICENT NUCLEATED SETTLEMENTS.
F.... VEHICLE FERRY
RAILWAY LINE (EMBANKMENT)
EMBARKED ROADS:
TARMAC ROAD
MAIN BRICK PAVED ROAD
MINOR BRICK PAVED ROAD
EXISTING JAMUNA EMBANKMENT
PROPOSED JAMUNA EMBANKMENT
LIMITS OF THE CHAR LAND STUDY
0
5
10Km
25°15' N
25°00' N
24°45' N
89°45' E
90°00' E
PHUL CHARI GHAT
DEWANGANJ
Sugar Factory
BAHADURABAD GHAT
BELGACHHA
ISLAMPUR
OLD BRAHMAPUTRA RIVER
MAIJBARI
MELANDAH
CHATAL RIVER
JAMALPUR
JAMUNA RIVER
RIVER JHENAI
MADARGANJ
KENDUA
Bousi Bridge
SARISHABARI
Fertilizer Factory
DAYALPUR
Water Pumping Station
JAGANNATHGANJ GHAT

Figure 3.2.4

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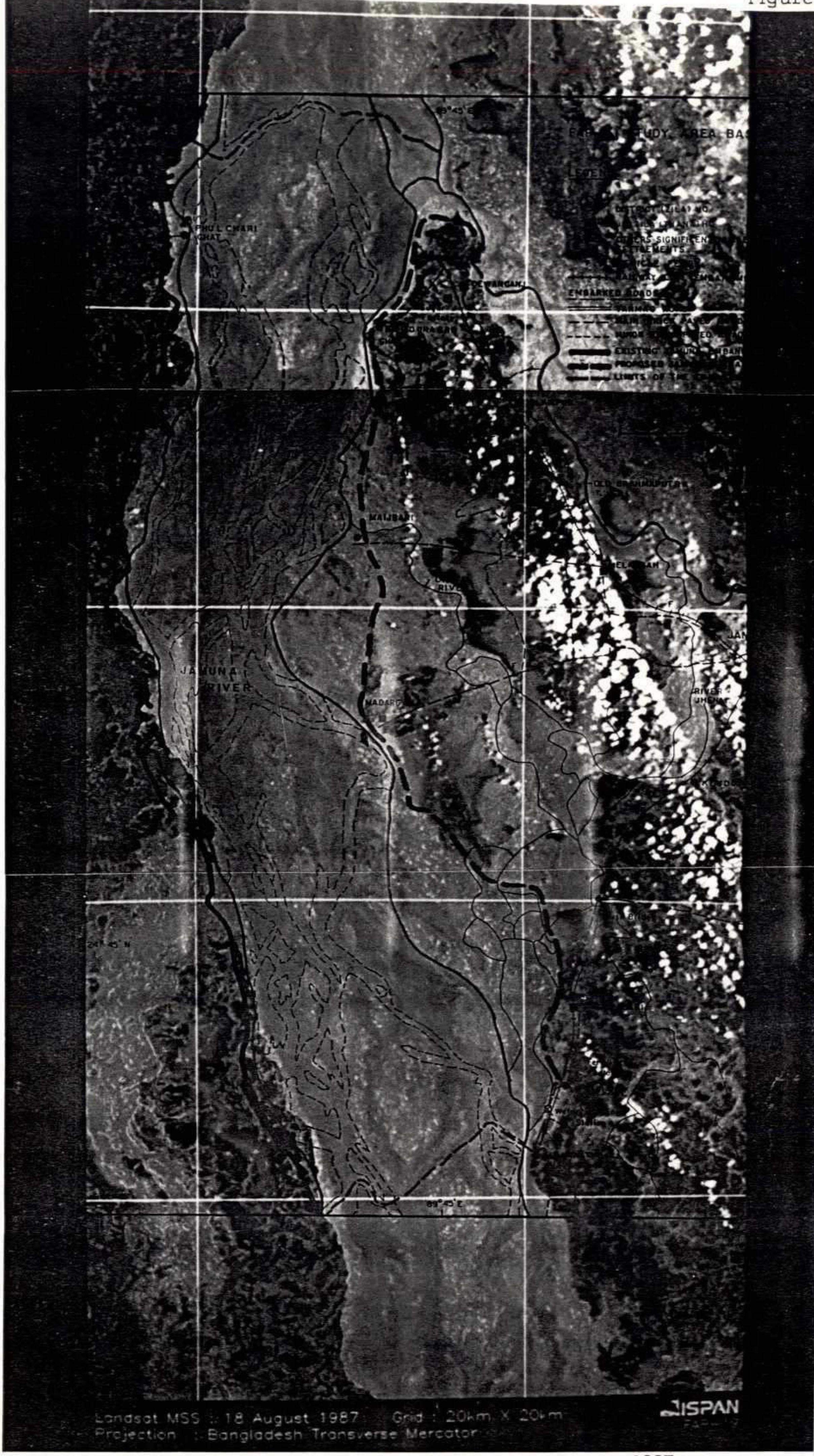
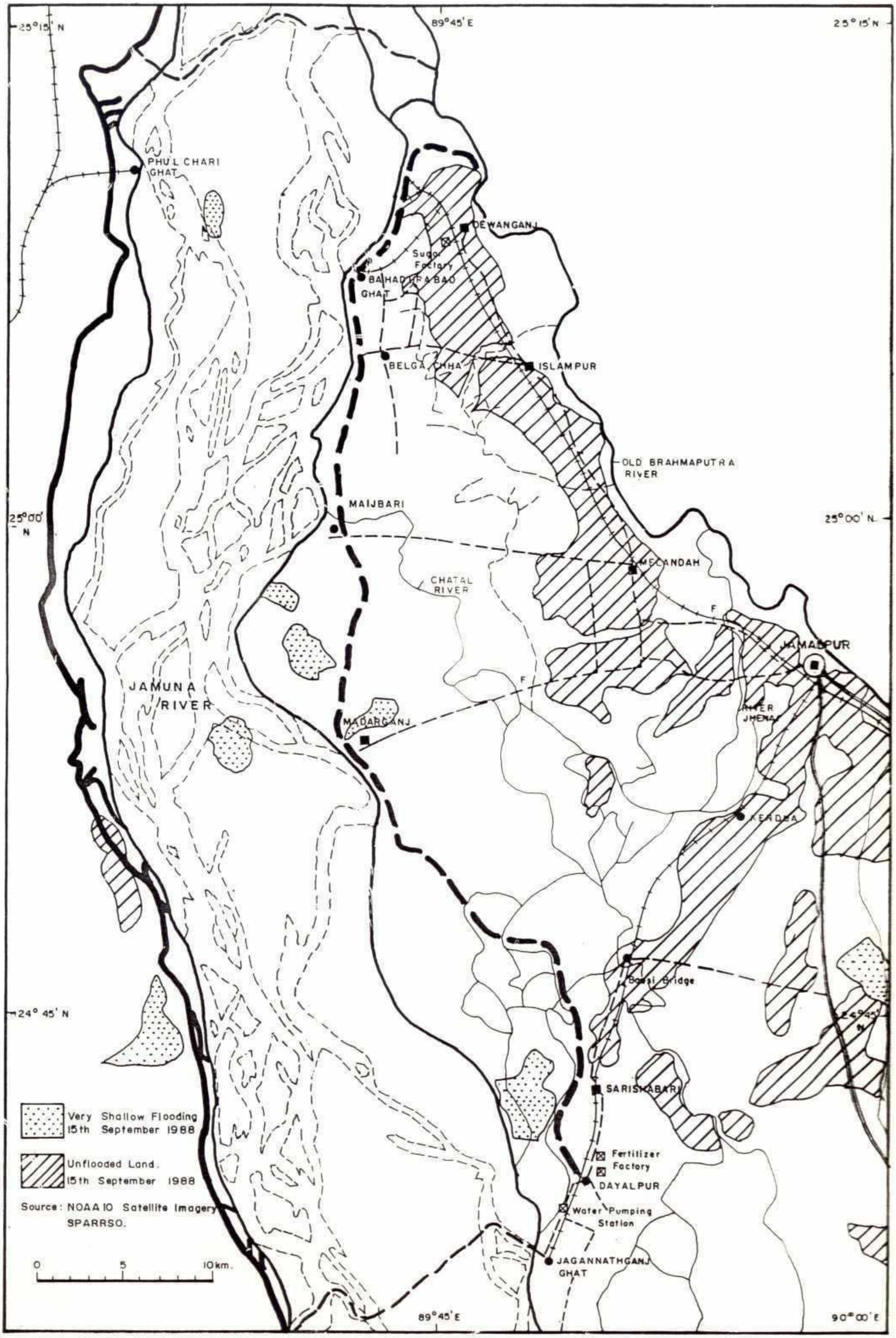


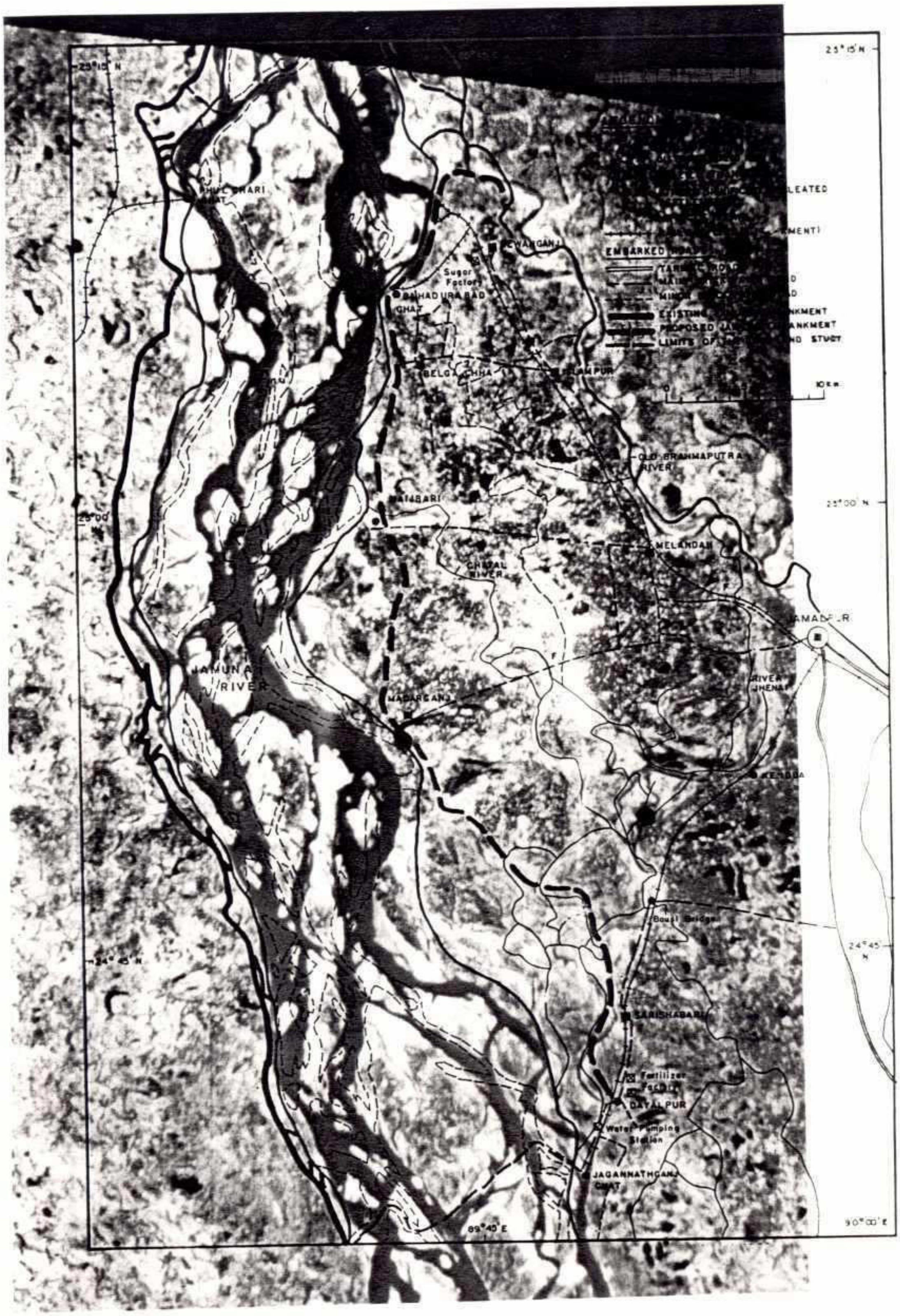
Landsat Image Peak Annual Flood Day - 18th August 1987

129

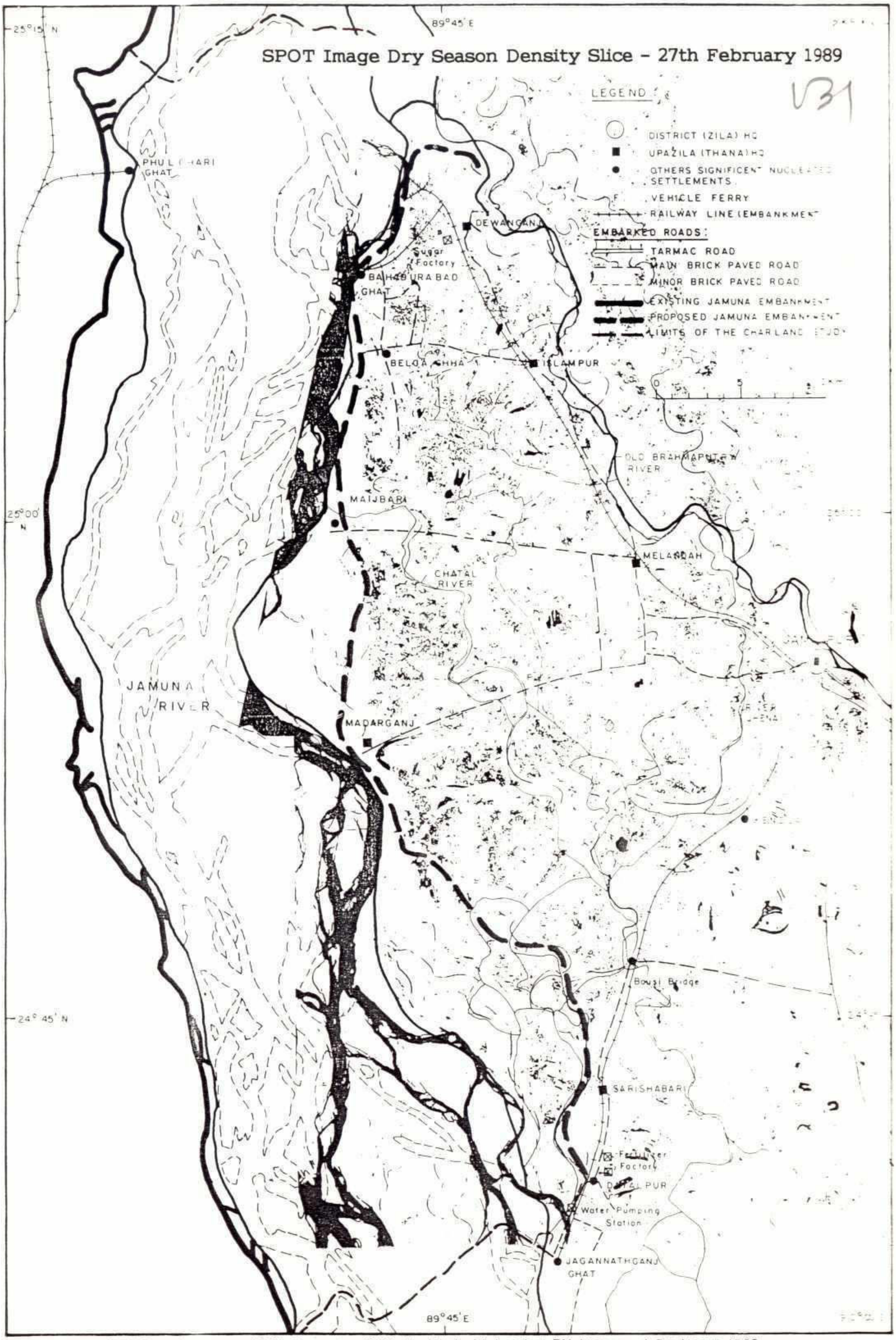
Unflooded Land SPARRSO Image 15th September 1988



130

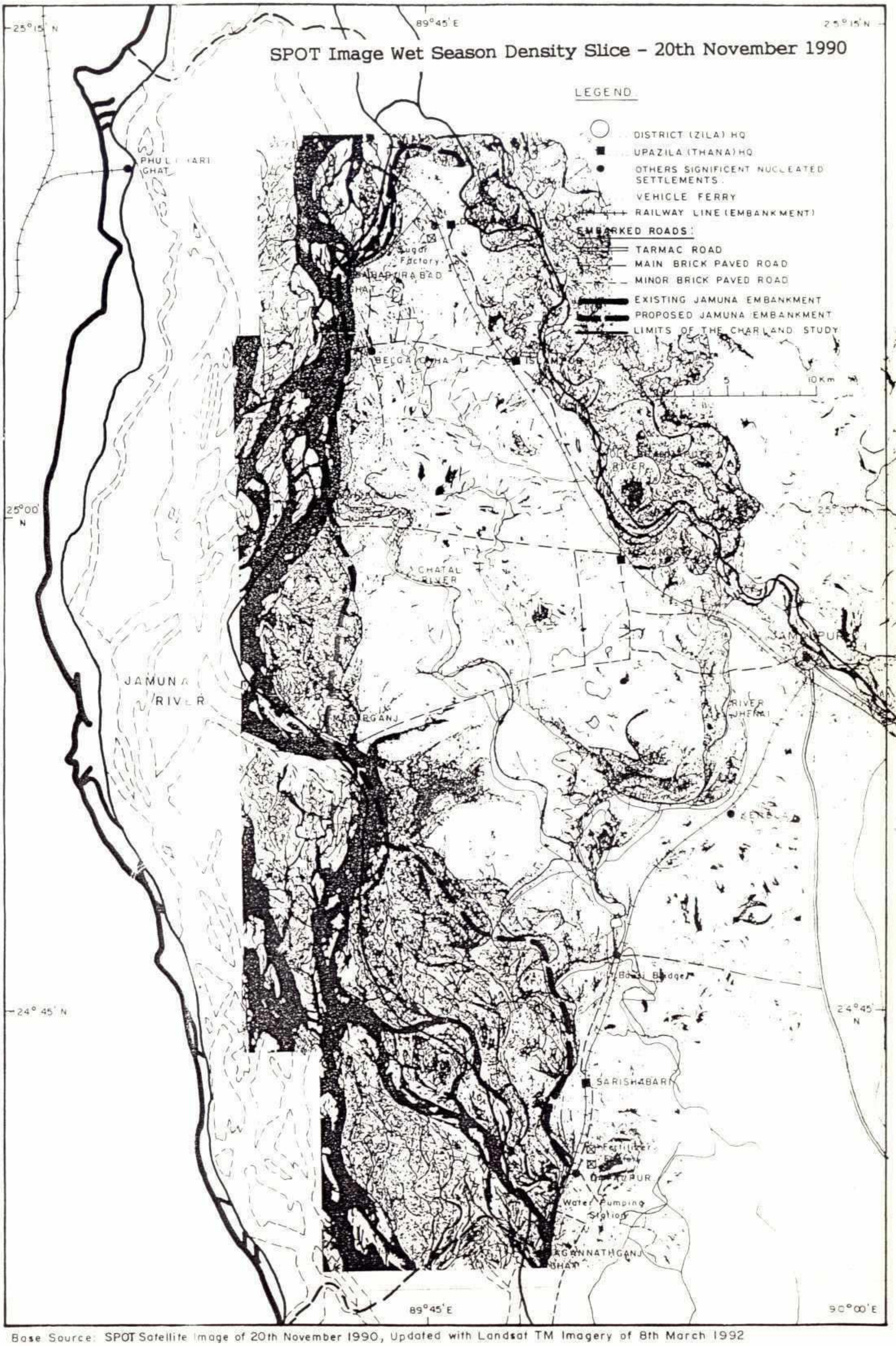


Landsat Image 8th November 1988



Base Source: SPOT Satellite Image of 20th November 1990, Updated with Landsat TM Imagery of 8th March 1992

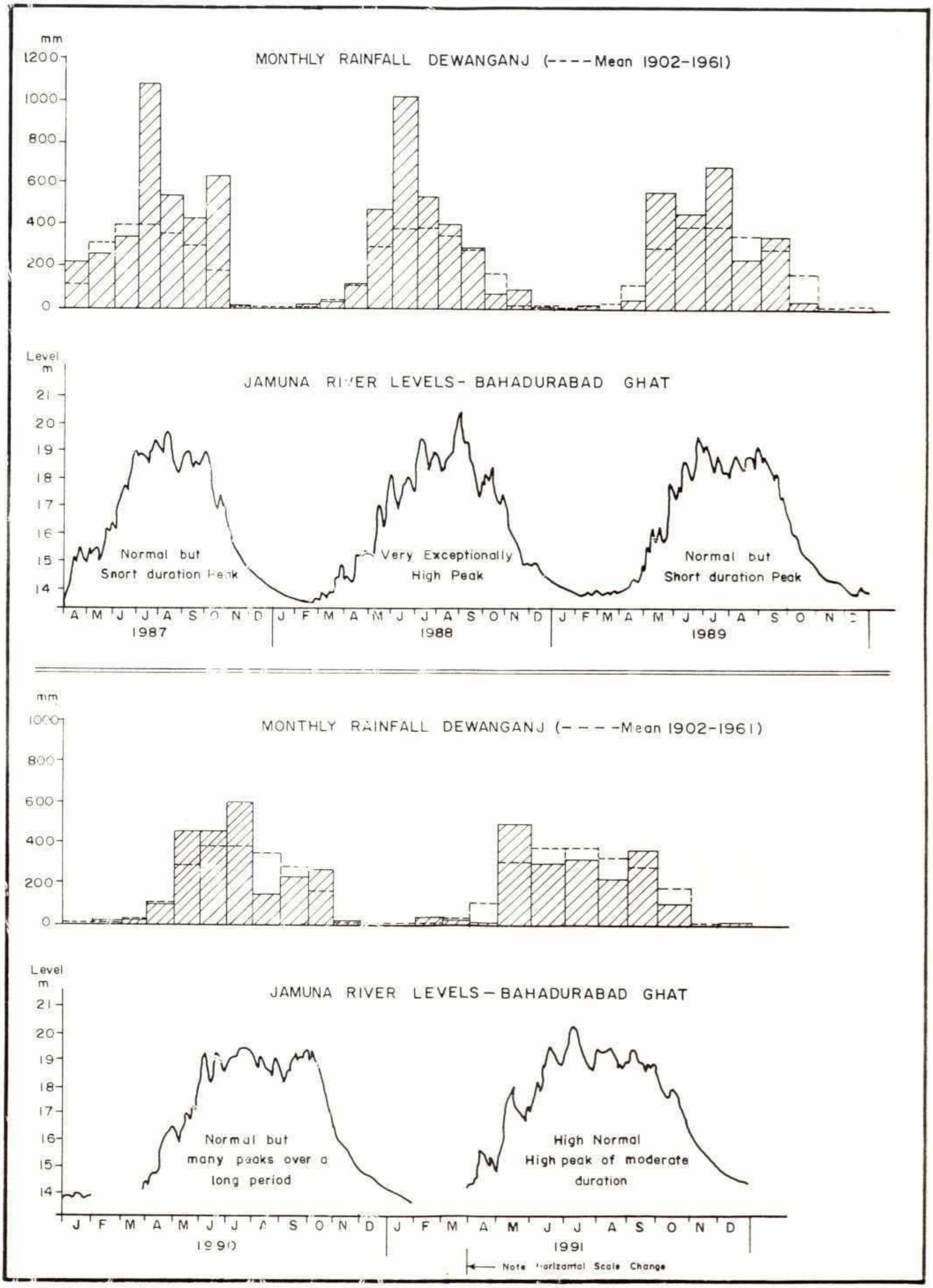
Figure 3.2.8

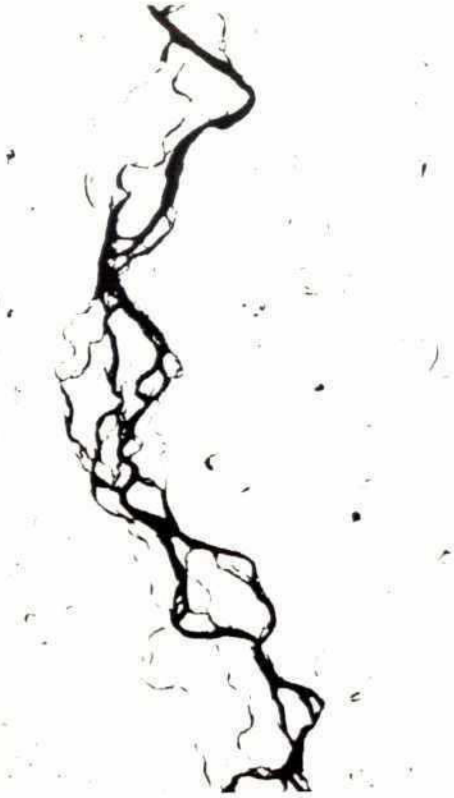


Base Source: SPOT Satellite Image of 20th November 1990, Updated with Landsat TM Imagery of 8th March 1992

Figure 3.2.9

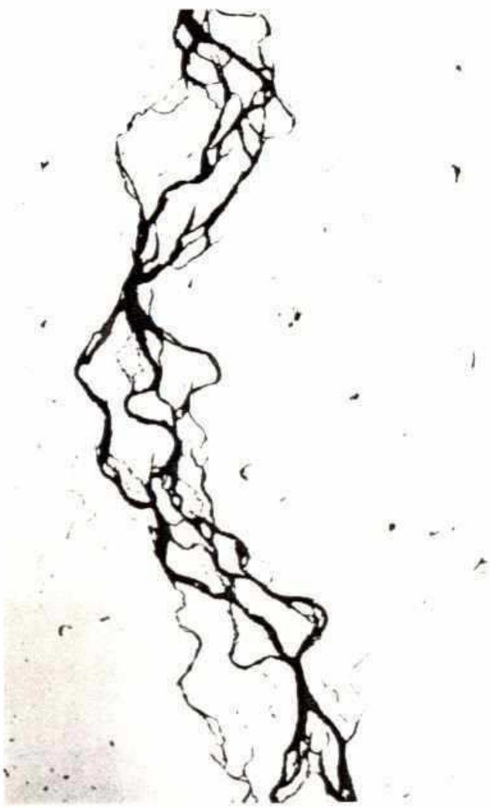
River Flood Hydrograph Bahadurabad Ghat and Monthly Rainfall Dewanganj 1987 - 1991



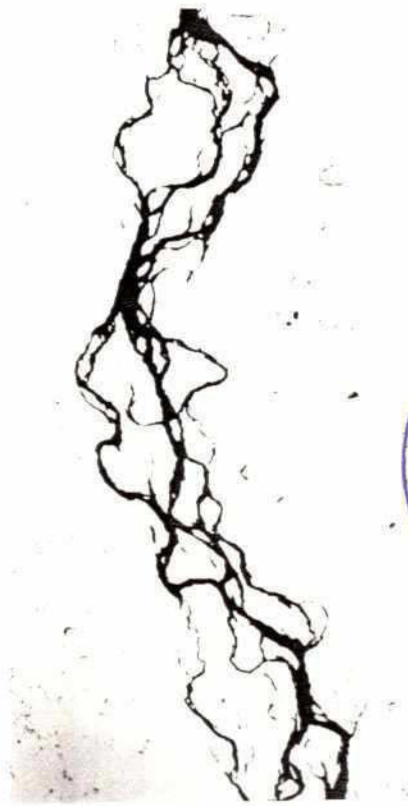


21st February 1973

10th January 1976



22nd February 1978



21st February 1980

Dry Season Low Flow Channel and Flood Patterns 1973, 1976, 1978, 1980

Figure 3.2.11

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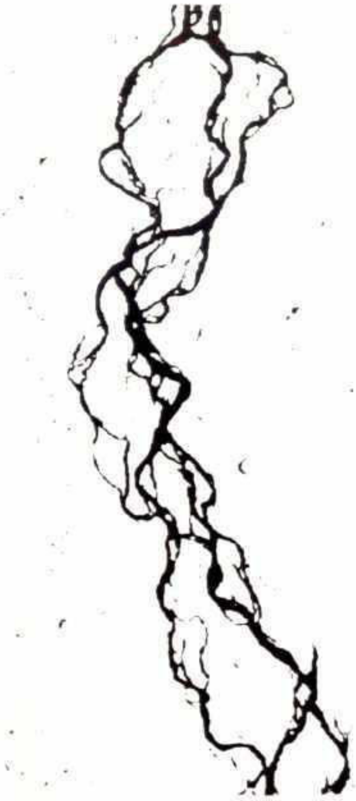
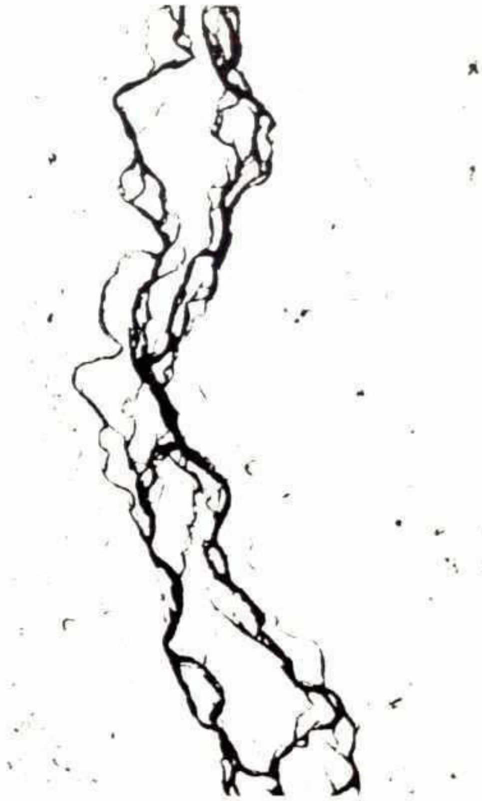
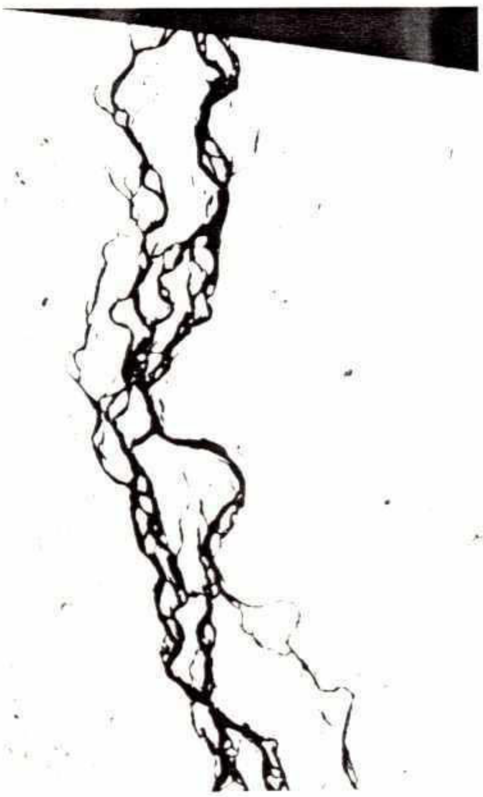


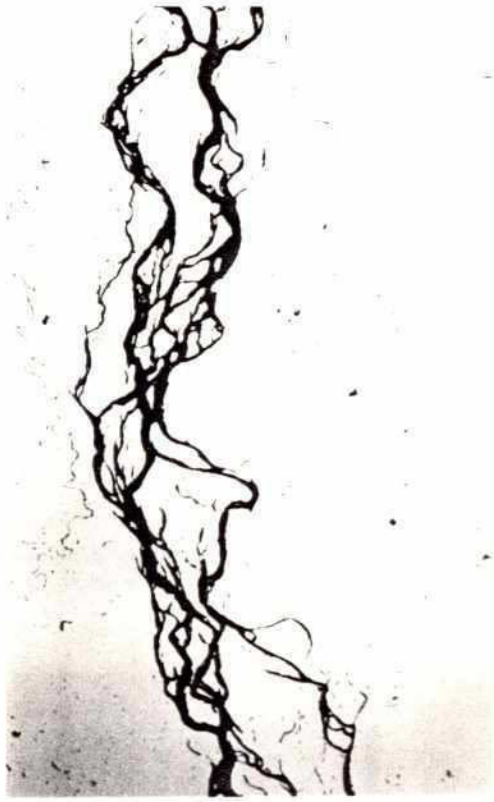
6th February 1984



7th February 1987



30th January 1990



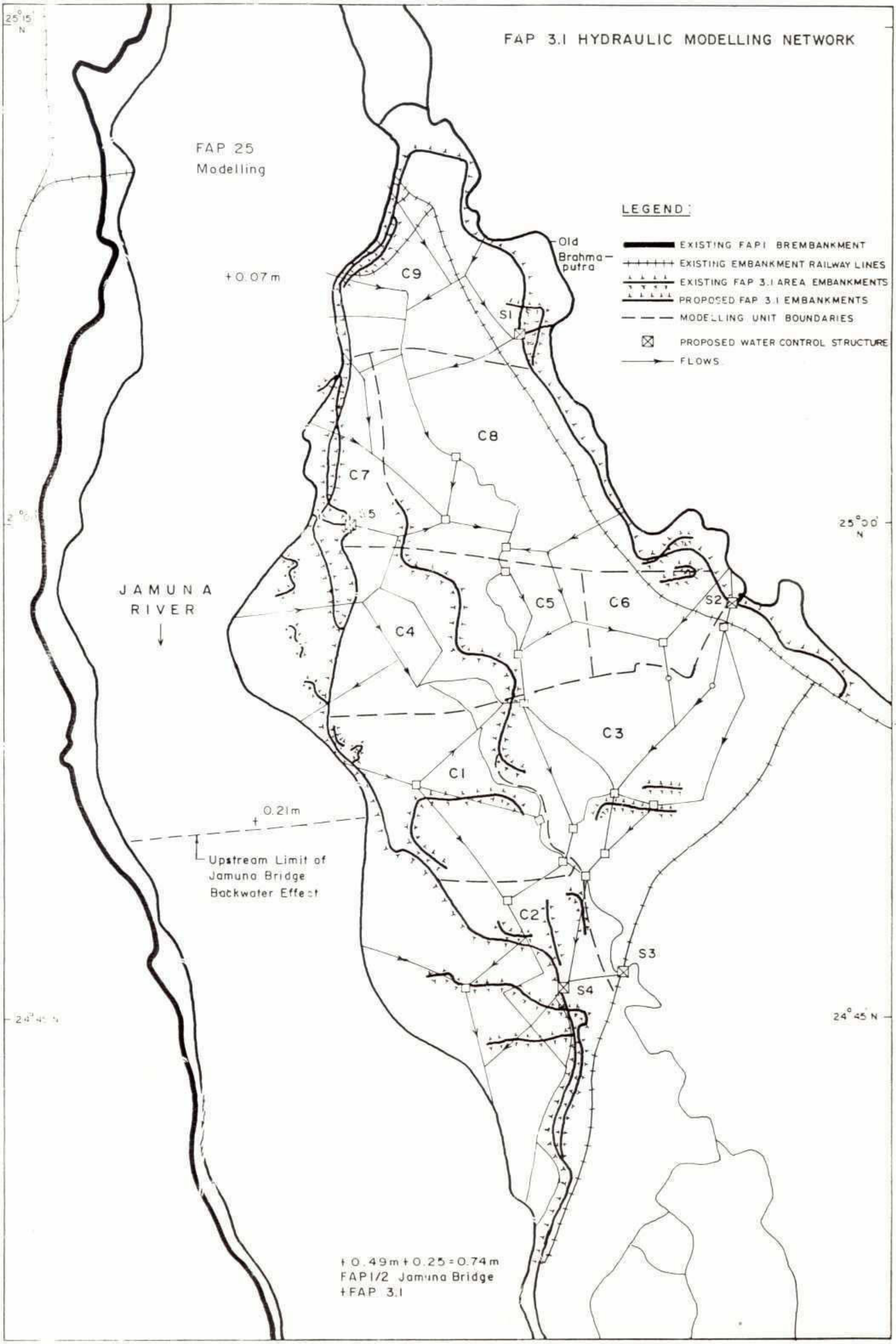
8th March 1992

Dry Season Low Flow Channel and Flood Patterns 1984, 1987, 1990, 1992

136

Figure 3.2.12

Hydraulic Model Network - Option B5



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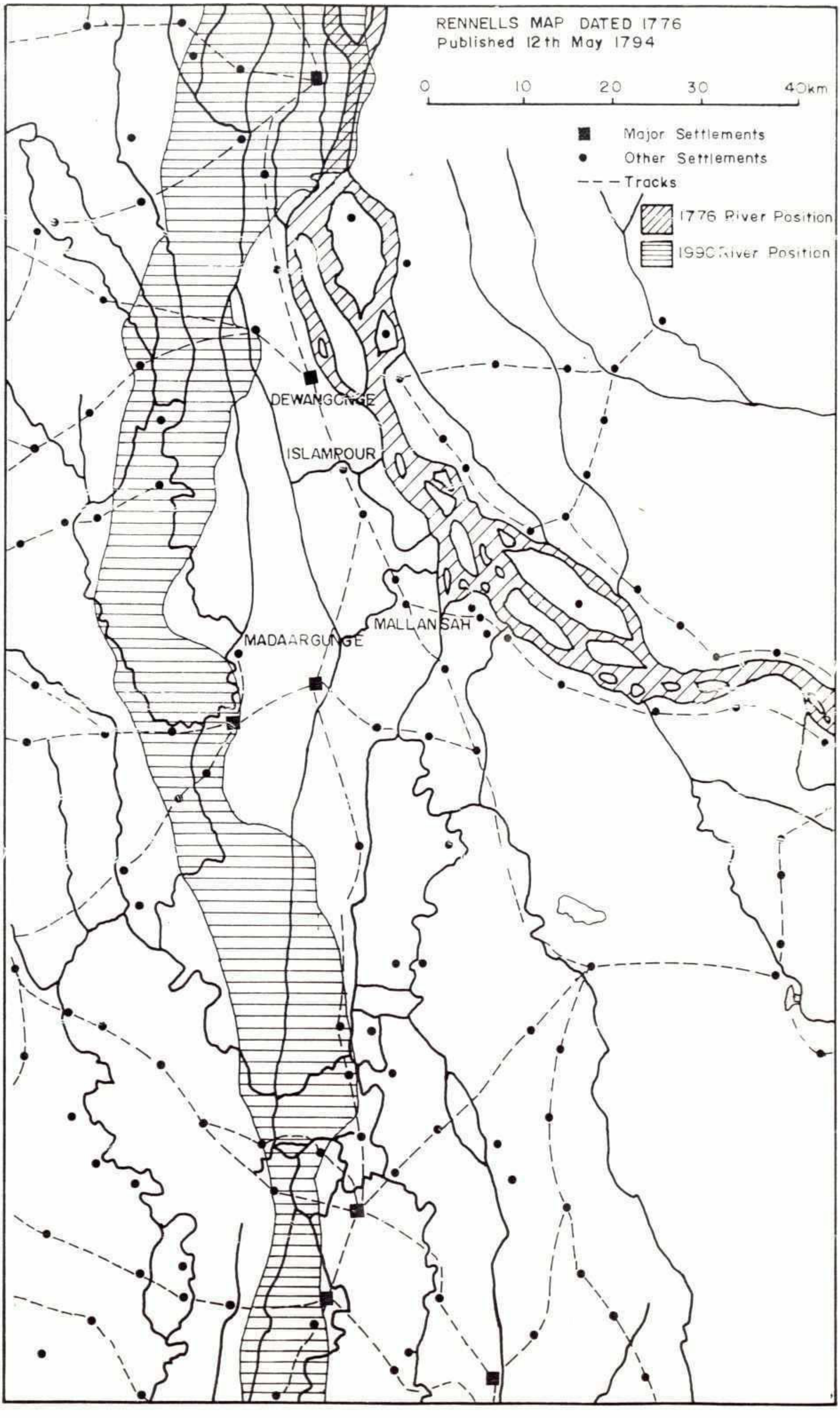
Rennells Map 1776 with Superimposed 1990 River Position



V3 8 Figure 3.2.14

FAP 3.1 River Alignment and Char Location Map 1907-1937 with Superimposed 1992 River Position

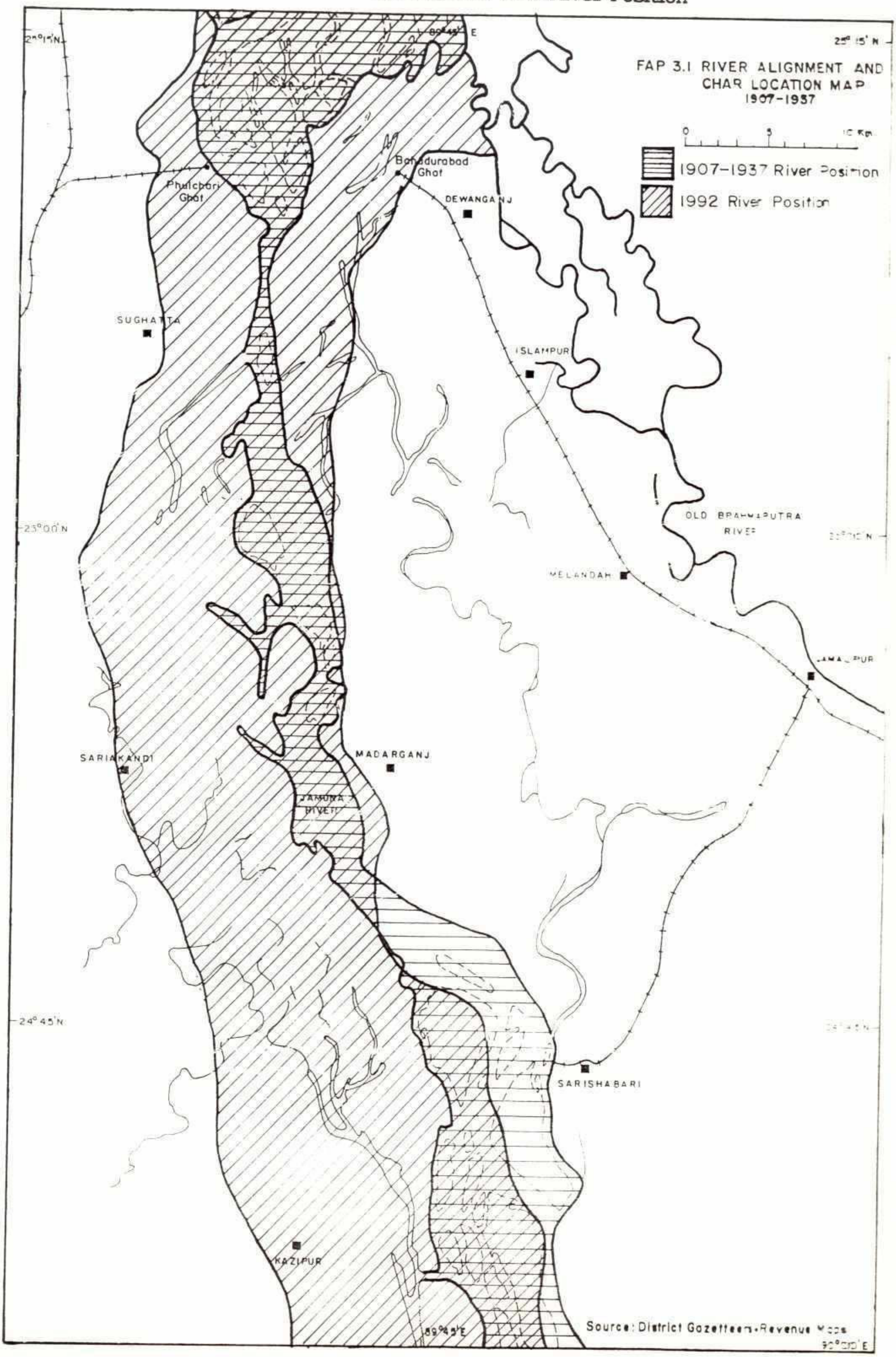
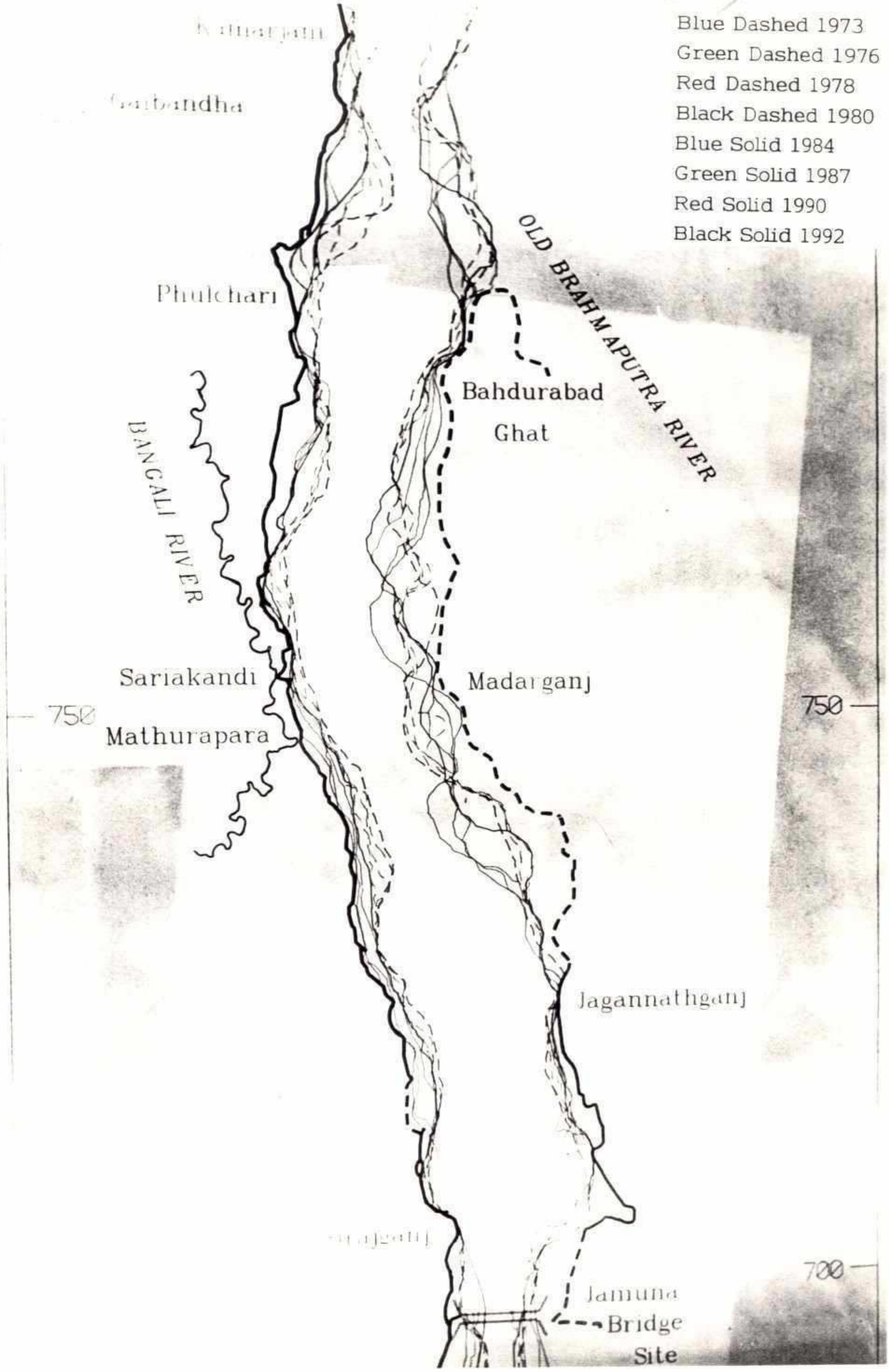


Figure 3.2.15



Jamuna Bank Alignments 1973-1992

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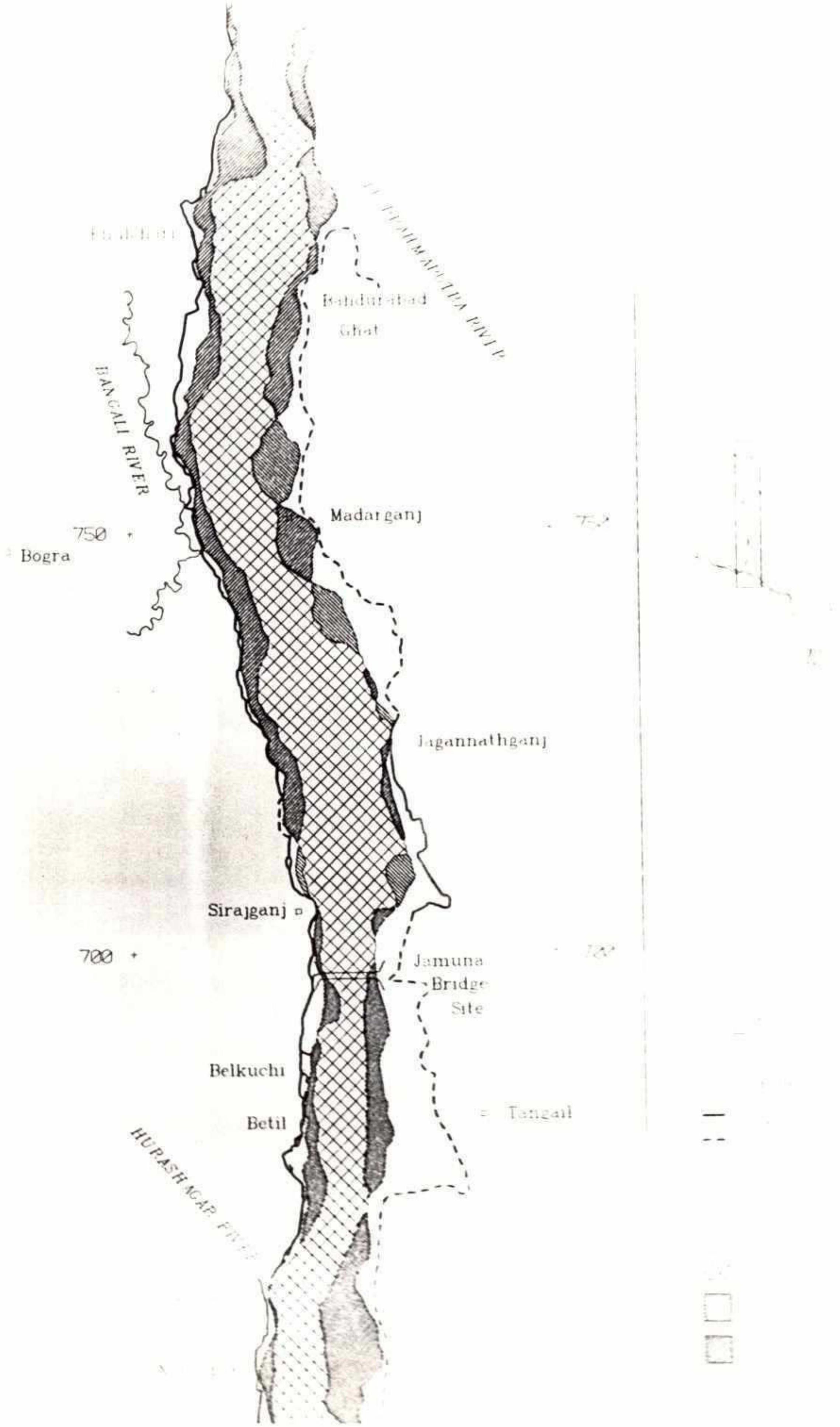
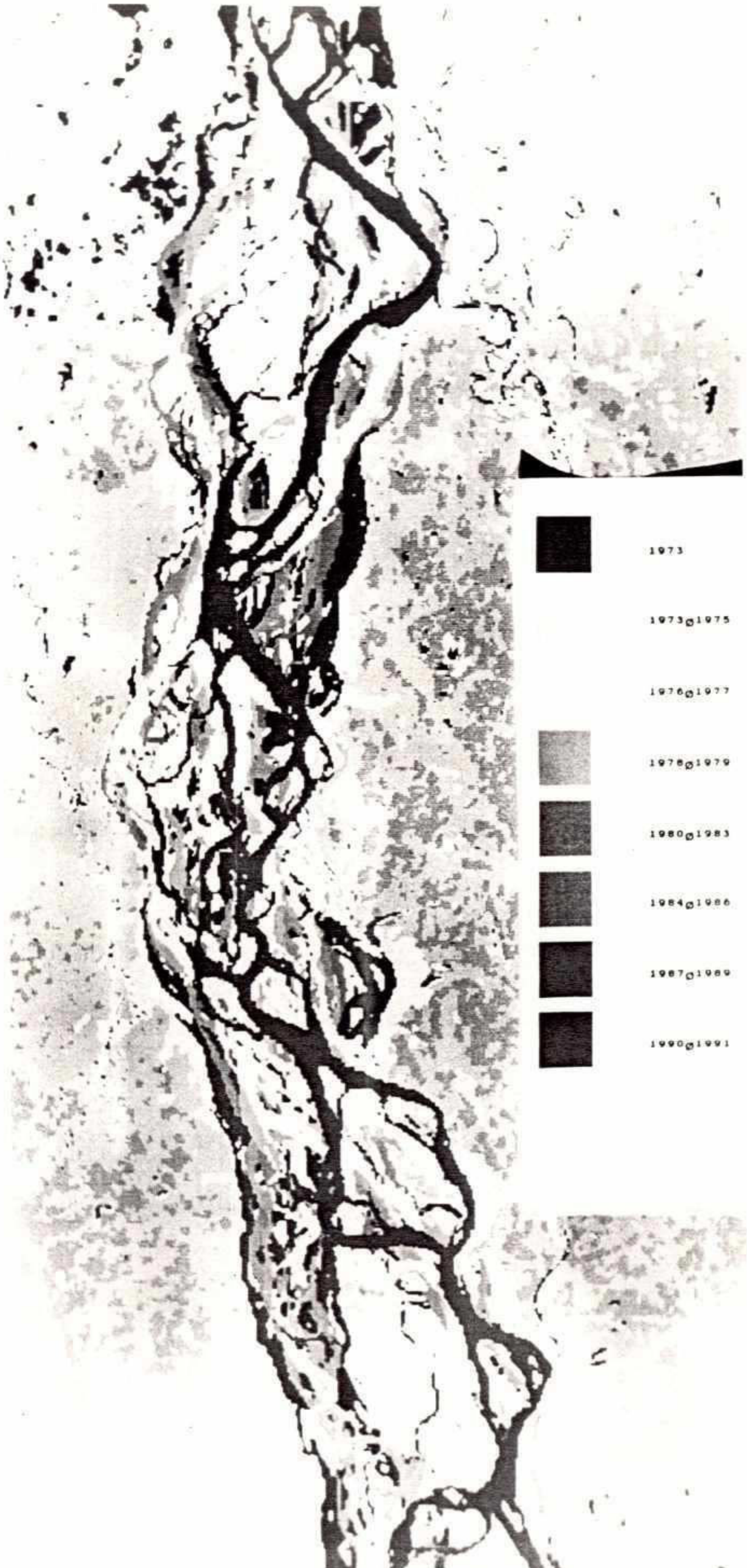
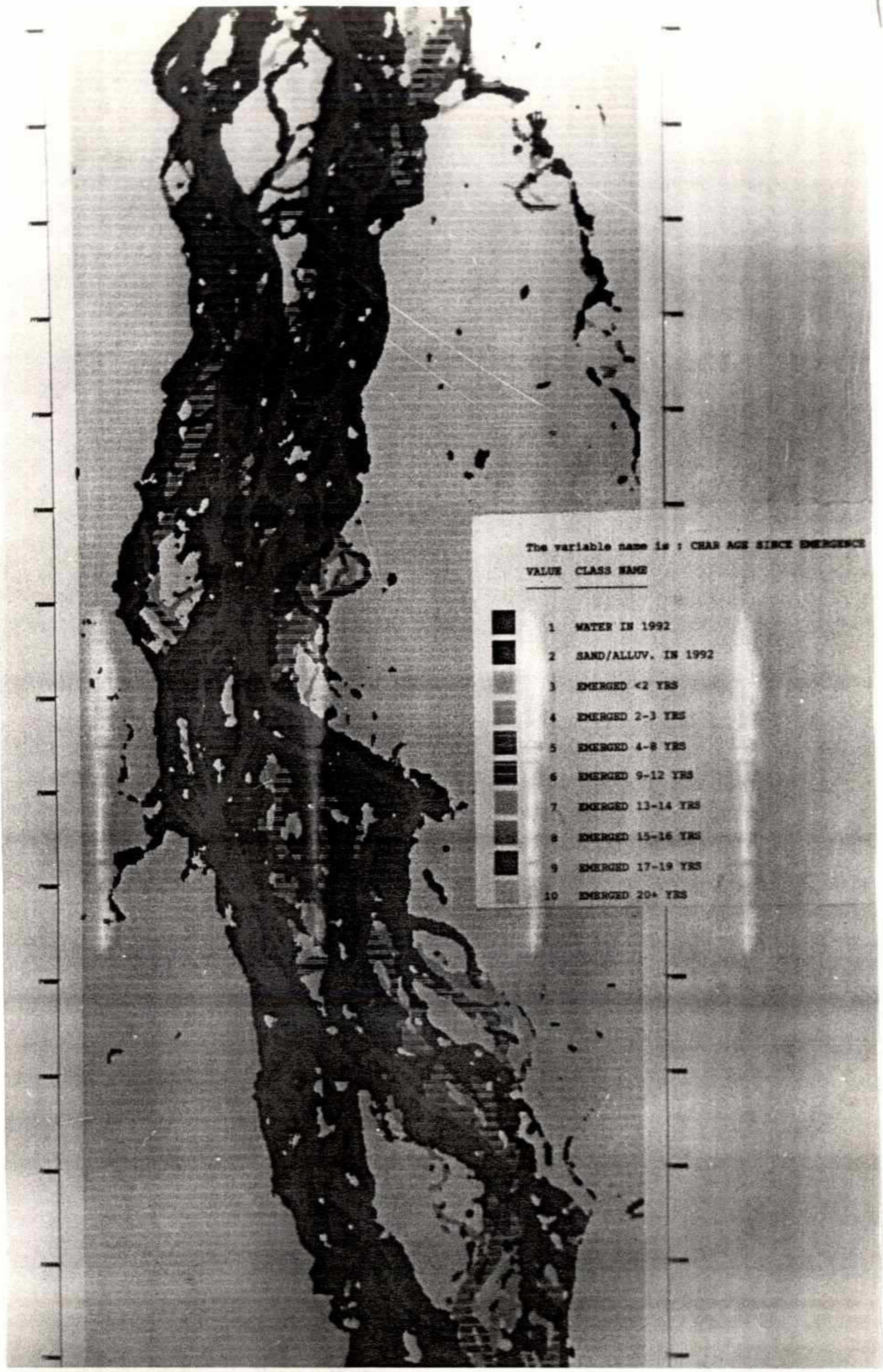


Jamuna Main Bank Erosion and Accretion 1973 to 1992



Progressive Main Bank Erosion Over the Last 20 Years



Progressive Land Accretion Over the Last 20 Years

143

Figure 3.2.19

Char Type Classification Map

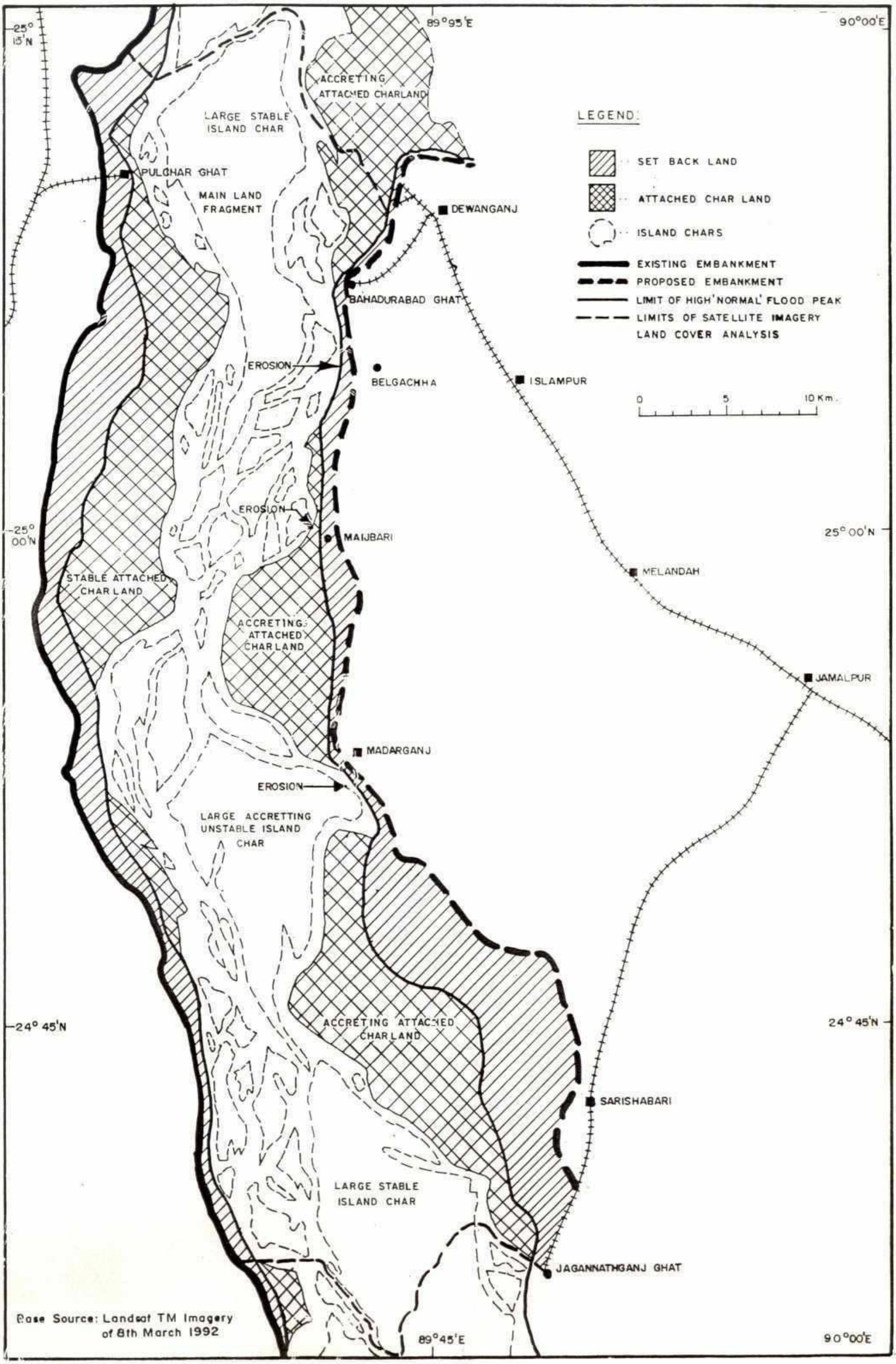


Figure 3.2.20

1991/92 Water Sample Locations

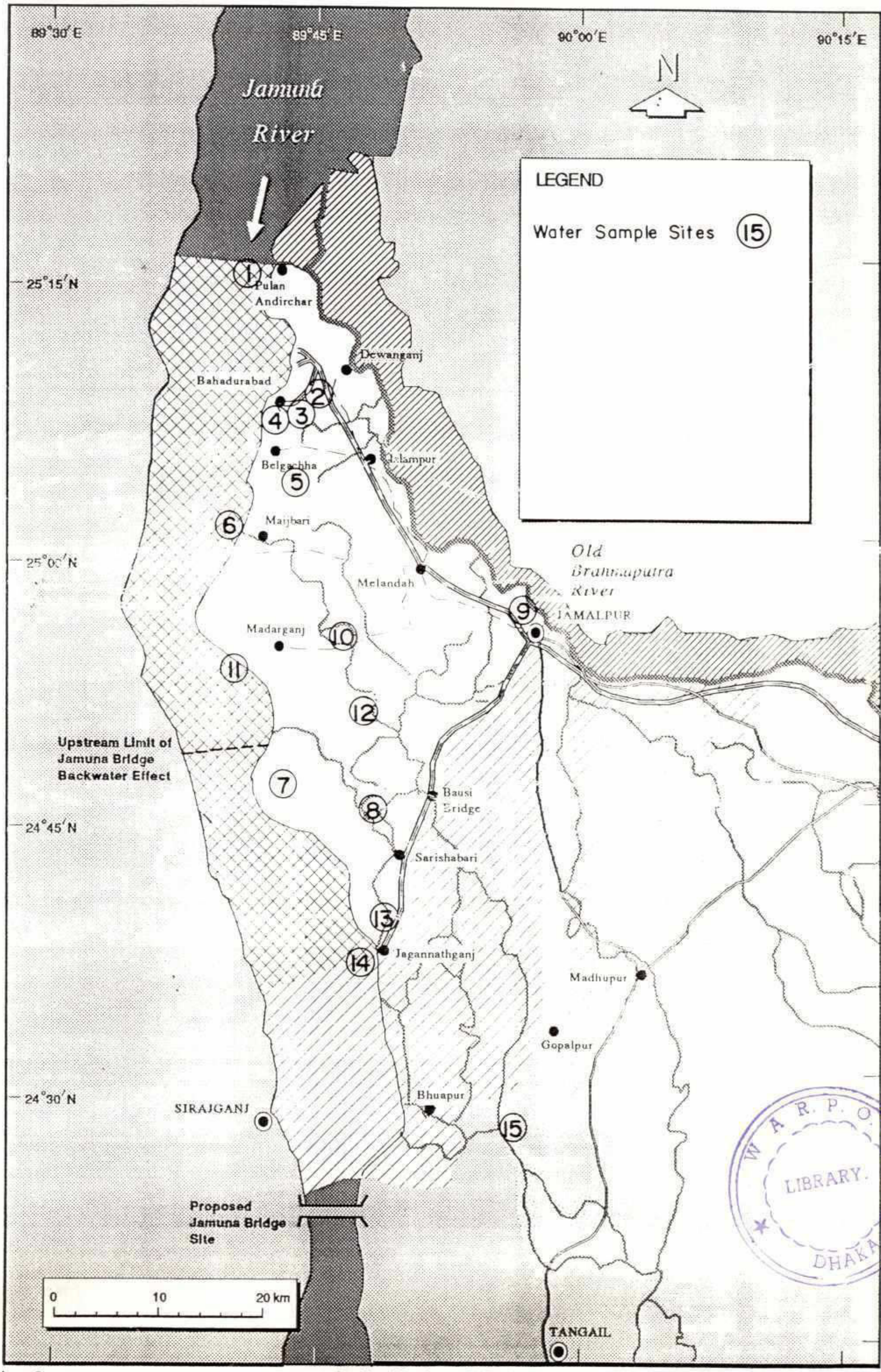
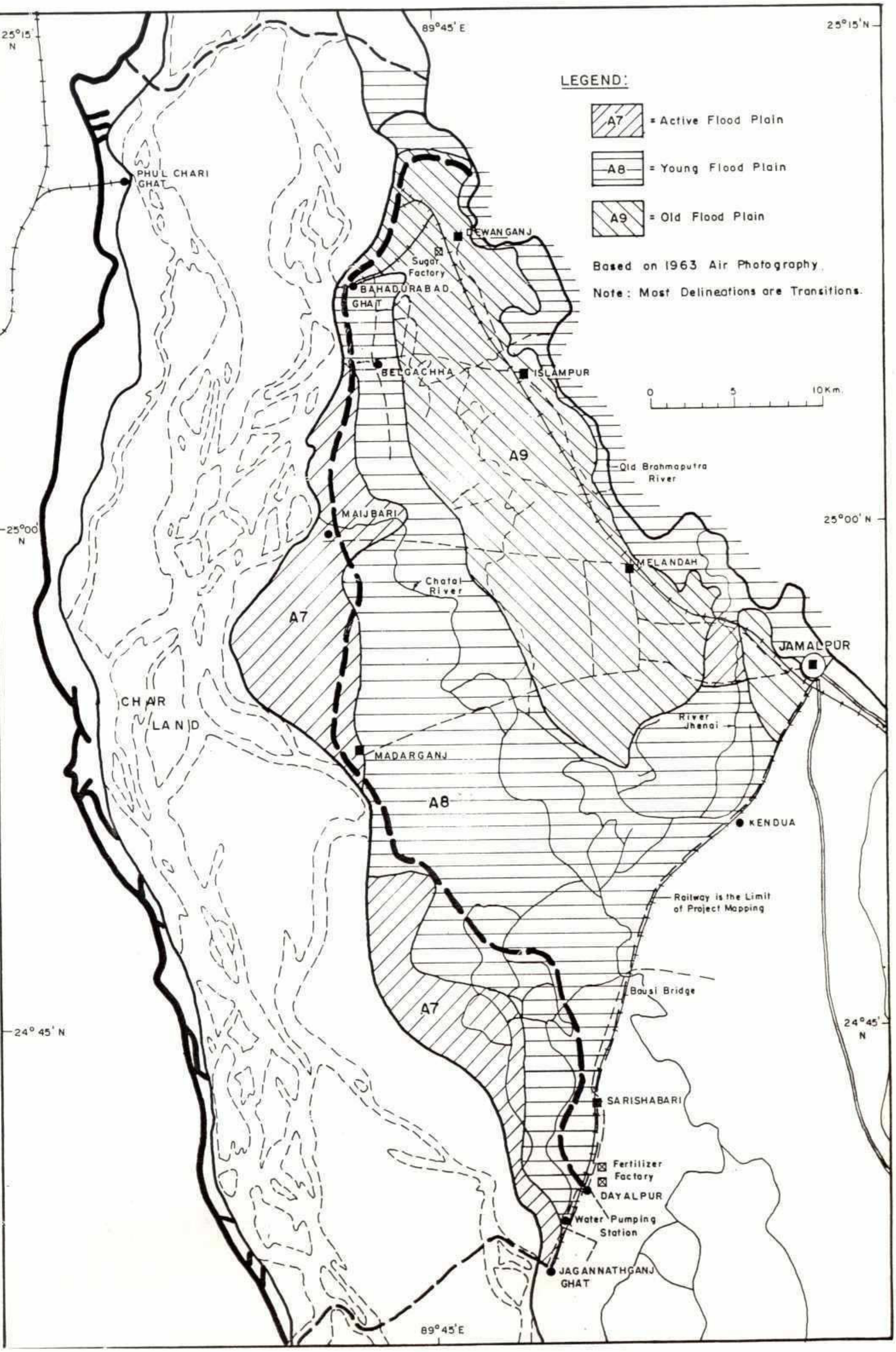


Figure 3.2.21

FAO 1988 Agro-Ecological Zones



146 Figure 3.2.22

FAP 3.1 Land Systems

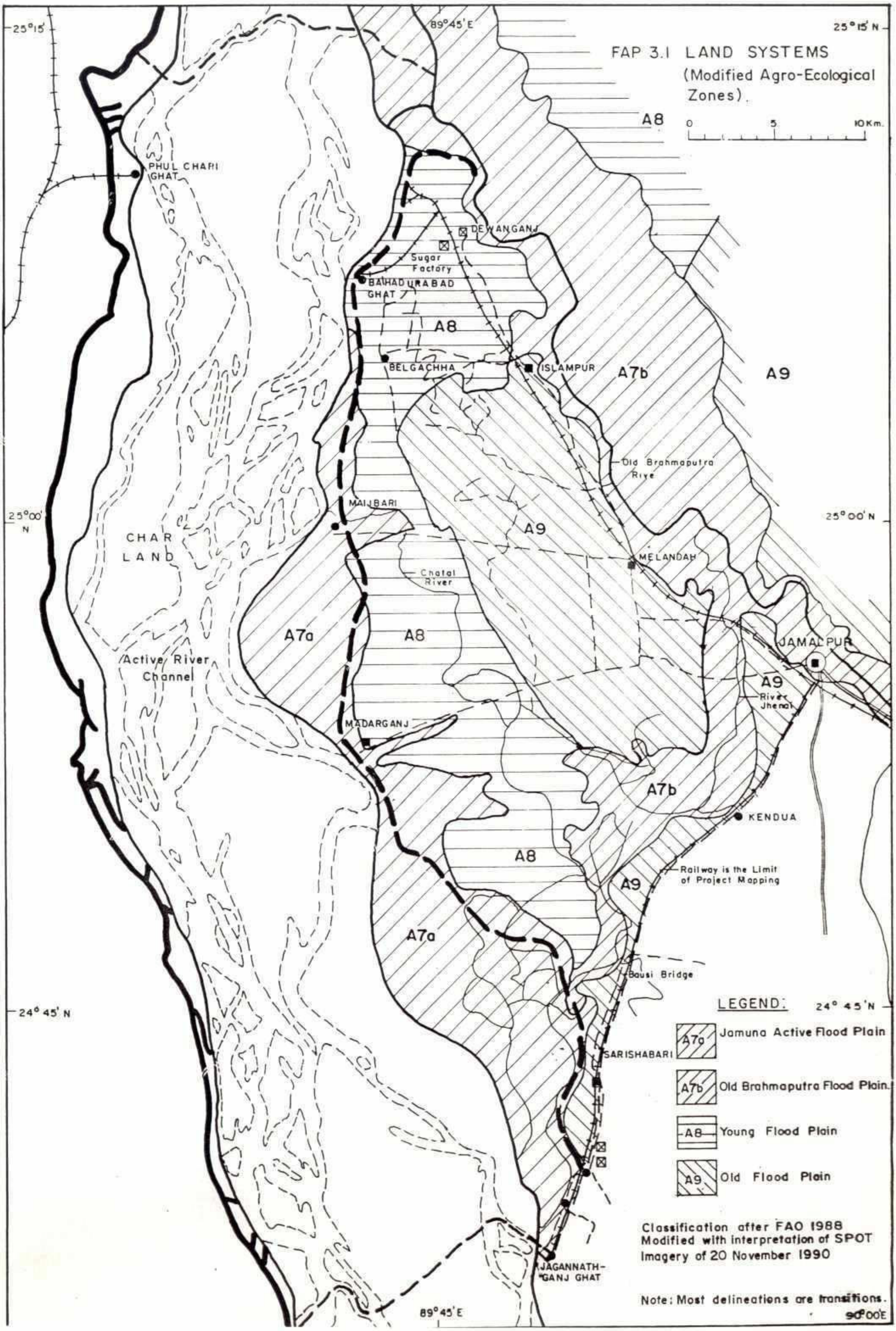


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Figure 3.2.23

Soil Chemistry Map

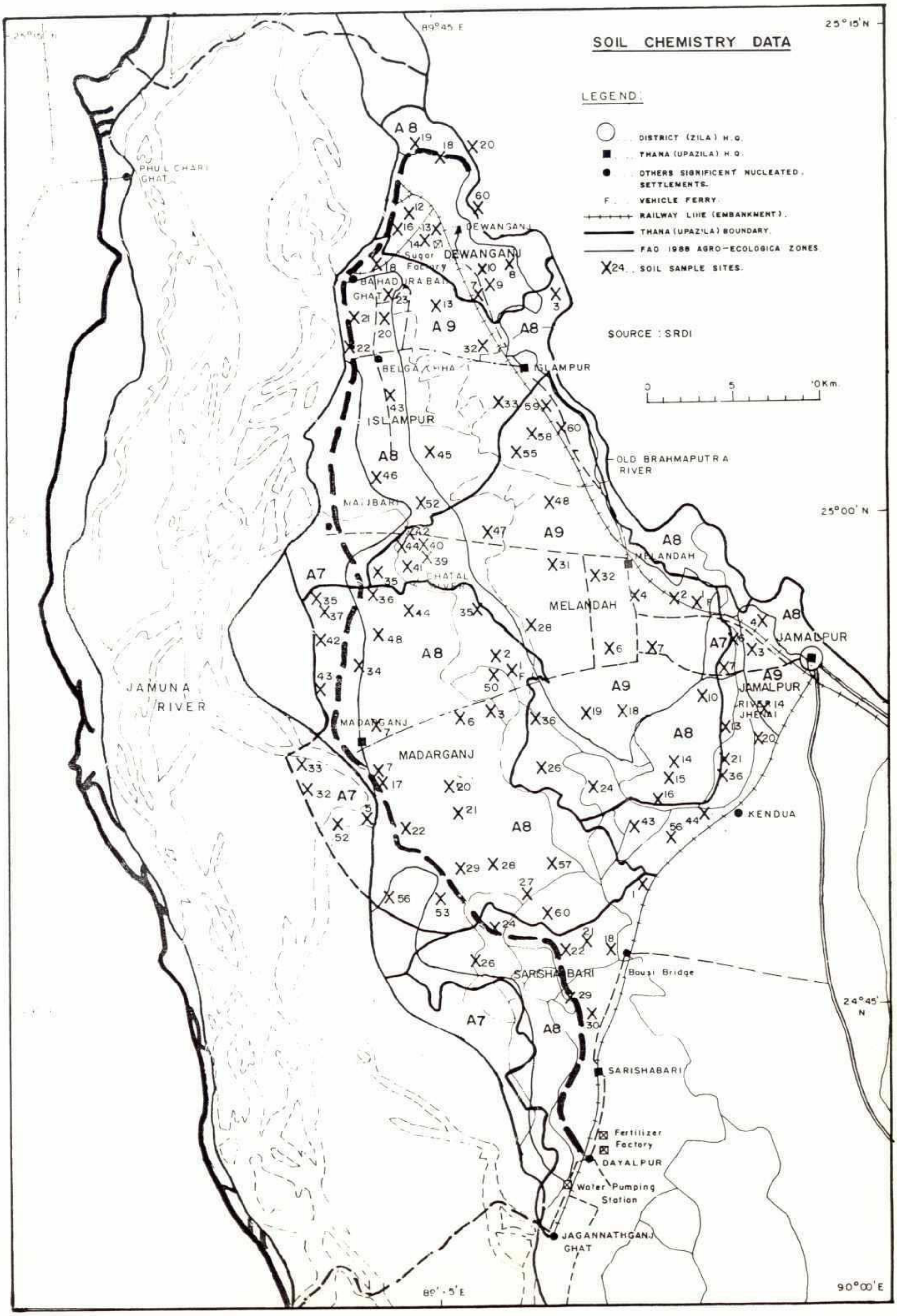

Figure 3.2.24

Socio-Economic Survey Sample Sites

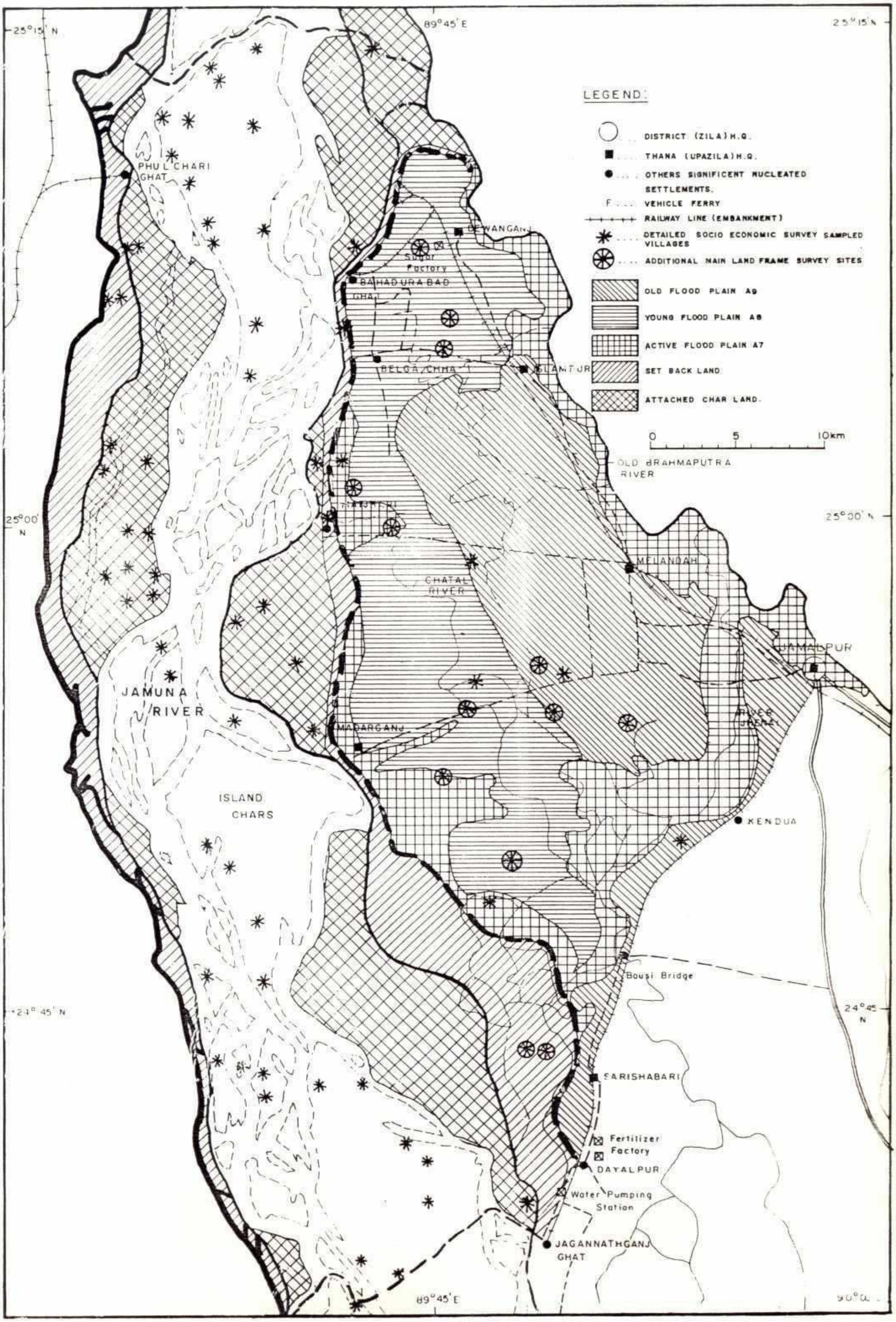

Figure 3.2.25

Population Density 1981

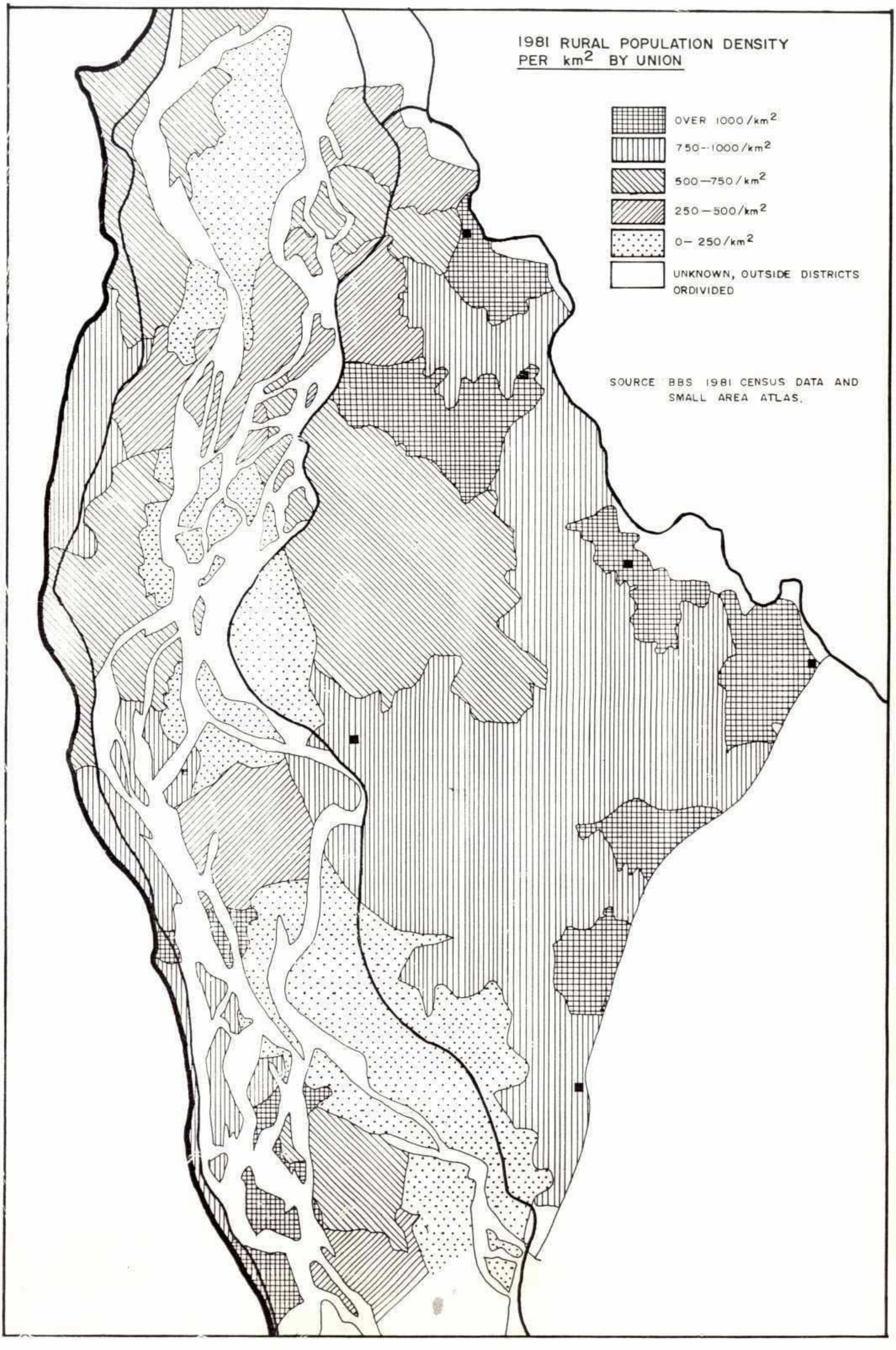

Figure 3.2.26

FAP 3.1 Administration Map

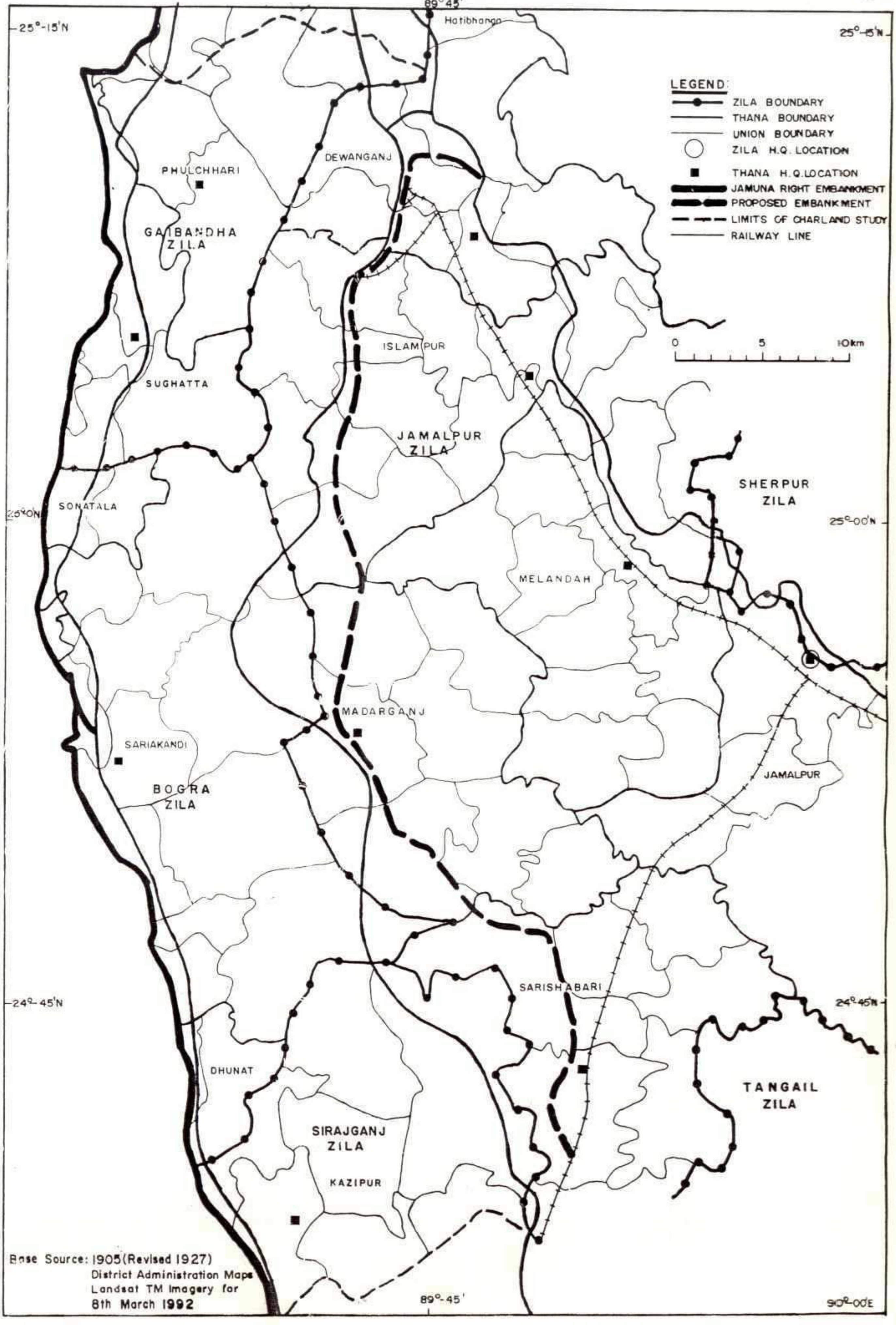

Figure 3.2.27

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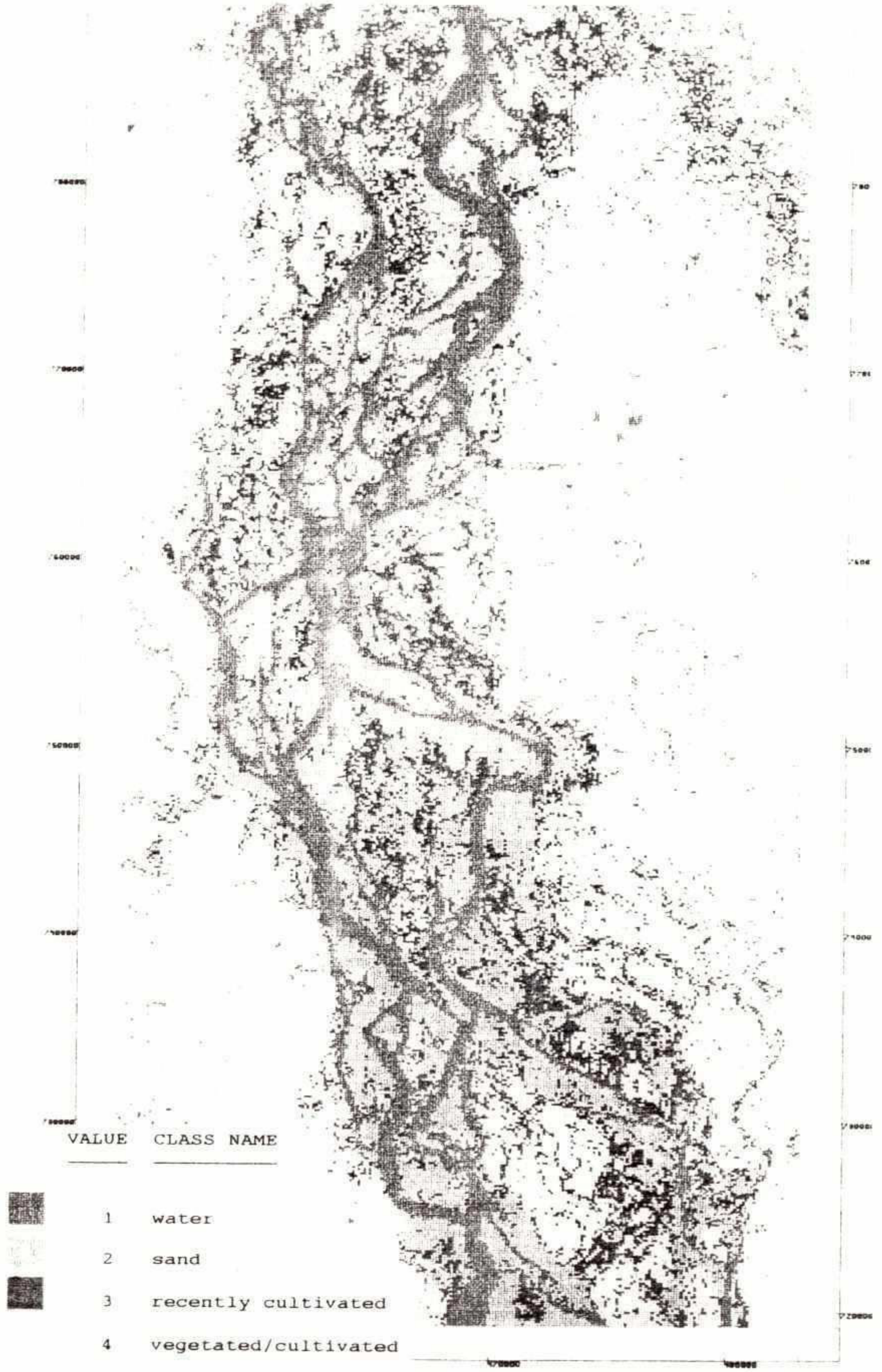
FAP 3.1 JAMALPUR PRIORITY PROJECT STUDY
IN COLABORATION WITH FAP16/19

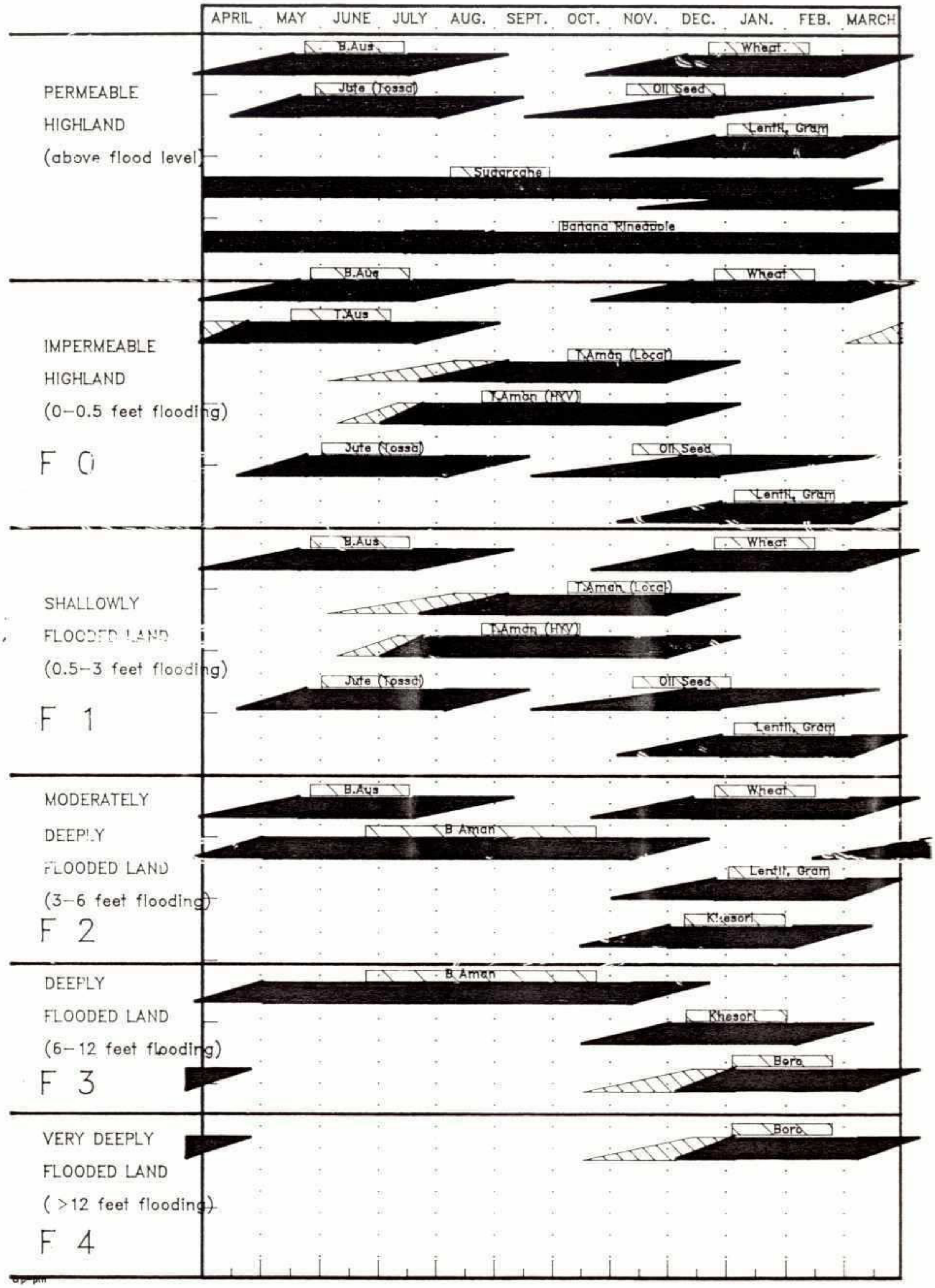


LAND UTILIZATION CLASSIFICATION

SOURCE: Ground survey + digital classification of LANDSAT TM imagery 8th march 1992

Figure 3.2.28

Generalised Schematic Cropping Pattern Diagram



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Comparative Subjective Impact Assessment Matrix for WO and Options A, B, C, D

ISSUES	P	NOW	WO	A	B	C	D	MP	MC
THE NATURAL ENVIRONMENT									
Hydrology									
Surface									
Flooding Damage to Land	*	0	-6 *	-4	+4	+2	+6		
Drainage Problems	*	0	-4	-2	+4	+2	+6		
Groundwater Availability									
Irrigation		0	0	0	0	0	-1		
Domestic Water Supply		0	0	0	0	0	-1		
Erosion									
Jamuna	*	0	-4	-4	-2	-4	-1		
Within Project Area		0	-2	-2	+2	+1	+3		
Sedimentation									
Jamuna		0	-2	-2	-2	-2	-2		
Within Project Area		0	-2	-2	+2	+1	+4		
Clogging/Smothering		0	-2	-2	+2	+1	+4		
Soil Fertility		0	0	0	-2	-1	-3		
Freshwater Ecology									
Water Quality									
Domestic Water Quality	*F	0	-2	+2	+2	+2	+1		
Agriculture Water Quality		0	+2	+2	+3	+3	+3		
Land Resources									
Soil									
Quality/Chemistry		0	0	0	-1	-1	-1		
Erosion		0	-2	-2	+2	+1	+3		
Ecology									
Flora		0	-2	-2	-4	-3	-4		
Fauna		0	-4	-4	-5	-5	-5		
Seismic Activity (*1)									

THE HUMAN ENVIRONMENT	P	NOW	WO	A	B	C	D	MP	MC
Economic Livelihoods									
Risk	*	0	-6 *	+2	+5	+4	+3		
Settlement		0	-4	+2	+5	+4	+3		
Land Tenure									
Scarcity		0	-2	-2	-2	-2	-2		
Land Values		0	+2	+2	+6	+5	+6		
Common Resource Rights	*								
Fish		0	+2	+2	-5	-2	-6*	VD	
Fuelwood		0	-4	-4	-4	-4	-4		
Grazing		0	-2	-2	-2	-2	-2		
Fodder		0	-2	-2	-4	-3	-4		
Agricultural Output	*F	0	+2	+3	+6	+5	+6		
Fishing ("Professional")		0	+1	+1	-5	-3	-6*	PO	CO
Forestry and Fuelwood		0	-2	-2	-2	-2	-2		
Livestock		0	-2	+2	-1	0	-1		
Wage Paid Employment	*F	0	+2	+2	+5	+4	+5		
Industry		0	+2	+2	+4	+3	+4		
Drinking Water Availability	*F	0	0	0	0	0	-1		
Human Health	*								
Waterborne Diseases	*								
Diarrhoea	*	0	?	?	?	?	?		
Cholera		0	?	?	?	?	?		
Insect Borne Diseases									
Malaria	*	0	-2	-2	-3	-3	-3		
Japanese Encephalititis		0	+2	+2	+2	+2	+2		
Filariasis		0	+2	+2	+2	+2	+2		
Drinking Water Quality	*	0	-2	+2	+1	+1	+1		
Sanitation	*	0	-2	+2	+3	+3	+3		
Nutrition	*	0	-1	+1	-4	-2	-3		
Mental Health	*	0	-2	+3	+5	+4	+5		

	P	NOW	WO	A	B	C	D	MP	MC
Access and Transport Infrastructure									
Waterborne									
Jamuna	*LF	0	-2	-2	-2	-2	-2		
Within Project Area		0	-2	-2	-5	-3	-6*	VD	PC
Railway		0	-1	-1	+6	+6	+6		
Road	*	0	-4	-2	+4	+2	+3		
Archaeology and Cultural Sites		0	0	0	0	0	0		
DOWNSTREAM IMPACTS	P	NOW	WO	A	B	C	D	MP	MC
Main Jamuna	*	0	-4PF	-4PF	-6PF	-5PF	-6PF	PO	CO
Old Brahmaputra Left Bank		0	-2PF	-2PF	?	?	?		
Old Brahmaputra Downstream		0	-2PF	-2PF	?	?	?		
Downstream of Bausi Bridge		0	-2PF	-2PF	+2	+2	+2		

LEGEND

RANKING OF IMPACT

-6 Severe Irreversible Negative Impact
-5 Highly Negative Impact
-4 Significant Negative Impact
-3 Moderate Negative Impact
-2 Slight Negative Impact
-1 Very Slight Negative Impact
0 Present Baseline Situation and No Change
+1 Very Slight Positive Impact
+2 Slight Positive Impact
+3 Moderate Positive Impact
+4 Significant Positive Impact
+5 Very Significant Positive Impact
+6 Highly Significant Positive Impact
VD = Mitigation Very Difficult
PO = Mitigation Possible
CO = Mitigation Costly
PC = Mitigation Prohibitively Costly

ABBREVIATIONS/HEADINGS

P = Priority Issues
NOW = Present Situation
WO = Without Project Situation
A = Option A
B = Option B
C = Option C
D = Option D
MP = Mitigation Possible?
MC = Mitigation Costly?

(+1) = A Constraint not an Impact
* = Major Issues
F = In Times of Flood
LF = In Low Flows
PF = In Peak Floods
? = Insufficient Data to Assess

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Project Area Subjective Impact Assessment Ranking Matrix for Options A and B

ISSUES	P	LP	NOW	WO	A	B	MP	MC
THE NATURAL ENVIRONMENT								
Hydrology								
Surface								
Flooding Damage to Land	*	*	0	-5 *	-5	+4		
Drainage Problems	*	*	0	-4	-2	+4		
Groundwater Availability								
Irrigation			0	0	0	0		
Domestic Water Supply			0	0	0	0		
Erosion								
Jamuna	*	*	0	-4	-4	-2		
Within Project Area			0	-2	-2	+2		
Sedimentation								
Jamuna			0	-2	-2	-2		
Within Project Area			0	-2	-2	+2		
Clogging/Smothering		*	0	-2	-2	+2		
Soil Fertility			0	0	0	-2		
Freshwater Ecology								
Water Quality								
Domestic Water Quality	*F		0	-2	+2	+2		
Agriculture Water Quality			0	+2	+2	+3		
Land Resources								
Soil								
Quality/Chemistry			0	0	0	-1		
Erosion			0	-2	-2	+2		
Ecology								
Flora			0	-2	-2	-3		
Fauna			0	-3	-3	-4	NW	
Seismic Activity (*1)								

THE HUMAN ENVIRONMENT	P	LP	NOW	WO	A	B	MP	MC
Economic Livelihoods								
Risk	*	*	0	-5 *	+2	+4		
Settlement		*	0	-4	+2	+4		
Land Tenure								
Scarcity		*	0	-2	-2	-2		
Land Values			0	+2	+2	+5		
Common Resource Rights	*							
Fish			0	-2	-2	-4	VD	
Fuelwood			0	-4	-4	-4	PO	
Grazing			0	-2	-2	-2		
Fodder			0	-2	-2	-4		
Agricultural Output	*F	*F	0	+2	+3	+5		
Fishing ("Professional")			0	-1	-1	-4	PO	CO
Forestry and Fuelwood			0	-2	-2	-2		
Livestock			0	-2	+2	-1		
Wage Paid Employment	*F	*	0	+2	+2	+4		
Industry			0	+2	+2	+4		
Drinking Water Availability	*F		0	0	0	0		
Human Health	*							
Waterborne Diseases	*							
Diarrhoea	*		0	?	?	?		
Cholera			0	?	?	?		
Insect Borne Diseases								
Malaria	*		0	-2	-2	-3		
Japanese Encephalititis			0	+2	+2	+2		
Filariasis			0	+2	+2	+2		
Drinking Water Quality	*		0	-2	+2	+1		
Sanitation	*		0	-2	+2	+3		
Nutrition	*		0	-1	+1	-2	VD	CO
Mental Health	*		0	-2	+3	+4		

	P	LP	NOW	WO	A	B	MP	MC
Access and Transport Infrastructure								
Waterborne								
Jamuna	*LF		0	-2	-2	-2		
Within Project Area			0	-2	-2	-5*	VD	PC
Railway			0	-1	-1	+5		
Road	*		0	-4	-2	+4		
Archaeology and Cultural Sites			0	0	0	0		
DOWNSTREAM IMPACTS	P	LP	NOW	WO	A	B	MP	MC
Main Jamuna	*	*	0	-3PF	-3PF	-5PF*	PO	CO
Old Brahmaputra Left Bank			0	-2PF	-2PF	?		
Old Brahmaputra Downstream			0	-2PF	-2PF	?		
Downstream of Bausi Bridge			0	-2PF	-2PF	+2		

LEGEND

RANKING OF IMPACT

-5 Severe Irreversible Negative Impact
-4 Highly Negative Impact
-3 Significant Negative Impact
-2 Moderate Negative Impact
-1 Slight Negative Impact
0 Present Baseline Situation and No Change
+1 Slight Positive Impact
+2 Moderate Positive Impact
+3 Significant Positive Impact
+4 Very Significant Positive Impact
+5 Highly Significant Positive Impact

VD = Mitigation Very Difficult
PO = Mitigation Possible
NW = Mitigation Not Worthwhile
CO = Mitigation Costly
PC = Mitigation Prohibitively Costly

ABBREVIATIONS/HEADINGS

P = "Expert" Priority Issues
LP = Local Peoples Priorities
NOW = Present Situation
WO = Without Project Situation
A = Option A
B = Option B
MP = Mitigation Possible?
MC = Mitigation Costly?

(+1) = A Constraint not an Impact
* = Major Issues

F = In Times of Flood
LF = In Low Flows
PF = In Peak Floods
? = Insufficient Data to Assess

Figure 3.3.3

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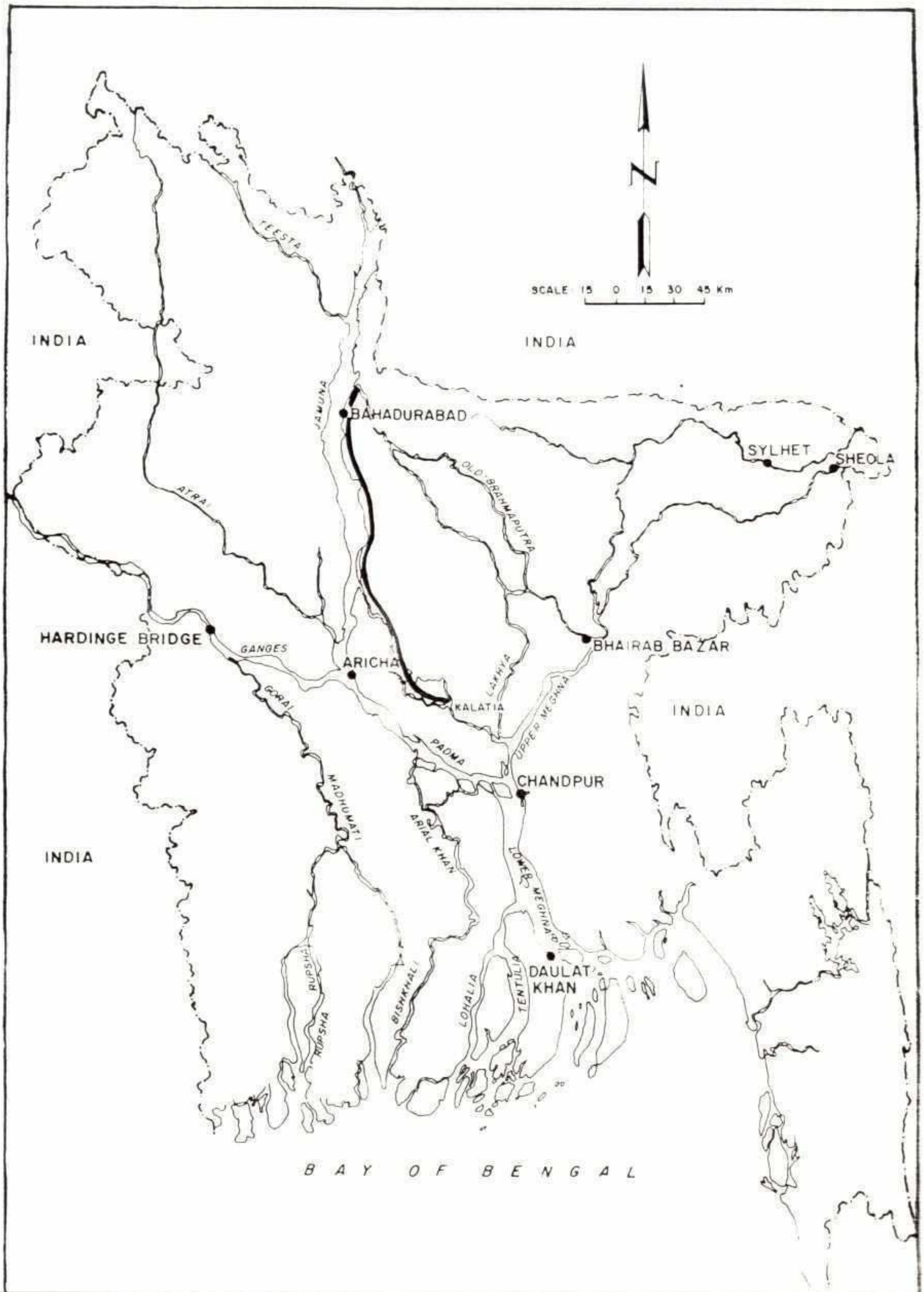
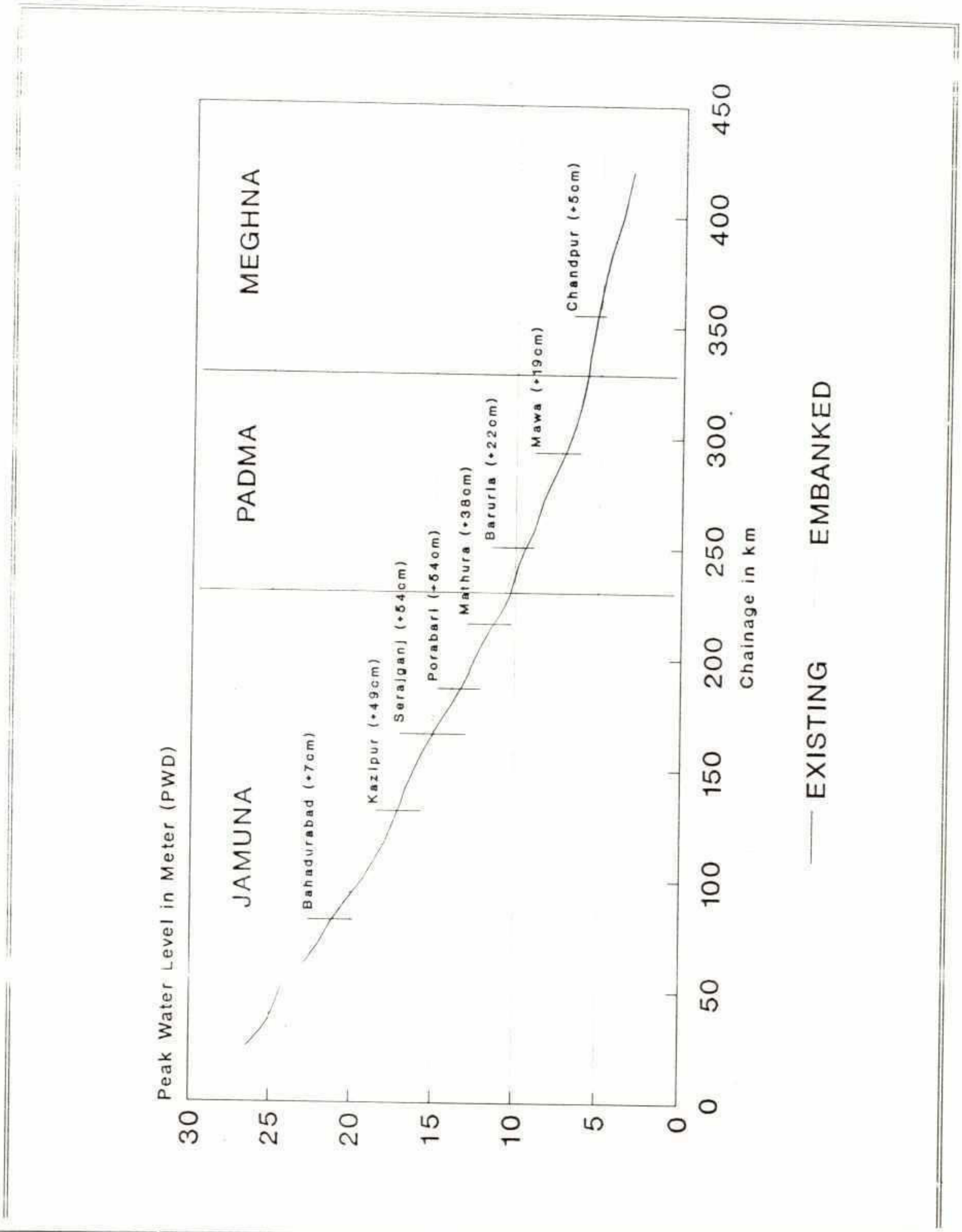
FAP 25 Main River Modelling - Location Map



FAP25 FLOOD MODELLING & MANAGEMENT	FLOOD HYDROLOGY STUDY	
	Location of Embankment used to run FAP25-GM	
	JUNE 1992	FIGURF 7.5

FAP 25 Main River Modelling - Brahmaputra/Jamuna/Padma Simulation

with FAP 3.1 Embankment and Dhaleswari Left Embankment



FAP25 FLOOD MODELLING & MANAGEMENT	FLOOD HYDROLOGY STUDY Comparison of Peak Water Level Profile : Jamuna-Padma-Lower Meghna System in 1988	
	JUNE 1992	FIGURE 7.6 b)

Appendices

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APPENDIX A

ENVIRONMENTAL REFERENCES AND BIBLIOGRAPHY

ENVIRONMENTAL REFERENCES AND BIBLIOGRAPHY

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APPENDIX B

LIAISON AND CONTACTS

LIST OF ORGANISATIONS AND INDIVIDUALS CONTACTED DURING THE COURSE OF THE ENVIRONMENTAL COMPONENT OF THE STUDY

As part of the day to day work of the study, liaison has been made with the following individuals and organisations on both a formal and informal basis.

Members of the Flood Plan Co-ordination Organisation (FPCO) including the Panel of Experts, specifically:

Ainun Nishat
Pat Lane, Environmental Specialist
Jim Dempster
Steve Jones, Socio-Economist
Hugh Brammer, Agriculturalist
Syed Waliullah, Sociologist
Masud Ahmed, Institutions Specialist
Saleh Mustafa Kamal, Environmental Specialist

Mesbahuddin Ahmed, Media/Public Relations Specialist, World Bank/FPCO
Kathy Alison, Flood Action Plan Conference Organiser

World Bank
Ross Wallace

CCCE
Alain Vanden Abeele
M Gross-Claude

USAID
Helen Gunter

CIDA
Wendy Hunter Rayfield

REGIONAL FAP STUDIES:

North Central Region (FAP 3)
Don Brown, Team Leader,
Alan Potkin, Environmentalist,
Akhter Hossain, Environmentalist
David Milton, Hydrologist
Mike Hayter, Groundwater Specialist
Ron Bastin, Social Development Specialist
M Le Gash, Agricultural Economist
Erroll Cole, Irrigation and Drainage Specialist
Jim Scullion, Fisheries Specialist
Jean Marie Lacombe, Resident Representative, BCEOM
Shamsur Rahman, Assistant Resident Representative, BCEOM

North West Region (FAP 2)
Tom Franks, Team Leader
Nic Chisholm, Agricultural Economist
Bryan Spooner, Environmental Co-ordinator
Jim Monan, Rural Sociologist
Peter Ede, Hydrologist
Doug Cross, Ecologist
Pat Watson, Fisheries Specialist

South East Region (FAP 5)
John Dunn and Mike Politzer, Team Leaders
Bryan Spooner, Environmental Co-ordinator
Don Moore, Resident Representative, Mott MacDonald Ltd
H Ikewada, Agriculturalist
Jim Monan, Rural Sociologist
Patricia Almada-Villela, Ecologist and Fisheries Specialist
Afsana Wahab, Health and Nutrition Specialist
M Azam Ali, Health and Nutrition Specialist
Shahadat Ali, Fisheries Specialist

South West Region (FAP 4)
Raj Thiagarajah, Team Leader
Mike Pooley, GIS Specialist
D U Khan, Environmentalist
Tony Watkins, Agricultural Economist
Mr Samad, Groundwater Specialist
Rezaur Rahman, Soil and Land Resources Specialist

North East Region (FAP 6)
Herb Wiebe, Team Leader
Sara Bennett, Environmentalist

FLOOD ACTION PLAN SUPPORTING STUDIES

FAP 16 Environment
Stan Hirst, Team Leader
Mujibul Huq, Co-Team Leader
Aminul Islam, Environmental Scientist
Philip Jones, Institutions Specialist
Lutful Huq Choudry, Public Participation Specialist
Steve Minkin, Fisheries Nutrition, Vector Borne Diseases Studies
Dr Reaz Rahman, Health and Epidemiology Specialist
Firouz Rooyani, Environmental Planner Tangail EIA
Golam Monowar Kamal, Environmentalist
Kazi Fazlur Rahman, Advisor

A Ragib, Wildlife Specialist
Ron Livingston, Wetlands Specialist

FAP 23 Flood Proofing / FAP 14 Flood Preparedness
Richard Aten, Chief of Party
Mr Mahmoud
Harry Blair
Paul Thompson, Socio-Economist
Suzanne Hanchette
Murray Leaf
Ian Tod
Dr Alamgir, Team Leader

FAP 20 Compartmentalisation
Paul Zijderveld, Team Leader
Dirk Frans, Sociologist
Egbert Hemel, Drainage Specialist
Albert Heringa, Environmentalist
Gertjan de Graaf, Fisheries Specialist

FAP 19 GIS
Tim Martin, Team Leader
Eric Pfirmin
Mike Pooley

FAP 12/13
Mike Daplyn, Team Leader
David Potten, Project Director
Paul Thompson, Team Leader
Graham Dean, Remote sensing Specialist
Stan Weston

FAP 9A Secondary Towns Protection
Chris Pastakia, Environmentalist

FAP 21/22, Bank Protection and River Training
Catherine Bertrand, Environmentalist
Khondakar Nizamuddin

FAP 17 Fisheries
Mike Smith,Team Leader
Jim Scullion, Fisheries Ecologist
Leesa Khalid
Bernie McCarton, Fisheries Biologist

FAP 25 Hydraulic Modelling
Alistair McDonald
Emaduddin Ahmad, Hydraulic Modelling Engineer
Finn Hansen, Hydraulic Modeller

NON FAP PROJECTS AND PROGRAMMES

Jamuna Bridge Environmental Study
David Ryman, Team Leader
Doug Cross, Ecologist
Gwyn Evans, Drainage Specialist
Nehal Karim

Deep Tubewell Programme
Guy Jones
Alistair Perrott

Systems Rehabilitation-EEC
Malcolm Bennet, Team Leader
Frank Cooper, Senior Engineer
Albert Heringa, Environmentalist

Forestry Master Plan Project
W Treygo, Environment Planner

Hydraulics Research Ltd - Kushtia Project
Martin Burton

FAO Irrigation Programme
David Giles

CENTRAL GOVERNMENT DEPARTMENTS AND ORGANISATIONS

Environmental Pollution and Control Board, Ministry of Local Government

Ministry of the Environment and Forest
Humayan Kabir, Senior Assistant Secretary

Fisheries Department
Nazrul Islam, Deputy Chief (Planning)
Rakhal Chandra Kansa Banik, Senior Scientific Officer, FRSS

Directorate of Land Records and Survey,
Azaharul Islam, Deputy Director

Ministry of Energy and Mineral Resources
Zahid Hossain, Research Officer, Petroleum and Mineral Resources Division

Institute of Public Health
Mr Malek, Chemist
Mr Farooque, Public Analyst

SPARRSO, A M Chowdhury, Director

Bangladesh Standard and Testing Institution,
Mr Akhtaruzzaman, Assistant Director

GOVERNMENT AND PARASTATAL ORGANISATIONS IN THE STUDY AREA

Jamalpur Sadar

D C Jamalpur
M Kalam, Statistical Office
Ainul Huq, Statistician, Civil Surgeon Office, Jamalpur

Melandah Upazila
M Abdul Hai (Bacchu), Upazila Parishad Chairman
M M Rahman, U N O
Md Azizul Haque, Junior Statistical Officer

Sarishabari Upazila
Altaf Hossain, Statistical Officer
Sohrab Ali, Junior Statistical Officer
Abul Hossain, Upazila Livestock Officer
Asaduzzaman, Assistant Surgeon, Veterinary

Madarganj Upazila
Sree Ashok Kumar Dhar, Statistical Officer
Rashedul Islam, Social Worker
Abdul Awal Khan, Resident Medical Officer

Dewanganj Upazila
Akhtaruzzaman Siddiqui, Statistical Officer
Tulshi Das Shaha, Dewanganj Livestock Centre

Jill Bangla Sugar Mill, Dewanganj,
Abdus Salam Mollah, General Manager

Jamuna Fertilizer Company Ltd,
Md Siddiqur Rahman, Managing Director

NON GOVERNMENTAL ORGANISATIONS & RESEARCH INSTITUTIONS

BCAS (Bangladesh Centre for Advanced Studies)
Saleemul Huq, Executive Director
Atiq Rahman

Development Planners and Consultants
Mashiur Rahman, Executive Director
M A Rauf, Director
Santi Ranjan Howlader, Economist

In addition, other staff at the Department of Geography at Jahangirnagar University including Mohd. Shamsul Alam

Research and Advisory Services
Shapan Adnan
Bruce Currey

Centre for Development Research, Bangladesh (CDRB)
Dr Mizanur Rachman Shelly, Chairman

Mennonite Central Committee,
Edward Gomes, Program Leader

Service Civil International,
Dr Mizanur Rahman Shelly, President
Shafiqul Islam Lenin, National Secretary
Mujibul Huq Dulu, Bhurpur Project Coordinator

Save the Children (UK),
Mozibur Rahman

Oxfam/Ford Foundation
Alison Barrett
Shapan Adnan

Action Aid Bangladesh
Robert Reitemeier, Director
Field Staff at the Belgachia Office

Jamuna Char Integrated Development Project
Mujibul Huq Dulu

Unnayan Sangha, Md Rafiqul Islam, Project Co-ordinator

International Union for the Conservation of Nature

Bangladesh Environmental Lawyers Association
Mohiuddin Farooque, Secretary General

International Institute of Environmental Studies and Disaster Management
Kamrul Huda

SPECIALIST EXPERTS BY DISCIPLINE

Freshwater Ecology, including water quality and aquatic weeds:
Envirocare (PVT) Ltd
Doug Cross, Ecologist

Ferdousi Ruby, Department of Physical Chemistry, University of Dhaka

Flora, Botany, Medicinal Plants:
National Herbarium (BARC), Dr Salar Khan, Advisor
Asian Wetland Bureau, Faizal Parish
Forestry Department, Mohakhali, Mr Akond

Fauna, Hunting/Wild Animal Products:
A Ragib

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APPENDIX C

FLORA, WILDLIFE AND MEDICINAL PLANT LISTINGS

Table 3.C.1: Flora Listing.

Legend:

A7a = Jamuna Active Flood Plain,
A7b = Old Brahmaputra Flood Plain
A8 = Young Flood Plain
A9 = Old Flood Plain

1 = Widespread,
2 = Common,
3 = Occasional,
Charlands = Active River Channel.

4 = Rare,
5 = Threatened,
6 = Extinct.

Local Name English Name	Botanical Name	Type	Description & Use	Habitat	Past Occurrence	Present Occurrence
Ada Ginger	Zingiber officinale	Plant	Spice, edible.	A8, A9	1 (pre 1917)	1
Akand	Calotropis procera	Plant	Medicianl use.	A7, A8	2	2
Akashmoni,	Acacia moniliformis	Plant	Road side plantation.	A7,A8	4	2
Akh Sugarcane	Saccharum officinarum	Plant	Juice edible.	A8	2	2
Am Mango	Mangifera indica	Tree	Fruit edible, fuel and household work, inferior timber, plywood.	A8, A9	2 (pre 1917)	2
Amloki Emblic Myrobalan	Phyllanthus embelica	Tree	Bark and fruits used medicinally.	A9	3	4
Amra Dulcis Hogplum	Spondias mangifera	Tree	Fruit is edible.	A8, A9	3	4
Anarash Pineapple	Ananas sativas	Plant	Fruit is edible.	A9	2	2
Arhar Pigeon Pea	Cajanus cajan	Plant	Arhar-Dal, used as food.	A8, A7a	3	3
Ashareylata	Capparis zeylanica	Creeper	Creeper.	A8, A9	4	6
Aswat Peepul Tree	Ficus religiosa	Tree	Used medicinally. It is a sacred tree for Hindus, bazars are located under such trees.	A8, A9	2 (pre 1917)	3
Ata phal Custard Apple	Anona squamosa	Tree	Homestead, fruit edible.	A8, A9	3	4
Babla Babul	Acacia nilotica	Tree, fodder	Fodder, throughout area concertration around Sarishabari.	A8, A9	4	3
Bajna Prickly Ash	Zanthoxylum rhetsa	Tree	Inferior quality timber.	A7a, A9	3	4
Badam Indian Almond	Terminalia catappa	Root	Oil, fruit edible.	Charlands	3	3
Ban Bans Bamboo B.longispiculata	Bambusa tulda	Tree	For fencing, household work.	A8, A9	3	3

Local Name English Name	Botanical Name	Type	Description	Habitat	Past	Present
					Occurrence	
Ban tejpata Indian Rhododendron	Melastoma malabathricum	Tree	Spice.	A8, A9	4	6
Bantamak	Nicotiana plumbaginifolia	Plant	Medicinal use.	A9	4	3
Bara lebu Limi, Lemon	Citrus medica	Homstead plant	Used as salad, pickle making.	A7a,A8,A9 Charlands	2	2
Bara sim Broad Bean	Vicia faba	Creeper	Vegetable.	A8, A9	2 (pre 1917)	2
Bara - dumur Fig	Ficus racemosa	Tree	Used in medicine.	A7a, A8	2	5
Barbati Cowpea	Vigna sinensis	Vegetable	Vegetable, edible.	A7a,A8,A9	2	2
Batavi Lebu Lemon	Citrus grandis	Homstead plant	Used as salad, pickle making.	A7a,A8,A9	2 (pre 1917)	2
Begun Brinjal	Solanm melongena	Vegetable	Vegetable.	A7a,A8,A9	1 (pre 1917)	1
Bel Wood Apple	Aegle marmelos	Tree	Fruit used as medicine and also a good fire wood.	A9	2	2
Bet Cane Palm	Calamus viminalis	Creeper	Used for crafts.	A9	4 (pre 1917)	6
Bhadara	Gmelina hystrix	Tree	Used for household work.	A7a, A8	3	4
Bina White Mangrove	Avicennia officinalis	Plant	Used to protect soil erosion along mud roads, roof making.	A7a, A8 charlands	1	1
Bot Banyan Tree	Ficus bengalensis	Tree	Juice used for medicine.	A8, A9	2 (pre 1917)	3
Chalta	Dillenia indica	Tree	Fruit edible.	A8, A9	2 (pre 1917)	3
Chameli Downy Jasmine	Jasminum pubescens	Creeper	Flowering plant, a scandentshrub.	A8, A9	2	3
Chatian Devils Tree	Alstonia scholaris	Tree	Available in villages. It is used for making boxes.	A8, A9	2 (pre 1917)	3
Chichinga	Trichosanthes anguina	Vegetable	Vegetable, edible	A7a,A8,A9	1	1
Chirata Cinnamon	Swertia chiritia	Plant	Herb used medicinally.	A9	2 (pre 1917)	4
Darchini Cinnamon	Cinnamomum zeylanicum	Spices	Spices.	A8, A9	3 (pre 1917)	6
Debdaru Mast Tree	Polyalthia longifolia	Tree	Planted avenue tree.	A8, A9	3	3

Local Name English Name	Botanical Name	Type	Description	Habitat	Past	Present
					Occurrence	
Dhatoora Datura	Datura alba	Tree	Used in medicine, leave and fruits have medicinal value.	A8, A9	3 (pre 1917)	5
Dholkalmi	Ipomoea fistulosa	Creeper	Used to protect soil.	A7a,A8,A9 Charlands	1	1
Dalia Dahlia	Dahlia hybrida	Plant	Flowering plant.	A8, A9	2	2
Dhoney Coriander	Coriandrum sativum	Spices	Spice, edible.	A8, A9	1	2
Dopati Balsam	Impatiens balsamina	Plant	Flowering, seasonal.	A8, A9	2	2
Eucalyptus Eucalyptus	Encalyphis fitriodora.	Tree	Introduced. Medicinal oil.	A9	2	2
Fulkuri	Ageratum conyzoides	Weed	Common under growth in fallow land.	A8, A9	2	4
Gab Mangosteen	Diospyros embryopteris	Tree	The bark and fruit are used for tanning fishing nets and for painting the the bottom of country boats.	A8, A7a	2	2
Gamari White Teak	Gmelina arborea	Tree	Timber used for furniture.	A8, A9	2 (pre 1917)	2
Ganda Marigold	Tagetes erecta	Plant	Flowering, seasonal	A8, A9	1	2
Gandi gajari	Miliusa Velutina	Tree	It is used for agricultural implements and firewood.	A8, A9	2	3
Ghora Neem Persian Lilac	Melia azedarach	Tree	Leaves used as medicine.	A7a,A8,A9	2 (pre 1917)	2
Golalu Potato	Solanum tuberosum	Vegetable	Underground steam.	A8, A9	1	1
Golap Rose	Rosa centifolia	Tree	Seasonal flower	Charlands	2 (pre 1917)	2
Gulancha	Tinospora cordifolia	Plant	Medicinal plant.	A8, A9	3	3
Hijal	Barringtonia acutangula	Tree	available in low lying areas and marshy land. The timber is suitable for boat building cart and well construction.	A9	3 (pre 1917)	4
Ipil - Ipil	Leucaena latisiliqua	Tree	Introduced recently.	A8, A9	3	4
Jaba China Rose	Hibiscus rosa-sinensis	Plant	Seasonal flower	A8, A9	2	2
Jalpai Olive	Elaeocarpus robustus	Tree	Timber used for furniture and fruit for pickle making.	A8, A9	2 (pre 1917)	2

Local Name English Name	Botanical Name	Type	Description & Use	Habitat	Past	Present
					Occurrence	
Jam Jambu	Eugenia jambolana	Tree	Good timber for house construction, fruit edible.	A8, A9	2 (pre 1917)	2
Jambura	Citrus grandis	Tree	Fruit edible.	A8, A9	2 (pre 1917)	2
Jarul Crepe Myrtle	Lagerstroemia flosreginae	Tree	Good timber tree, used for boat making.	A7a,A8,A9	2 (pre 1917)	3
Jiga	Coromandelica	Tree	Wood is used in spear and cart wheel, fire wood.	A7a,A8,A9	2	2
Jiyal Jiga	Lannea grandis	Tree	Wood is used in spear, cart wheel, spoke, rice poundery, house building, oil presses.	A7a,A8	2	2
Jog Dumur Fig	Ficus glomerata/racemosa	Tree	The leaves, barks and fruits are used in medicine.	A7a,A8	2	2
Kadam	Anthocephalus cadamba	Tree	Used in medicine.	A8,A9	2 (pre 1917)	3
Kagagi Lebu Lemon	Citrus aurantifolia	Small tree	Fruit used for pickle making.	A7a,A8,A9	1	1
Kalmishak Water Bindweed	Ipomoea aquatica	Creeper	Kalmishak used as vegetable.	Charlands	1	1
Kamini Chinese Box	Murraya paniculata	Tree	Flowering plant in the garden.	A8,A9	2	2
Kamranga Carambola	Averrhoa carambola	Tree	Fruit edible.	A8	2	2
Kanakchampa	Ochna squarrosa	Plant	Seasonal flower.	A8,A9	2	2
Karabi Oleander	Nerium indicum	Plant	Seasonal flower.	A8,A9	2	2
Kash, Chan	Imperata cylindrica	Grass	Used as roofing materiial.	A7a, Charlands	1	1
Kata Mandar Coral Tree	Erythrina variegata.	Plant	Used mainly for fencing.	A7a,A8	2	2
Katanotay/Notey Prickly Amaranth	Amaranthus spinosus/viridis	Plant	Fooder for livestock.	A7a,A8	2	3
Kath bel Elephant Apple	Feronia limonia	Tree	Fruit is edible.	A8,A9	2 (pre 1917)	3
Kathal Jack Tree	Artocarpus integrifolia	Tree	Wood is valuable, & used as construction materials, furnitures.	A8,A9	2 (pre 1917)	2
Kesaraj Bhringaraj	Wedelia chinensis	Plant	Fairly common.	A8,A9	3	6
Khag, Kash Thatch Grass	Saccharums pontaneum	Plant	Use to protect soil erosion.	Charlands	1	1

Local Name English Name	Botanical Name	Type	Description & Use	Habitat	Past	Present
					Occurrence	
Khajur Datepalm	Phoenix sylvestris	Tree	Juice edible, fire wood.	A9	2 (pre 1917)	4
Kochori	Caesalpinia digyna	Aquatic weed	Food for cow	Charlands	1	1
Kochu Common Arum	Colocasia esculenta	Plant	Medicinal value, under ground steam, leaves area used as curry.	A8,A9	1	1
Kola sapientum Banana	Musa kanchkala (plantain)	Plant	Fruit edible.	A8,A9	1	1
Kool, Boroi Indian Plum	Zizyphus mauritiana	Tree	Fruit edible.	A8,A9	2	2
Koroi (Sishu)	Albizia procera	Tree	Timber wood.	A8,A9	2 (pre 1917)	2
Krishnachura Gold Mohur Tree	Delonix regia	Tree	Flowering plant.	A8,A9	2 (pre 1917)	2
Kumarilata Indian Sarsaparilla	Smilex macrophylla	Creeper	The stem has a strong fibre which can be used as tooth stick.	A8,A9	2	3
Kumra Pumpkin	Cucurbita pepo Dc.	Vegetable	Creeper, vegetable.	A7a,A8,A9	1	1
Kunjalata	Ipomoea quamoclit	Creeper	Creeper, flowering plant.	A7a,A8,A9	2	4
Lajjabati Sensitive Plant	Mimosa pudica	Plant	Medicinal use.	A7a,A8	2	6
Latkan	Baccaurea ramiflora	Tree	Fruit edible.	A8,A9	2	3
Lau (Ground) Bottle Gourd	Legenaria siceraria	Vegetable	Creeper, vegetable.	A7a,A8,A9	1	1
Litchu Litchi (Leechee)	Litchi chinensis	Tree	Fruit edible.	A8,A9	2 (pre 1917)	2
Madhobilota	Hiptage benghalensis	Creeper	Sweet scented flower.	A8,A9	2	3
Maheskanda	Diospyros cordifolia	Tree	Found near the "Durmut" area.	A9	2 (pre 1917)	4
Marich Chillee	Capsicum frutescens	Spice	Edible	A7a,A8,A9	1 (pre 1917)	2
Masur/Masuri Pulses	Lens culinaris medik	Plant	Used as food.	A8,A9	1 (pre 1917)	1
Mehede	Lawsonia inermis	Plant	Medicinal use.	A8,A9	2	2
Mehgoni	Swetenia mehgoni	Tree	Timber used for furnitures.	A8,A9	4	4

Local Name English Name	Botanical Name	Type	Description & Use	Habitat	Past	Present
					Occurrence	
Misti Alu Sweet Potatoo	Ipomoea batatus	Root	Under ground stem is edible.	A8,A9	2	2
Moog Pulses	Vigna radiata	Plant	Seasonal planet, used as food	A8,A9	2	2
Mouri	Foeniculum vulgare	Spice	Spice	A7a,A8 Charlands	2	2
Nalkhagra	Phragmites karko	Creeper	Creeper, check soilerosion	A7a,A8 Charlands	2	2
Nanki, Janki	Bauhinia malabarica	Planet	Planet, aesthetic.	A8	2	2
Narkel, Narikel Coconut	Cocos nucifera	Tree	Fruit edible	A8,A9	2	2
Nata	Caesalpinia bonducella	Creeper	Seed used as medicine	A8,A9	2	2
Neem	Azaderachta indica	Tree	Medicinal use	A8,A9	2	2
Orbori	Phyllanthus acidus	Tree	Fruit edible	A8,A9	2	2
Orchid Orchid	-	Creeper	Creeper gardening	A8,A9	3	4
Palash	Butea frondosa	Tree	The wood is used in making gun powder, charcoal. The leaves, flowers, seeds & gum are used medicinally.	A8,A9	3	4
Pargacha	Loranthus ampullaceus roxbi	Parasitice	Parasitice found on most trees	A8,A9 Charlands	2	2
Pathor Kuchi	Kalanchoe pinnata	Medicinal plant	Medicinal plant	A8,A9	2	4
Pepe	Carica papaya	Fruit edible	Fruit edible	A7a,A8	2	2
Piaj Onion	Allium cepa L. (Liliaceae)	Under-ground stem	Underground stem, used as food	A7a,A8	1	1
Pitraj	Apnana mxis polystachya	Tree	Fruit oil used to relief pain	A8	2	4
Plitamandar	Erythrina indica variegata	Tree	Wood used for box making and as a fencing tree.	A8,A9	2	2
Pyara, Gaya Gauva	Psidium guajava	Tree	Fruit edible	A7a,A8,A9	2	2
Radhachura	Caesalpinia pulcherrima	Tree	Flowering plant	A8,A9	2	4
Rakta Karobi	Nerium indicum	Tree	Flowering plant	A8,A9	2	3

Local Name English Name	Botanical Name	Type	Description & Use	Habitat	Past	Present
					Occurrence	
Rasun Garlic	Allium Sativum L. (Liliaceae)	Spices	Spices	A7a,A8,A9	1	1
Roina	Amoora rohituka	Tree	Used for making boxes	A8,A9	2	6 (1970-72)
Sajna	Moringa oleifera	Tree	Fruit used in curry has medicinal value	A8,A9	2	3
Sal, Gajari	Shorea robusta	Tree	Used for timber, posts, and fire wood	A9	2	4
Saluk	Nymphaea nouchali	Aquatic, fruit	Aquatic, fruit			
Sarpagandha	Rauwolfia serpentina	A herb roots	A herb roots are used midicinally	A8,A9	2	4
Satim (chatim)	Alstoia scholaris	Tree	Used for box construction	A8,A9	2	3
Segun Teak	Tectona grandis	Tree	Timber wood	A8,A9	3	4
Shapla, Kumudini Lotus	Nymphaea nouchali	Aquatic weed	Used as table	A8 Charlands	1	2
Shefalica	Nyctanthes arbortristis	Plant	Planted in gardens. The leaves are used medicinally	A8,A9	2	3
Shimul	Salmalia malabarica	Tree	Used in match manufacture.	A8,A9	2	3
Shonali/Sonalu	Casia fistula	Tree	Used in tanning.	A8,A9	3	4
Sinduri	Mallotus philippinensis	Tree	It is used for handles of hoes and axes.	A9	3	4
Siris	Albizia lebbek	Tree	Used as fuel and medicinal value.	A8,A9	2	3
Sunn	Crotalaria juncea	Plant	Fibre for rope making.	A8 Charlands	2	2
Supari, Gua	Areca catechu	Tree	Tanning plant.	A8,A9	2	2
Swarnalata	Cuscuta reflexa	Plant parasite	Plant parasite.	A8,A9	3	4
Swet kanchan	Bauhinia variegata	Tree	Used medicinally.	A8,A9	3	4
Tal Palm	Borassus flabellifer	Tree	Fruit and timber.	A8,A9	2	3
Tamal	Diospyrus montana	Tree	No previous report of their availability. Only found near the "Durmut Shah Kamals Mazar Sharif"	A8,A9	3	4

Local Name English Name	Botanical Name	Type	Description & Use	Habitat	Past	Present
					Occurrence	
Tetul	Tamarindus indica	Tree	Precious wood, fruit edible. The seeds are used in jelly industries and painting, wood, glue.	A8,A9	2	2
Tit begun Brinjal	Solanum indicum	Plant	Medicinal uses, vegetable	A7a,A8,A9	2	2
Topapana Water Hyacinth	Trapa natens	Aquatic weed	Aquatic weed	A8, Charlands	1	1
Tut, Tunt	Morus indica	Tree	Introduced into the area	A8,A9	4	2

Source: FAP-3.1, Field Survey, December 1991 - August 1992.

Table 3.C.2: Wildlife Listing.

1 = Widespread, 2 = Common, 3 = Occasional,
4 = Uncertain, 5 = Rare, 6 = Threatened,
7 = Extinct.

LO = Open country, LWE = Wetland, LWO = Woodland, LH = Homestead,
L = Land, T = Tree, W = Water, WC = Contained water, LC = Charland,
WMR = Main river, WIR = Internal rivers, WO = Open water.

English Name Bengali Name	Scientific Name	Habitat	Past	Present
			Occurance	
Mammals				
Bat (Flying Fox) Badur	Pteropus giganteus	T	1 (pre 1917)	2
Bengal Fox Khek Shial	Vulpes bangslensis	L	2 (pre 1917)	2
Common Mongoose Bara Beji	Herpestis edwardsi	L	2	2
Fishing Cat Mecho Biral	Felis viverrina	LH	2	2
Jackal Shial	Canis aureus	L, LC	2 (pre 1917)	2
Jungle Cat Bon Biral	Felis chaus	L	2	2
Rats Indoor	Rattus rattus	LH	1	1
Small Indian Civet Khatash	Viverricula indicus	L	2	2
Small Indian Mongoose Beji	Herpestis auropunctatus	L, LWO	1	2
Dog Kutta	Cuon alpinus	L, LH	1	1
Common Tree Shrew Kath Birali	Tupaia glis	T	1	2
Reptiles				
Bengal Lizard Gui Shap	Varanus bengalensis	L	2	2
Checkered Keelbacked Water Snake Dhora Shap	Xenochrophis piscator	W, LWE	1	1
Bengal Cobra Jati Shap	Naja naja	L, W, LWE	2	3
Common Skink Anjoni	Mabuya carinata	L	2	3
Common Smooth Water Snake Paina Shap	Enhydris enhydris	LWE, W, L	2	2
Common Worm Snake Dumukho	Typhlina diardi	L	2	5
Darkbellied Marsh Snake Kalo Mete Shap	Xenochrophis cerasogaster	W, L	1	1

English Name Bengali Name	Scientific Name	Habitat	Past	Present
			Occurance	
Garden Lizard Rakta Chusha	Calotes versicolor	L	3	4
House Lizard Tiktiki	Hemidactylus brooki	T, LH	1	1
King Cobra Raj Gokhra	Ophiophagus hannah	L, LWE	3 (pre 1917)	6
Land Tortoise	Geochelone emys	L, LWE	2	2
Large Land Lizard Kalo Gui Shap	Varanus bengalensis	L, LC	2	2
Rat Snake Darais Shap	Ptyas mucosus	L, LWE	1	1
Rock Python Moyal Shap	Python molurus	L, LWE	2	5
Russells Viper Chandrabora Shap	Vipera russellii	L, W	3 (pre 1917)	5
Striped Skink Anjon	Mabuya dissimilis	L	3	3
Wall Lizard Tokkhak	Gekko gecko	T, LH	2	3
Common House Lizard Tiktiki	Hemidactylus flaviviridis	L, LH	1	1
Yellow Lizard Haldey Gui	Varanus flaviscens	L, LWE	2	5
Yellow Water Lizard Hungui Shap	Varanus flaviscens	L	2	5
Amphibians				
Bull Frog Kula, Shona Bang	Rana tigerina	L.W, LWE	1	1
Cricket Frog Jhi-Jhi Bang	Rana Limnocharis	L., W.	1	1
Skipper Frog Kotkoti Bang	Rana Cyanophlyetis	L., W.	1	1
Common Toad Kuno Bang	Bufo Melanostictus	L, LH	1	1
Tree Frog Gecho Bang	Rhacophorus leuco mystax	T	2	3
Tree Frog Gach Bang	Rana temporalis	T	2	3
Turtles & Tortoises				
Common Roofed Turtle Kori Kaitta	Kachuga tectum	L, W, LWE	2	3
Soft Shelled Turtle Sim Kasim	Chitra indica (habitat: Padma-Jamuna)	L, W, LWE	2	2

English Name Bengali Name	Scientific Name	Habitat	Past	Present
			Occurance	
Spotted Flap Shell Turtle Shundhi Kasim	Lissemys punctata	L, W, LWE	2	3
Fish				
Anchovies Phasa	Setipinna phasa	WIR, WO	2	5
Bata	Labeo bata	WMR, WIR	2	3
Bighead Carp	Aristichthys nobilis	WMR, WIR	2	3
Butter Catfish Kani Pabda	Ompok bimaculatus	WIR	2	2
Carp Catla	Catla catla	WMR	2	2
Chela	Rohtee cotio	WC, WO	2	2
Common Carp Carpio	Cyprinus carpio	WMR, WIR	2	2
Carp Ghainna	Labeo gonius	WMR, WIR	2	5
Climbing Perch Kai	Anabas testudineus	WC, WO	2	3
Carp Kalibaus	Labeo calbasu	WMR, WIR	2	3
Catfish Tengra	Mystus cabasius	WO, WC	1	1
Catfish Tengra	Mystus cabasius	WO, WC	1	1
Darkina	Rasbora daniconius	WIR	2	2
Featherback Foli	Notopterus notopterus	WIR, WC, WO	2	3
Featherback Chital	Notopterus chitala	WMR	2	5
Gang Tengra	Gagata viridescens	WIR, WC WO	2	2
Garfish Kaikka	Xenentodon cancila	WIR, WO, WC	2	3
Giant Prawn Golda Chingri	Macrobrachium rosenbergii	WMR	2	5
Herring Ilish	Hilsa ilisha	WMR	1	1
Katal	Labeo gonius	WMR, WIR	2	2
Lal Chewa	Apocriptus lanciolatus	WIR, WO	2	7 (1986 - 87)

English Name Bengali Name	Scientific Name	Habitat	Past	Present
			Occurance	
Long bbled Catfish Ayre	Mystus aor	WMR	2	2
Loach Panga	Acanthophthalimus pangia	WMR	2	3
Long barbed Catfish Rita	Rita rita	WIR	2	3
Long bbled Catfish Tengra	Mystus vittatus	WIR, WO WC	2	2
Loach Gutum	Lepidocephalus guntea	WIR	2	4
Minnow Kachki	Corica soborna	WIR, WC	2	3
Mola Mola	Amblypharygodon microlepis Amblypharygodon mola	WIR, WO	1	1
Mrigal	Cirrhinus mrigala	WMR, WIR	2	2
Nilotica Nilotica	Oreochromis nilotica	WO, WC	2	2
Prawn Gura Icha	Paleomon styliferus	WMR, WIR, WO, WC	2	2
Puffer fish Potka	Chelonodon fluviatilts	WO, WC	1	1
Punti	Puntius sophore	WO, WC	2	3
Perch Khailsha	Colisa fasciatus	WC, WO, WIR	2	2
Perch Bheda	Nandus nandus	WIR	3	4
River Herring Chapila	Gudusia chapra	WIR, WC	2	5
River Catfish Baspata	Ailia coila	WO, WC	2	2
River Catfish Baghair	Bagarius bagarius	WMR, WIR	2	3
River Catfish Bacha	Eutropiichthys vacha	WIR, WMR	2	4
River Catfish Kajuli	Eluthysis punctalin	WMR, WIR	1	3
River Catfish Pangas	Pangasius pangasius	WMR	2	3
River eel Bamosh	Anguilla bengalensis	WIR, WMR	2	2
Rui	Labeo rohita	WMR, WIR	2	2

English Name Bengali Name	Scientific Name	Habitat	Past	Present
			Occurance	
Bull Herone		L, LWO	2	3
Bush Lark Bharat Pakhi	Mirafra assamica	L, LWO	2	4
Common Babbler Satarey	Turdoides caudatus	L, T	2	3
Common King Fisher		LWE, WIR	1	1
Cotton Teal Bali Hans	Nettapus coromendelianus	L, T	1	2
Common Moyna Bhat Shalik	Aeridotheres tristis	LO	2	2
Indian Cuckoo Bau-Kotha-Kou Pakhi	Cuculus micropterus	L, T	3	5
Eagle	Haliaeetus leucoryphus	LWE	2	5
Eagle Owl Hutum Pencha	Bubo bubo	L, T, LWO	2 (pre 1917)	5
Fly Catcher		L, T	2	5
Golden backed Wood Peaker Kaththokra	Dinopium benghaiense	T	2	3
Green Bee-eater Suichura	Merops orientalis	LO	2	3
Grey headed Moyna Kath Shalik	Sturnus malabaricus	T	1	1
Grey Heron Dhushar Bok	Ardea cinerea	LWE	2	2
Hoopoe Soliaman Pakhi	Upupa epops	LO	2	5
House Crow Pantikak	Corvus splendens	LH	1	1
House Sparrow Charui	Passer domesticus	LH	1	1
Indian Pipit	Anthus hodgsoni	L, T, LWO	2	3
Indian Rollar		LO	2	3
Indian Sandlark		L, T	2	3
Pheasant tailed Jacana Jol Moyur	Hydrophasianus chirurgus	LWE	2 (pre 1917)	5
Jungle Crow Dar Kak	Corvus macrorhynchus	L, T	1	2
Jungle Pigeon Jalali Kabutor		LWO	2	2

English Name Bengali Name	Scientific Name	Habitat	Past	Present
			Occurance	
King Valture Raj Shakun	Sareogyp	LO	2 (pre 1917)	7
Magpie Robin Doyel	Copsychus saularis	LWO, T	2	2
Maratha Wood Peaker		LWO	2	3
Marsh Sandpiper Jalar Chapakhi	Tringa stagnatilis	LWE	2	3
Marsh Harrier Jolar Chil	Circus aeruginosus	W, WIR	2	2
Marshy Kite		LO	2	2
Pallas's Fish Eagle	Haliaeetus leucoryphus	LWE, WMR	2	3
Pariah Kite Bhuban Chil	Milvus migrans	LO	2	2
Pied King Fisher		LWE	2	3
Pied Moyna Go Shalik		LO	1	1
Pintail Snipe Kadakucha, Chaga	Gallinago stenura	LWE	2	3
Palm Swift		T, LWO	2	3
Pond Herone		LWE	2	3
Red Wattled Lapwing		LWO	2 (pre 1917)	3
Purple Moorhen Kalim	Porphyrio porphyrio	LWE	2	2
Glossy Stare Kalo Shalik	Aplonis panayensis	L, T, LWO	1	1
Blue Rock Pigeon Jalali Kabutor	Columba livia	LWO	2	3
White breasted Water Hen Dahuk	Amaurornis phoenicurus	L, LWE	2	3
Koel Kokil	Eudynamus scolopacea	L, T, LWO	1	1
Bank Moyna Gang shalik	Aeridotheres ginginianus	WIR, WMR	1	1
River Lapwing	Vanellus vanellus	WIR, WMR	2	2
Rose Ringed Parakeet Tia	Psittacula krameri	T	2	2

English Name Bengali Name	Scientific Name	Habitat	Past	Present
			Occurance	
Common Sandpiper Chapakhi	Tringa hypoleucos	LWE	2	2
Shikra		T,L	2	3
Shwallow		LWE	2	3
Small Indian Pratincole Babu Batan	Glareola lactea	WIR, WMR	2	3
Solitary Snipe Ban Chaha	Gallinago solitaria	LWE	2	3
Spotted Dove Tila Ghugu	Streptopelia chinensis	LWO, T	1	1
Strok billed King Fisher Megh-hao	Pelargopsis capensis	LWO, T	1	2
Purple Sunbird Niltuni	Nectarinia asiatica	LWO, T	2	2
Tree Pie Kutum Pakhi	Dendrocitta vagabunda	L.T.	2	3
Western Marsh Harrier Jolar Chil	Circus aeruginosus	LWE, WMR, WIR	2	3
White-breasted Kingfisher Machranga	Helcyon smyrnensis	LWE, WMR, WIR	1	1
Yellow Wattled Lapwing Hot-ti-ti	Vanellus malabaricus	LO, WMR, WIR	1	1
Yellow fronted Pied Woodpecker Pakra Kaththokra	Picoides mahrattensis	T	2	3
Weaver Bird Babui	Ploceus philippinus	T	2	2
Spot-billed Duck Patihans	Anas poecilorhyncha	LWE	2	2
Bar Headed Goose Rajhans	Anser indicus	LWE	2	2
Tailor Bird Tuntuni	Orthotomus sutorius	L.T.	3	3

Source: FAP-3.1 Field Survey December, 1991 - August 1992.

Scientific Names	Local Names	Chemical Composition	Use
Clerodendron infortunatum	Bhati	Clerodin, Sterol, Xanthophyll, Carotene, Leaves contain: Ash 8.0%, Protein 21.2% Crude fibre 14.8%, Reducing sugars 3.0% Total sugars 17.0%. Leaves contains a fixed oil consisting of: Lenolenic acid, Oleic acid, Stearic acid, Lignoceric acid.	Indigestion, Stomach acte, Warm infestation, Fever due to malaria, External use: Skin disease, Head and body louse infestation, Non-malignant tumor.
Cuscuta reflexa	Swarnalata	The stem contains: Cuscutin and cuscutalin, The seed contains: The pigments of amarbelin, Cuscutin, Wax (esters), Greenish yellow semi drying oil (linolenic 9.9%, linolic 17.2%, oleic 25.5%, stearic 27.2%, and palmitic acid 11.5% and unsapnifiable substance (phytosterol).	Low grade fever, Liver pain, Worm infection. External use: Trauma, Washing wound.
Datura alba.	Dhatoora	Alkaloids viz., hyoscyamine, hyoscine, atropine, scopolamine, norhyoscyamine, Vitamin C, Other constituents viz., fixed oil and allantoin.	Bite from mad dog or fox, Baldness, Madness, Mastitis, Asthma.
Diospyros embryopteris.	Gab	Tannin, Acids viz., tannic acid, malic acid, Fatty oil.	Chronic dysentery, Diabetes, Excessive bleeding during menustration, Hiccup in children.
Entada scandens.	Gilla		
Ficus bengalensis.	Bot	Milky juice, Sterols, glycoside, Terpenoids, Albuminoids, ficosterol, glutathiome cellulose, lignin.	Nasal bleeding, Burning sensation of whole body, Strain, Toothache, Pendulus breast.
Ficus glomerata.	Jogdumur	Leaves contain: Carotenoid, meliatin, and an alkaloid. Pericarp contains: bakayanin, neutral substance (neo-bakayanin and bakayanic acid). Fruit contains: an alkaloid, azaridine (also called margosine), a sterol, tannins, glucose and starch. Seeds contain: drying oil 40%, unsapon matter 1.26%, saturated fatty acids 11.4% (palmitic and steario) and unsaturated fatty acids 88.6% (oleic and linoleic), unsaponifiable matter (phytosterol and aromatic hydrocarbons). Bark contains: alkalorids (azaridine and paraisine) and active substance mp. 154 degree. Heart wood contains: a crystalline lactons (baka lactone), a liquid with terpenic odour, a resinous material and tanins.	Prevention of acne, Increase sight and hearing, Asthma.

Scientific Names	Local Names	Chemical Composition	Use
Ficus racemosa.	Bara-dumur	Dichlorobenzoic acid, Dihydropsoralen, Hydroxycoumarin, Enzyme.	Bleeding, Relief of pain due to bite of poisonous insects, Boil, Gingivitis, Vaginal discharge.
Ficus religiosa	Aswat	Protein, Inorganic elements viz., calcium, phosphorus, Glycosides, Resins, tannin, caoutchouc, Traces of alkalsids.	Burn, Ear infection, Infected cut, Vomitting.
Grewia laevigata	Atmora, Mura		
Holarrhena antidysenterica	Kuteswar, Kurchi	Alkaloids viz., holadysamine, holadysine, holarrhidine, irchdiamine - kurchaline, kurchassine, alphakurchessine, kurchiline, kurchimine, kurchiphyllamine, kurchiphylline, 3-N-methylholarrhimine, 20-N-methylholarrhimine, N, N, N^1, N^1-tetramethylholarrhimine, 3-alphaaminoconan-5-one, conkuressine dihydro-iso conessimine, dihydroconkuressine, 7-alpha dihydroxyconessine, holanamine, kurcholessine, holantosine A, holantosine B, holarosine A, holarosine B, conessine, kurchine, kurchicine, non-conessine, conesimine, iso-conesimine, conimine, conamine, conarrhimine, conessidine, conkurchine, lettocine. Sterols viz., B-sitosterol, G-sitosterol.	Blood dysentery, Bleeding piles, Round worm-infestation, Boil.
Hymenodictyon excelsum.	Bhutum		
Jatropha curcas.	Chanda		
Melia azedarach.	Ghora nim		
Melia indica.	Nim		
Moringa pterygosperma.	Sajna		
Nyctanthes arbortristis.	Sefalika		

Scientific Names	Local Names	Chemical Composition	Use
Oroxylum indicum	Bhinga		
Phyllanthus emblica.	Amlaki	Ascorbic acid, Amino acid viz., glycine, Tannin, Polyphenolic compounds viz., corilagic, ellagic acid, terchebin, gallic acid, chebulic acid, chebulinic acid, Fixed oil, Lipids viz., phosphatides, Essential oil.	Leucorrhoea, Bilary colic, Hyperacidity, Sepsis.
Randia demantorum	Mankata		
Rauwolfia serpentina		Alkaloids viz., ajmaline, ajmalinine, ajmalicine, serpentini, serpentinine, isoajmaline, neoajmaline, rauwolfine, Oleoresin, serposterol.	Vasodialator, Insommonia, Psychosis.
Syn Randia Spinosa.			
Rauwolfia pentina.	Sarpagandha		
Swertia chiritia.	Chirata	Ophelic acid, Chiratin, Amarogentin, Gentiopicrin, Yellow crystalline phenols, Saccharine.	Haemoptysis, Morning sickness, Influenza, Severe vomitting, Severe Asthma.
Terminalia belerica.	Bahera	Tanin, Fixed oil, Saponin, Resinous compounds, amorphous glycosidal compounds.	Dry cough, Laryngitis, Asthma, Dysentery, Leukoderma.
Tinosporacordifolia	Gulancha	Gilonin, Geloninin, Glycoxides of myristic and palmitic acid, unidentified bitter principle, a neutral substance, Glycosides.	Psoriasis, Rheumatic fever, Palpitation, Cough, Jaundice (Hepatitis).
Vitex negundo	Nishinda	Alkaloids viz., nishindine & unidentified alkaloids, Essential oil, Sterols, Terpenoid constituents.	Boil, Dandruff, Arthritis, Sciatica, Roundworm infestation, Dyspepsia, Asthma, Pharyngitis, Tonsititis, Bedsore.

Source: FAP-3.1, Field Survey December 1991 - August 1992.
Bhattacharjaya Shibkali, Chiranjib Banowshodhi (in Bangla) 1-10 Volumes
Ananda Publishers Pvt. Ltd. Calcutta, 1991.

agriculture and fisheries) are to be the basis for this. This is likely to require the formation of water users groups who will be involved in the drawing up of operational criteria leading to the production of an Operation and Maintenance Manual for the project. This will also need to consider the development of a rational road transport network that goes some way towards replacing the present waterborne navigation system that is likely to be severely curtailed by the flood protection of the study area.

- For flood proofing in the unprotectable land, the nature, number, spacing and size of refuges and locations all to be decided with the local people who are likely to need technical advice and assistance in these matters.

3.3 Environmental Management and Mitigation

Broader, longer term environmental management issues will also need to be considered, particularly the drawing up of an implementable fisheries mitigation programme covering the following:

- Beel management to address the issue of changed and managed water levels and priorities between rice cultivators and fishermen.
- Borrow pit location and depth policies linked to possible fish pond culture fisheries programmes.
- Flood control inlet and outlet structure design to minimise losses to fish recruitment and operation of these for fisheries management in the internal rivers.

In addition consideration may need to be given to the ways of maximising the agricultural benefits of the project (its main economic justification) by including the planning for an agricultural support programme (extension, credit, marketing etc) at the detailed design phase.

3.4 On-going Data Collection and Monitoring

There are also major items of environmental baseline data collection monitoring work (particularly concerning the natural environment) that require to be on-going. In the present absence of an identified and operational institution to do this it would seem sensible for the study to continue this process for the time being. This will need to collect data:

- Continue the water quality sampling programme in the dry and wet seasons.
- Instigate human health and nutritional studies, the draft TOR of which are attached. This requires baseline and monitoring data collection programmes

for these two subjects, particularly waterborne disease.

- Soil fertility under controlled flooding conditions and irrigation.

A project monitoring and evaluation unit needs to be set up which includes inter-disciplinary staffing to address all aspects of the projects performance and monitor this against expectations and feed this back into the planning and implementation process. This includes the basic agricultural assumptions that underpin the economic justification for the project, particularly the level of irrigation uptake, cropping pattern change and increase in cropping intensity along with changes in labour demand and incomes levels.

In addition, once the Finmap digital elevation model data and the computer hydrological modelling are interfaced to produce mapped outputs of flood depth, extent, duration and timing under different flow conditions in a with and with-out project situation, then more detailed impact analysis of the level normally expected for such a major intervention can commence. This first stage will be to review this data to address its environmental impact implications and carry out studies looking at the spatial and social differentiation of negative impacts.

4. Liaison and Assistance from other FAP Supporting Studies

The detailed design phase will require close liaison with other FAP supporting studies, many of which are long term and will by then be starting to yield relevant results. These include:

- FAP 15 on land acquisition and compensation which has already completed but the conclusions of which are very important to this phase of the study.

- FAP 19 Geographical Information Systems
- FAP 25 Hydrological Modelling
- FAP 18 Topographic mapping

The combined work of these three should allow a computer hydrological simulation to be made which will utilise the digital terrain model and interface it with the hydraulic model.

- FAP 17 Fisheries, particularly with regard to mitigation and management measures.

- FAP 23 Flood proofing, specifically for unprotected areas.

- FAP 21/22 Bank Protection for consideration of three specific areas of Jamuna bank erosion in the study area.

- FAP 24 River Surveys for topographic information in the Char lands which can be related to flood risk and flood proofing.

- FAP 20 Compartmentalisation, particularly their work on public participation.

- FAP 26 Institutional Study

- FAP 16 Environmental study, particularly their water and vector borne disease study, a study on the nutritional consequences of fisheries loss and an assessment of FCD impacts on soil fertility, particularly in relation to siltation, sedimentation and irrigation, all of which are on-going. In addition a possible national study on agro-chemical use is being contemplated.

- The National Agricultural Support Programme which could give assistance with the consideration of appropriate programmes for the area.

5 Staffing

The staff disciplines considered to be required include those listed below. It is presently not possible to give an indication of likely staff times as this requires the development strategy programme to be more firmly fixed:

Foreign Specialist Staff:

- Environmental Planner- with experience in the design and implementation of water resources projects
- Rural Development Sociologist/Institutions Specialist
- Freshwater Ecologist
- Fisheries Expert

Local Staff:

- General Environmentalist
- Human Health Specialist
- Nutritionalist
- Ecologist
- Sociologist
- Rural Development Institutions Specialist
- Fisheries Specialist

The following additional local staff may also be required depending upon the detailed nature of the development strategy to be followed and the nature of mitigation programmes:

- Agricultural Extension Specialist
- Rural Development Planners and Implementation Staff for the flood proofing programme if this were to go ahead.

TERMS OF REFERENCE FOR A DATA COLLECTION PROGRAMME FOR A BASELINE HEALTH AND NUTRITIONAL STUDY

1 Data Collection Procedures

a) Rapid Rural Appraisal (RRA)

RRA is an investigative methodology aimed at producing quicker results than conventional sample surveys whilst avoiding many of the biases and weaknesses that are liable to be encountered by less disciplined methods of rapid data collection. The study will cover all unions of the project area which will reflect the range of conditions existing within it. In this study a very wide range of people including government officials, farmers, fishermen,traders, labour, landless, and men and women will be included for discussion. Cross checking of a check list, including important nutritional issues will be done among the peoples from various disciplines in order to collect as many different views as possible. A spot map will be used for future identification of the investigation area. RRA will be done by highly skilled professionals not by the general investigators. One team will cover one union per day.

b) Household Questionnaire Survey

A framed questionnaire survey will be done to collect the quantitative data on some definite parameters.

i) Design of the sample frame

In order to cover the entire project area, the steps that will be taken to design the household sampling frame are:-

- listing of all unions and villages in all unions
- selecting villages from all unions randomly
- listing sample households in the villages from 1991 voter list, and tax list;
- the existence of the household head in that village will be cross-checked
- based on the list a cluster of 5 households will be randomly selected for each 1000 households. For villages with more than 1000 households two clusters will be selected
- from each selected household information of different parameters will be collected

ii) Parameters for Study

- household members, age group and education

- land property, land use and household income
- annual household expenditure
- occupation, work load
- weekly food intake
    - type
    - quantity
    - frequency of intake
    - intra-family food distribution
        - working male
        - working female
        - school going children
        - working children
        - household head
        - old members
        - housewife(s)
        - others(Sick, etc)

- sources of food items/availability
- food habit/food choice/attitude
- cooking and processing-frequency and the way selection of items for daily cooking is made
- food sanitation

- General Health

    - Disease
        - type and frequency
        - months of initiation
        - duration
        - cause/source
        - fate

- Clinical and Anthropometric data
    - height
    - weight

- Sanitation
    - family
    - personal

- Household water supply
    - sources for
    - washing
    - bathing
    - drinking

    - Quality during different time of the year

- Health Care
    - Access to health care centres
        - distance
        - availability of doctors
        - attention sought and received
        - availability of medicine
        - quality of treatment
        - supplementary nutrient sources and supplies

- family planning facilities and adoption

- Herbal medicine practice
  - availability
  - interest

- Homeopathic
- Mental health of the family, previous cases, causes and effects
- Level of health education
  - awareness about nutrition and health care
  - need for improvement
  - interest in learning and improvement

c) Seasonal Study or Case Study

In order to study the seasonal effects on nutrition intake and choice on different categories of rural people a seasonal or case study will be done in 3 AEZ in the JPPS area. Following steps and procedures will be followed:

- 3 AEZ's
- 3 Villages : 1 flood prone
  1 flood free
  1 Char

in each AEZ
- 9 categories of people
  - Fishermen
  - Farmers (a) Large, (b) Medium, (c) Small
  - Landless (other than labour)
  - Labour (a) Agricultural, (b) Industrial/Non-agricultural
  - Transport workers
  - Erosion victims
  - Small traders, Char residents, female headed households will be selected from each village

- 3 household in each category will be selected for study

- 6 visits (a) 2 during crop peak period (Rabi - April-May, Kharif - Nov-Dec)
  (b) 2 during crop lean period (Rabi - Feb-March, Kharif - Sept-Oct)
  (c) 1 during fish break period (Sept-Oct)
  (d) 1 during fish lean period (May-June)

The survey will be done over a year to collect information on all the parameters suggested for household sample survey. An additional biochemical study will be done on blood haemoglobin. Studies on skin diseases, deficiency symptoms mid-arm circumference for children will also be carried out.

d) Secondary Sources
- NGO's, Thana, Sadar Hospital, Thana Health Complex.

MITIGATION

1 **Health and Nutrition Education**

To create awareness among different classes of people it will be necessary to educate them on health and nutrition which will include:

a) Relationship between food and health
b) Nutritive value of different food items
c) Balanced diet
d) Nutritional requirements of different classes and different age groups
e) Deficiency diseases, symptoms and solutions
f) Cooking and processing of food
g) Sanitation

2 Change in Cropping Patterns

Jamalpur Priority Project Study area is a surplus food grain production area where average total calorie intake was 2122 per day per person. This amount is not below average body need level, but it mostly comes from rice meal. The requirement of other nutrients has not been met. Pulses are the cheap source of protein. As Jamalpur is a grain surplus area, some paddy land could be diverted to pulse production. The soil is mostly suitable for pulse crop cultivation and it is possible to grow more pulses in the area. In order to motivate people for pulse production, a comparative analysis of cost and return figures is needed for pulse and rice and an assurance of the production of benefits is also needed. In the motivational programme, the adverse effects of monocropping of the environment need to be included.

3 Culture Fishery

The status of fishery resources in the study area over last six years has changed and the trend was towards positive increment. The overall loss of riverine fish resources (5.75%) has been adjusted through increase in floodplain fisheries (11.52%) and also cultured pond fisheries (18%). Therefore, the trend is a positive one (14%). However, with this trend the annual fish resources harvested in last year was 1821 tons which calculates only 5 gm per person per day. The average protein requirement per person per day ranges from 42.6 - 58.6 gms. To mitigate the problem 396 ha of culturable ponds which are exposed to flooding every year and 189 ha of derelict ponds could be improved and used for fish culture. Recently it was recommended (FAP 13, 1992) that borrow pits in the country side will be better utilized for secured fish culture programme. Therefore, borrow pits will be another source for culture fishery. Leasing these borrow-pits to the landless and the affected household will help to increase protein supply to the family.

4 Poultry Production

The present trend of decreasing livestock may be mitigated through poultry production. As the waterbodies and wetlands will not be decreased, but the risk of flood will be decreased and the borrow-pits will be secured, production of chickens and ducks is a good possibility of mitigation of protein deficiency. Chickens and ducks are easy to raise and give returns in a short time. Eggs will also be produced and this will be a productive industry for the improvement of protein deficiency in the area. The credit for the initial inputs could be provided by the local NGO's on loan basis.

5 Vegetable Production

Incidences of vitamin and mineral deficiency among the adults are high and the problem is becoming serious in the study area. To solve the problem, increases in vegetable production should be one of the major targets. To fulfil the target, homestead area utilization should be planned. A planned kitchen garden will produce enough vegetable for each household.

5 Education/Motivation Programme

Changes in food habits need to be pioneered. This will require motivating the residents to eat a balanced diet which will be within their expenditure range, and processing the proper part of the vegetable with high vitamin and mineral content. Demonstrations of kitchen garden vegetable production and processing will be needed.