Government of the People's Republic of Bangladesh
Bangladesh Water Development Board
Water Resources Planning Organization

FLOOD ACTION PLAN

NORTHEAST REGIONAL WATER MANAGEMENT PROJECT (FAP 6)

KALNI-KUSHIYARA RIVER MANAGEMENT PROJECT FEASIBILITY STUDY

MAIN REPORT
VOLUME 1

Final Report
March 1998

SNC ♦ Lavalin International
Northwest Hydraulic Consultants

in association with

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Bangladesh Engineering and Technological Services

Canadian International Development Agency

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COVER PHOTO: A typical village in the deeply flooded area of the Northeast Region. The earthen village platform is created to keep the houses above water during the flood season which lasts for five to seven months of the year. The platform is threatened by erosion from wave action; bamboo fencing is used as bank protection but often proves ineffective. The single *hijal* tree in front of the village is all that remains of the past lowland forest. The houses on the platform are squeezed together leaving no space for courtyards, gardens or livestock. Water surrounding the platform is used as a source of drinking water and for waste disposal by the hanging latrines. Life in these crowded villages can become very stressful especially for the women, because of the isolation during the flood season. The only form of transport from the village is by small country boats seen in the picture. The Northeast Regional Water Management Plan aims to improve the quality of life for these people.

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ACRONYMS AND ABBREVIATIONS

AC Land	Assistant Commissioner, Land
ADB	Asian Development Bank
ADC	Additional Deputy Commissioner
AEZ	Agro Ecological Zone
BADC	Bangladesh Agricultural Development Corporation
BARI	Bangladesh Agricultural Research Institute
BASR	Bangladesh Agriculture Sector Review
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BFDC	Bangladesh Fisheries Department Corporation
BIDS	Bangladesh Institute of Development Studies
BIWTA	Bangladesh Inland Water Transport Authority
BRAC	Bangladesh Rural Advancement Committee
BRDB	Bangladesh Rural Development Board
BRRI	Bangladesh Rice Research Institute
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CCF	Commodity Conversion Factor
CD	Capacity Development
CDN	Canadian
CE	Chief Engineer
CEA	Canadian Executing Agency
cft	cubic feet
CHC	Canadian High Commission (Dhaka)
CIDA	Canadian International Development Agency
cm	centimetre
CO	Community Organizer
CPI	Consumer Price Index
CRI	Cost Recovery Index
CWC	Central Water Commission
d	draught
D	Depth
DAE	Department of Agricultural Extension
DC	Deputy Commissioner
DCA	Development Credit Agreement
DOE	Department of Environment
DOF	Department of Fisheries
DOWA	Department of Women Affairs
DPC	District Project Committee
DPHE	Department of Public Health Engineering
DSSTW	Deep Set Shallow Tube Well
DTM	digital terrain model
DTW	Deep Tube Well
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return

EMP	Environmental Management Plan
EPP	Environmental Protection Plan
FA	Fisheries Association
FAP	Flood Action Plan
FCDI	Flood Control Drainage and Irrigation
FFWP	Food for Works Program
FPCO	Flood Plan Coordination Organization
FRI	Fisheries Research Institute
FW	Future With Project
FWO	Future Without Project
GDP	Gross Domestic Product
GEV	General Extreme Value
GIS	Geographic Information System
GOB	Government of Bangladesh
GPS	Global Positioning System
GSB	Geological Survey of Bangladesh
ha	hectare
HH	Household
hr	hour
HTW	Hand Tube Well
HYV	High Yielding Variety
IEC	Important Environmental Components
ILO	International Labor Organization
IRR	Internal Rate of Return
IUCN	International Union for the Conservation of Nature
kg	kilogram
KIP	Karnaphuli Irrigation Project
KK	Kalni-Kushiyara
KKCDMP	Kalni-Kushiyara Community Development and Monitoring Project
KKRB	Kalni-Kushiyara River Basin
KKRIP	Kalni-Kushiyara River Improvement Project
KKRMP	Kalni-Kushiyara River Management Project
km	kilometre
KSS	*Krishi Samabaya Samity*
LAD	Least Available Draught
LAO	Land Acquisition Officer
LB	Left Bank
LBS	Left Bank Side
LCS	Landless Contracting Society
LGED	Local Government Engineering Department
LLP	Low Lift Pump
m	metre
MB	Mechanized Boat
MCA	Multi-Criteria Analysis
MLGRD&C	Ministry of Local Government Rural Development and Co-operatives
mm	millimetre
Mm^3	Million cubic metres
MOA	Ministry of Agriculture

MOF	Ministry of Finance
MOE&F	Ministry of Environment and Forestry
MOF&L	Ministry of Fisheries and Livestock
MOL	Ministry of Land
MOS	Ministry of Shipping
MOSW&WA	Ministry of Social Welfare and Women Affairs
MOWR	Ministry of Water Resources
MPO	Master Plan Organization
mt	metric tonne
mTk	million taka
NCA	Net Cultivable Area
NERP	Northeast Regional Water Management Project
NFMP	New Fisheries Management Policy
NGO	Non-Government Organization
NMB	Non-Mechanized Boat
NPV	Net Present Value
NRR	Natural Rate of Reproduction
NSA	Navigation Survey Area
NSC	National Steering Committee
OECD	Organization for Economic Cooperation and Development
O&M	Operation and Maintenance
PAP	Project Affected Person
PD	Person-Day
PIO	Project Implementation Office
PMP	Project Management Plan
POL	Petroleum, Oil, Lubricants
PPTA	Project Preparation Technical Assistance
PRA	Participator Rural Appraisal
PWD	Public Works Department
RB	Right Bank
RBM	Result Based Management
RBS	Right Bank Side
RRA	Rapid Rural Appraisal
R/S	Riverside
SDE	Sub-Divisional Engineer
SE	Superintending Engineer
SOB	Survey of Bangladesh
SRP	Systems Rehabilitation Project
STW	Shallow Tube Well
SWMC	Surface Water Modelling Centre
TA	Technical Assistance
TCCA	Thana Central Cooperative Association
Tk	Taka (Bangladesh currency. $1 CDN=approx. Tk 30)
TNO	*Thana Nirbahi* Officer
TOR	Terms of Reference
TPC	*Thana* Project Committee
TVA	Tennessee Valley Authority
TW	tube well

UNDP	United Nations Development Program
UNICEF	United Nations International Children Emergency Fund
UP	Union *Parishad*
USA	United States of America
USACOE	US Army Corps of Engineers
VP	Village Platform
WARPO	Water Resources Planning Organization
WHO	World Health Organization
XEN	Executive Engineer

GLOSSARY

aar bandh	a traditional method of platform protection using a bamboo frame and vegetative packing
aman	monsoon rice crop
aus	pre-monsoon rice or rice grown in *kharif* I season
b. aman	broadcast or deepwater aman rice grown in *Kharif* I and II seasons
bandhak	mortgage
bangla	Bengali language
barga	sharecropping system whereby the landowner and the operator share the inputs and the produce
bari	cluster of houses usually having kinship lineage
bazar	market
beel	floodplain lake that may hold water perennially or dry up during the winter season
bhita	homestead
bisra	patch between homestead and crop land
bondh	crop land
boro	rice grown during the dry, winter season
chailla	a grass (Hemarthria protensa) grown in low-lying floodplains
chalni	filter made of bamboo
char	newly emerged land, silted water body
chara bisra	slightly elevated land adjoining the homestead platform
chukti	a type of leasing system for singled-cropped land whereby the operator pays a fixed amount of rent after harvest
chukti kamla	a contracted laborer
class I channel	3.6 metre depth; 50 metre width perennial
class II channel	2.4 metre depth; 50 metre width perennial
class III channel	1.8 metre depth; 37 metre width perennial
class IV channel	1.5 metre depth; 37 metre width seasonal
country boat	wood hull boat of traditional design; capacity usually not more than 500 *maunds* (19 tonnes)
decimal	unit of land measure; 0.01 acre; 0.004 ha
demi paddy	submerged rice stalk and head
dhaincha	a leguminous plant (Sesbania sp.)
dhala	breaches across river banks
dhol kolmi	a woolly shrub (Ipomoea fistulosa)
doon	traditional irrigation equipment
dry season	5 months: December-April inclusive
duar	scour hole in river bed which provides habitat for fish and river dolphins
ghat	riverine landing or assembly place
gleaning	the collection of fallen rice kernels, from harvested fields
gopat	pathway
haat	big market
haor	depression on the floodplain
hati	neighborhood cluster

hizol	type of water tolerant tree
household	a family unit, who share common resources for cooking and eating
ikor	a type of water-tolerant grass (Sclerostachya fusca)
IWT craft	steel-hull boat 350-500-tonne capacity; single screw
jalmohal	waterbody used as fishery
kagra	a type of water-tolerant grass
kanda	high land on the *haor*, used for cattle grazing, cropping or rice threshing
kare	unit of land measurement, 1 *kare* is equal to 0.11 ha (approx.)
katha	unit of land measurement, 1 *katha* is equivalent to 0.08 acre
katha	branches of trees or bamboo piles placed in water to provide shelter for fish
khal	channel
kharif	monsoon crop season, including the *aus* and *aman* crop
khas	government owned land or water bodies
koroch	a type of water-tolerant tree
lakh	100,000
macha	platform made of bamboo or timber
maund	indigenous unit of weight, equivalent to 40 *seers* or 37.3 kg
mauza	lowest level of geo-administrative unit
mohajan	money-lender
murta	a type of water-tolerant plant (Clinogyne dichotoma)
nitimala	guidelines
para	a neighborhood cluster (same as *hati*)
parishad	council
pucca	paved, made of brick, finished surface
rabi	dry season
rangjoma	type of leasing system where the operator pays a fixed rent in cash at the time of contract
sadar	headquarters (district)
samaj	traditional village institution
saree	women's wear
sidal	a type of dried fish
sutki	dried fish
t. aman	transplanted *aman* rice grown in *Kharif* II season or monsoon season
taka (Tk)	unit of currency, 1 US $ = 40 taka (approx.)
tarja wall	protection wall made from bamboo mat
thana	geo-administrative unit under a district comprising several unions
union	geo-administrative unit under a thana comprising several villages
union parishad	elected local government council at the union level
upazila	*upazila (thana)* introduced in 1982 and abolished in 1991
wet season	7 months: May-November inclusive

EXECUTIVE SUMMARY

The Project Area

The Kalni-Kushiyara River Management Project (KKRMP), located in the Northeast region of Bangladesh, covers a gross area of 335,600 ha. It extends over the districts of Sylhet, Sunamganj, Moulvibazar, Habiganj and Kishoreganj. The project is about 170 km away from the capital city of Dhaka and is accessible only by river.

The project area lies within the Sylhet Basin, a large bowl-shaped depression dissected by a maze of active and abandoned distributary channels and ox-bow lakes. Approximately 80% of the land is between 2 to 6 metre above mean sea level. The main river channels are contained by natural levees that project up to 3 m above the surrounding lowlands. The pre-monsoon season (March to May) is characterized by flash floods. During the 5 month monsoon period, about 96% of the project area remains under water.

Present Conditions in the Project Area

The average population density based on latest census (1991) is 526/km^2, which is much lower than the national figure of 755/km^2. In 1995, the population of the project area was estimated at 1.89 million (563/km^2), with 90% living in the rural areas. The low population density reflects the unsuitability of large tracts of land for settlement, since these tracts are subject to pre-monsoon and monsoon flooding. Most of the rural population live in settlements along the river on raised earthen platforms, which are surrounded by water during the monsoon.

This region is one of the poorest of Bangladesh. Presently 65% of the population is considered below the absolute poverty level, 50% below the hard core poverty level, compared to 48% and 28% respectively for the whole of Bangladesh.

Income distribution is highly skewed in favor of large landowners. The top 10% of households have an income share of 40% while the bottom 20% of households have an income share of 6%. Income inequality is higher than that of the country as a whole.

Approximately 75% of the area's population have never attended school. School dropout rates are high, particularly for female students.

The overall health situation is poor. The sanitation facilities used by 95% of households are below acceptable standards. Lack of space on eroded homestead platforms creates congested living conditions.

The economy of the project area, mainly based on agriculture, provides employment for 700,000 people. Although a variety of crops are grown, rice crops account for some 98% of the cultivated area. Farmers grow four main rice crops; *aus (3%)* and deep water *aman (9%)* during the pre-monsoon, *aman (3%)* during the monsoon and *boro* (83%) during the winter months. The figures clearly show that farmers are mainly dependent on *boro* crop.

The area is also characterized by the presence of high quality fisheries habitat, which provide employment to some 100,000 persons. Fishing is the only source of income for landless people during the monsoon season.

Navigation is essential to the area's access and goods transportation. Some 40% of the population depend solely on river communication. The majority of rural market places are located along the Kalni-Kushiyara River. Navigation provides employment to some 20,000 people.

The industrial base is underdeveloped. Although more than 2% of the total population of Bangladesh live in the project area, it accounts for only 1% of the manufacturing sector, most of it in food processing. Most smaller urban centres have no industry.

Past water resources management efforts consist of 11 projects built during the last 2 decades. These projects provide partial flood mitigation, drainage improvement, and dry season irrigation water to an area of 55,000 ha.

The Kalni-Kushiyara River system is the life-line of the people, the resource base for their livelihood and the vehicle for their survival. Agriculture, fisheries, transportation, and the region's environmental sustainability are all dependent on the hydrological and geomorphic characteristics of this system. At the same time, most of the problems faced by the people are inextricably linked to the changes in the river's hydrological regime.

Problems and Issues Facing the Project Area

Due to a major avulsion of the Kushiyara River, caused by natural and man-made interventions, some 30-40 years ago, the river is experiencing large ongoing sedimentation and instability which have led to widespread over-bank spills, breaches in the river banks, channel shifts and increased pre-monsoon flooding. These events have reduced crop yields, silted-up productive agricultural lands, eroded settlements, impaired navigation in the dry season and contributed to the loss of valuable fisheries habitat.

Small and medium farmers, who represent 50% of the total households and who own 30% of the cultivated area, often cannot sustain their livelihood, as pre-monsoon floods regularly damage their rice crops. Often, they are forced to mortgage or sell their land for their survival. Ultimately, medium farmers become poorer, small farmers become landless. Reduced production also affects employment for the landless (42% of all households) who are mostly agriculture laborers. Recurring pre-monsoon flood damage has accelerated the process of pauperization of the farming community.

To date, water management and flood mitigation initiatives have not addressed the underlying causes of these problems, and in some cases might have worsened the situation. People of the area find it increasingly difficult to cope with the river's deteriorating condition. There is no indication that the current situation caused by river instability will improve in the future. In fact, there is strong evidence that this condition will deteriorate further as the river bed is aggrading year after year. Without a comprehensive river stabilization program, the pattern of flooding, delay in post-monsoon drainage, channel shifts, erosion and sedimentation will continue and the resulting damages are expected to worsen.

Future Without Project

Over the next 30 years, if present trends continue without the project, the general situation is expected to deteriorate further.

Crop production in the future will continue to decline. Rice production will be reduced by about 32,500 tonnes. Existing projects designed to increase crop production will require rehabilitation, which may contribute to a worsening flood situations in areas outside the command of those projects.

The project's navigation network is deteriorating due to sedimentation which has reduced the navigability of the Kalni-Kushiyara River and its feeder routes. The Government water transport service (launch) will be totally disrupted during the dry season. Medium size boats, may also disappear from the lower reach of the Kalni River for extended periods during the dry season. The cost of passenger and freight traffic will increase considerably due to the need for frequent stoppage and transhipment caused by inadequate draught.

Continued siltation of permanent water bodies caused by over bank spills and breaches in the river banks will contribute to the deterioration of fisheries. Fish production will be reduced over 2,000 tonnes from its present level.

As a consequence, socioeconomic conditions will continue to deteriorate, contributing more landlessness in the region. It is necessary to intervene in order to reverse the process which accelerates the pauperization of the local population.

Objective of the Kalni-Kushiyara River Management Project

Given the nature of the problems facing the region, the Kalni-Kushiyara River Management Project has been formulated to meet multiple objectives, including:

- improving the river's stability and providing a more stable environment for development;
- reducing damages to agriculture by reducing pre-monsoon flood damage and improving post-monsoon drainage;
- improving living conditions along the river by reducing erosion damage to villages, and by creating new flood-free village platform, and
- improving navigation along the river during the dry season.

River Management Strategy

In order to meet all of the project's objectives, a coordinated river management strategy was developed. In this approach, river stabilization measures, including channel dredging, minimize pre-monsoon flooding and therefore improve significantly agricultural production. These measures also generate benefits for navigation, fisheries and human settlements. As part of the KKRMP feasibility study, a Pilot Dredging Project, carried out in 1995-96 demonstrated that waste spoil from channel excavation work can be used as a valuable resource to construct new flood-protected village platforms or to extend existing ones. At the same time, using the spoil to build new platforms provides an effective means of disposing of waste material, often a difficult problem commonly associated with channel excavation work.

Project Initiatives

The project includes the following initiatives, undertaken over a 168 km reach of the Kalni-Kushiyara River:

- River Stabilization Works: construction of two loop cuts (7 km), channel excavation (31 km), channel re-alignment and river training at 3 locations;

- Flood Control Works: construction of levees at strategic locations for a total length of 20 km to minimize river over-bank spills and breaches;

- Navigation Channel Improvements: dredging at 5 locations to develop Class II navigation channel (Least Available Draft of 2.4 m);

- Village Homestead Platforms: construction of 247 ha of homestead platforms at 44 locations using dredged spoil and including protection measures against wave action and associated infrastructure, and

- Implementation of an Environmental Management Plan: designed to enhance positive impacts and mitigate negative ones.

The construction initiatives are sequenced to avoid adverse downstream impacts and to minimize channel maintenance costs. The implementation program is scheduled for a period of 7 years, which includes 2 years for detailed design, floating of international tenders and land acquisition, and 5 years for the construction period.

Operation and Maintenance

Following the initial interventions, the project will require adaptive river management, which will include an annual program of activities that are similar to those undertaken in the project implementation program. Therefore, there will be a requirement for river maintenance which will include annual dredging for both channel stabilization and navigation, use of dredged spoil to construct homestead platforms, and environmental management. It is expected that over the life of the project (30 years including the implementation phase), some 40 additional platforms will be built during the Operation and Maintenance (O&M) phase.

Capacity Development

The study recognises that the sustainability of the project depends largely on effective operation and maintenance and that a coordinated approach between the institutions directly involved is imperative. To that effect an organizational structure is proposed to manage the project, which is both in accordance with the *modus operandi* of the Government of Bangladesh civil service and has also been tested effectively on other projects which involve complex inter-ministry interaction and stakeholder participation.

A capacity development component is proposed to assist the participating institutions in fulfilling their role during the O&M phase of the project.

Project Impacts

In the long-term, the project is expected to have strong positive impacts. Negative impacts are all almost entirely within the short-term (construction) period, and will be mitigated.

The project will virtually eliminate over bank spills and breaches of river banks during the pre-monsoon season and consequently lower water levels on the floodplain by 0.4 m to 0.6 m. The project will also improve post-monsoon drainage and will provide irrigation facilities during the dry season through the installation of regulating structures. The existing flood control infrastructures will be more effective due to the reduction of pre-monsoon flood levels. As a result, agricultural production in low land (currently flooded regularly) is expected to increase to the same level other farmers are obtaining under damage-free conditions, on most years. Annual rice production is expected to increase by about 82,800 tonnes, or 13% more than future forecast production without the project.

The project will provide Class II navigation conditions round the year. This is expected to increase freight traffic by about 200,000 tonnes, or 45% more than future forecasted traffic without the project.

Reduction of over bank spills and breaches in the river banks will reduce the rate of siltation in the permanent water bodies, thus improving fisheries habitat. The construction of a fishpass will increase floodplain fisheries on the left bank of the Kalni-Kushiyara River. Therefore, the project is also expected to reverse the continuing decline in open water fisheries by providing a modest net increase in production of over 1,300 tonnes.

The project will also provide substantial positive impacts by developing homestead platforms during the implementation and O&M phases. An area of 447 ha will be raised as homestead platforms: of this 75% will be used for rural household developments and the remaining 25% is expected to be used for homestead vegetation. An owner's land will gain 10 times in value when it becomes flood-protected homestead land. Landowners will use their raised and expanded platform space for improved post-harvest rice processing, vegetable, fruits and livestock production, as well as water and sanitation facilities.

About 44 homestead platforms will be developed within a span of 5 years during the implementation stage. These will provide 247 ha of new land for some 6,250 households. During the operation and maintenance phase of the project, about 200 ha of land will be developed for homestead platforms, which will facilitate homesteads for an additional 5,000 families.

The main negative impacts on land use and settlement is the acquisition of agricultural land for the 2 loop cuts. These impacts are unavoidable and affect locally some communities on the long-term. In order to minimize those impacts, compensation is required for approximately 160 landowners for loss of land as their primary economic resource. In addition to compensation, a certain number of mitigative measures will be implemented, reducing the magnitude of the impacts.

Project Assessment

Total financial capital costs of the project are estimated to be about Tk 2,788 million (1995 prices), CDN$ 90 million or US$ 68 million. These capital costs are inclusive of land costs and environmental management program costs (mitigation and enhancement), but exclusive of loan costs. The Economic Internal Rate of Return is estimated to be 17.2% and the Net Present Value is Tk 531 million, CDN$ 17.1 million or US$ 13 million assuming a discount rate of 12% per annum. The Net Present Value is relatively large, and together with the Economic Internal Rate of Return indicates that the project is economically viable and represents a good investment opportunity for Bangladesh.

The economic analysis evaluated the significant benefits for the following sectors of the economy: agricultural production, socioeconomic infrastructure, fisheries and navigation.

The largest beneficial impact (79%) of the proposed Kalni-Kushiyara River Management Project will accrue to the agricultural sector. The average annual agricultural economic benefits will amount to Tk 374 million, CDN$ 12.0 million or US$ 9.1 million . On a per-hectare basis over the Net Cultivated Area, this translates into Tk 1,348/year ha , CDN$ 43/year ha or US$ 33/year ha. As a point of reference, this represents 14% of a typical gross margin/year ha.

The expected benefits of the proposed project to the socioeconomic infrastructure of the region are numerous and varied. They include:

- Kalni-Kushiyara River bank flood protection;
- additional river bank protection & related land development;
- village platform flood and wave protection;
- village platform homestead gardens and fruit trees;
- village platform homestead grain drying;
- health and sanitation;
- quality of life improvement, and
- reduction of O&M for existing projects.

The annual incremental net benefits for the socioeconomic infrastructure are estimated to be Tk 76.3 million, CDN$ 2.5 million or US$ 1.9 million. These are the second largest benefits of the project, which represent 9.6% of the total benefits.

The fisheries sector is expected, on balance, to be slightly better off after the proposed project is implemented. The net annual incremental economic benefits are estimated to be Tk 43.7 million, CDN$ 1.4 million or US$ 1.1 million by project Year 9 and remain constant over the remaining life time of the project. These represent 6.9% of the total benefits.

Navigation annual economic benefits are projected at Tk 21.9 million, CDN$ 0.7 million or US$ 0.5 million by Year 7 of the project. These would increase in proportion to population growth to reach some Tk 35 million, CDN$ 1.1 million or US$ 0.9 million by Year 30. These represent 4.5% of the total benefits.

Poverty Alleviation

Poverty alleviation is one of the main objectives of the project.

The average per capita annual income in the project area is estimated at Tk 7,470/year (CDN$ 241, US$ 182/year). Household income is not sufficient to maintain a decent life for most of the households.

Improved channel stability and decrease in pre-monsoon flooding will increase agricultural production. Per capita food availability will increase from 0.66 kg/day/person to 0.75 kg/day/person.

The project will reverse the gradual decline of the fisheries sector. This is very significant since 60% of all households (and these are often relatively poor households) are fish-dependent. Fishing is the primary source of income of 28% of all households.

The creation of flood-secure homesteads will enhance vegetable and fruit production for an estimated 11,250 families. Improved production will improve nutrition and food security. Vegetable and fruit cultivation contributes about 7% of farm income.

Pre-monsoon flood protection associated with expanded homestead areas will encourage the development of livestock. The net value of this production would increase by about 10%. Livestock production already accounts for about 11% of farm household income.

There will be an overall increase in annual employment of 23,000 person years. This includes an increase in agricultural labor of 17,000 person year, of which roughly 10% will be shared by women. The net increase in employment opportunities for landless people is estimated at 6,000 person years.

Some 1,250 landless families will be relocated on the new flood-secure village platforms.

Finally, on balance, the proposed project would reduce risk and uncertainty; thus gradually changing attitudes and giving more hope and opportunity to the region (particularly the less-empowered). The immediate result will be additional private capital investment and growth. The attitudinal change itself, however, is the most important single ingredient in the gradual development of a more sustainable regional economy in a very fragile and unforgiving physical environment. This can become well-engrained during the very pro-active initial construction phase which provides significant employment opportunities. It sends a message "Somebody cares; we can do it." And then they will.

Gender Equity

Gender specific impacts of the project will be *strongly progressive*. Poor women will use their earnings from project construction to invest in a variety of income-earning opportunities including tree nurseries, cultivation on leased land and latrine construction. Further economic opportunities will be provided for poor women in post-harvest processing and rice gleaning. Women on flood-secure and expanded homestead platforms will increase production of vegetables, fruits, livestock and poultry. Family welfare will be enhanced through improved nutrition and water and hygiene facilities. Women's enhanced income will contribute to children's educational opportunities.

Women on homestead platforms will be exposed to new knowledge and skills. Women's decision-making capacity will be improved with increased knowledge and earning capacity. At the village level, women's labor and platform groups will be strengthened to participate in community development. Implementing agencies and male committees will be provided with basic gender awareness to support women's development throughout the project. It is anticipated that over the course of the project, Non Governmental Organizations and Government agencies will be attracted to the area to provide gender-specific programing.

Monitoring of Long-Term Benefits

A program is proposed to monitor the long-term benefits of the project on agriculture, fisheries, water transportation as well as on employment and income generation. This program, which will be initiated during the implementation phase is expected to continue throughout the life time of the project. Monitoring of benefits will be done by evaluating at regular time intervals the status of a series of indicators.

Project Risks

The project has risks, some of which are manageable, and some not. The important risks are as follows:

- the study shows that there could be an avulsion (change of channel) in the lower reach of the Kalni River in the near future. This avulsion would result in the abandonment of the lower Kalni River and sedimentation of the lower reach of the Baulai River, presently the major navigation route of the Northeast region. Timely implementation of the project will prevent this avulsion;

- social conflicts during the construction may arise. This type of risk is ever present as some people will loose their land and a large labor force will participate in the implementation. Project implementation has been organized to prevent these types of conflicts by the formation of Project Committees and Stakeholders Committees. Also, during construction, preference will be given to local labor, including a 25% allocation for women;

- a major flood may occur prior to or during project implementation. If the platforms are constructed and protected as per the specifications, they should not suffer significantly from a major flood event. However, this could result in a significant increase in dredging requirements. This is not manageable, and is often inherent in water resource development projects;

- future pre-monsoon flood levels may not be reduced as much as predicted. This would result in a reduction in the main economic benefit - increased agricultural development. The study analysis has demonstrated that implementing the project will result in a reduction in pre-monsoon flood levels in the Kalni-Kushiarya River channel; and based on historical flooding, available mapping, field inspection, and judgement, it is expected that flood levels will be equally lowered in cropped areas of the floodplain that are far-removed from the river channel. Although the methodology is conservative, neither the data nor technology are available to be absolutely certain about the magnitude of flood-level reduction, and

- maintenance is not adequately undertaken during the O&M phase of the project. This will eliminate most agricultural benefits, but proper O&M activities can be managed with successful capacity development and associated financial resources.

Conclusions and Recommendations

This inter-disciplinary assessment indicates that there are substantial net annual economic benefits generated by the proposed Kalni-Kushiyara River Management Project. It is estimated that there will be a positive net present value (assuming a 12% discount rate over 30 years) of approximately Tk 531 million (CDN$ 17.1 million, US$13.0 million) and an Economic Internal Rate of Return of 17.2% per annum.

The proposed Kalni-Kushiyara River Management Project is attractive because it is designed to be a multiple-use project which will positively impact on a large and diverse number of beneficiaries in terms of sources of income, increased employment opportunities, relative incomes, and gender. It is also explicitly designed to assist in empowering the "poorest of the poor"; promptly stop potentially irreversible environmental degradation (with its immeasurable but high social cost); and be institutionally, financially, and environmentally sustainable.

Thus, the Kalni-Kushiyara River Management Project is, on balance, considered to be economically viable and a very good public investment opportunity for Bangladesh. It is, therefore, recommended that:

- the project be implemented as soon as possible;

- careful monitoring and baseline data collection precede and accompany actual project implementation;

- all people who will be directly impacted by the project participate in the project implementation process;

- all proposed mitigation and enhancement programs be implemented simultaneously and in their entirety, since these are an integral part of the project, and

- fiscal and institutional O&M responsibilities be determined (to assure sustainability) prior to project implementation.

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1. INTRODUCTION

1.1 Background

The Kalni-Kushiyara River is one of the major river systems in the Northeast Region of Bangladesh (Figure 1.1). Over the last 30 years, it has experienced ongoing channel instability and sedimentation problems. The process has intensified during this period while the population has doubled. These problems have led to increased pre-monsoon flood damage, deteriorating river navigation, and loss of productive agricultural land and human settlements.

In its first phase, the Northeast Regional Water Management Project (NERP) identified the Kalni-Kushiyara River Improvement Project as a key initiative toward achieving integrated water management in the Sylhet Basin. In 1993, a pre-feasibility study diagnosed the main factors causing instability and examined various concepts for stabilizing and rehabilitating the channel. A program of river training and maintenance dredging was recommended. A separate pilot dredging project was also recommended to test and demonstrate specific concepts related to the dredging operations and the use of dredged spoil, in particular for constructing village platforms.

In 1994, the Canadian International Development Agency (CIDA), along with the Flood Plan Coordination Organization (FPCO) and the Bangladesh Water Development Board (BWDB), decided to proceed with both the pilot dredging project and a feasibility study for the Kalni-Kushiyara River Management Project (KKRMP). The findings and conclusions from the pilot project were intended to provide the feasibility investigation with information and experience that could not be established through conventional research.

1.2 Project Rationale and Objectives

Past flood control initiatives in the project area have focussed on constructing submersible embankments around individual *haors* (polders) that are scattered over the floodplain. These *haor* development projects were constructed with the implicit assumption that flood protection could be achieved independently from processes on the main river system. However, channel instability and sedimentation on the main river result in increased spills and breaches, lateral channel shifting, increased frequency of flooding and reduced post-monsoon drainage on the floodplain, necessitating continual project rehabilitation.

Measures to promote the development of a more stable channel regime are necessary for the long-term maintenance of the river system, and for ensuring the operation of infrastructure and river-based transportation systems in the surrounding area. Simply raising the height of existing embankments will provide temporary benefits, but long-term sustainable solutions will require remedial works to the main river.

Problems arising from sedimentation and channel instability can seldom be permanently "solved" by single, short-term interventions. Instead, it is more realistic to manage river problems through ongoing channel maintenance, by monitoring the channel's response to interventions and by adapting the program to the developments that occur. If potential problems can be diagnosed and remedial measures carried out in a manner that is compatible with the river's regime before major instability occurs, there is a reasonable chance of improving the river's stability. Importantly, it is essential to develop the institutional resources and capacity to carry out this type of adaptive river maintenance program to ensure that the improvements can be sustained.

The overall goal of the KKRMP is to provide sustained management of the Kalni-Kushiyara River. By doing so, this project will provide the basis for stable and reliable agricultural and economic growth in order to alleviate poverty and improve human welfare. More specifically, the project's purpose is to:

- improve the river's long-term stability and to create a more stable environment for development;
- reduce damage to agriculture by controlling pre-monsoon floods and improving post-monsoon drainage;
- improve living conditions along the floodplain by reducing erosion damage to villages and homesteads and by creating new flood-free village platforms, and
- improve navigation along the Kalni-Kushiyara River during the dry season.

1.3 Terms of Reference and Scope of Work

The scope of work to be done was defined in the NERP Terms of Reference (TOR) for Phase 2 Work, May 1994. Based on these TOR, this study investigates the technical, environmental, socioeconomic and economic feasibility, as well as the long-term sustainability of the proposed project in accordance with FPCO *guidelines* (FPCO, 1992 a). Public participation was also a fundamental component of the feasibility study. Furthermore, mitigation measures, where required, were an integral part of the study. The TOR also specified that the details of the organizational set-up (including the mechanism for cost recovery and, where applicable, beneficiaries participation) required for the operation and maintenance of the completed works be defined. Plans for the resettlement of people whose homesteads would be displaced by the proposed works were also required.

In order to meet these requirements, the scope of the feasibility study included:

- a detailed hydrotechnical and geomorphic analysis to assess the technical feasibility and impacts of proposed channel improvements;

- an engineering analysis to develop preliminary plans and cost-estimates of the works;

- comprehensive studies to assess the benefits of the project, including those accruing to agriculture, navigation, fisheries and improvements to communities and human settlement;

- an Environmental Impact Assessment (EIA) to identify the impacts of the proposed intervention on the bio-physical and socioeconomic environment;

- an Environmental Management Plan (EMP) to provide specific mitigative action plans to be carried out during the Implementation and Operation and Maintenance (O&M) phases of the proposed intervention;

- an environmental monitoring plan to monitor the effectiveness of the EMP action plans for reducing the proposed intervention negative impacts and enhancing the proposed intervention positive impacts;

- an institutional assessment to define the details of the organizational set-up required for implementing the proposed development and sustaining its benefits. This assessment includes defining the scope of capacity development activities that will be needed for the network of institutions, organizations and agencies that will have a stake in the proposed intervention, and

- an economic analysis of the proposed intervention, using the FPCO *Guidelines for Project Assessment* (FPCO, 1992 a), to assess the economic viability of the proposed intervention.

1.4 Report Layout

The report is organized as follows:

- Chapter 2, *Bio-Physical Context*, provides a brief description of the region, its climate, land, water, hydrology evolution and ecological characteristics;

- Chapter 3, *Socioeconomic Context*, characterizes people and settlement patterns along the river and floodplain, land use and agricultural practices, use of water bodies, river transport and trade in the project area;

- Chapter 4, *Institutional Context*, provides an overview of the existing range of roles and capacities of national and local government as well as non-government agencies that are key to the development and management of the bio-physical and socioeconomic environment in the project area;

- Chapter 5, *Problems and Issues*, reviews water management problems and issues and their impacts to development and human settlement in the project area;

- Chapter 6, *Future Without Project*, characterizes conditions in the project area over the next 30 years, assuming no new interventions are carried out;

- Chapter 7, *Project Alternatives*, describes the overall scope of a river improvement program including a description of the main components for two intervention alternatives. It also provides the implementation schedule and O&M program;

- Chapter 8, *Impact of Proposed Development*, describes the anticipated positive and negative medium/long-term impacts for both alternatives. The two alternatives are contrasted, and based on clear advantages, one alternative is retained for further study;

- Chapter 9, *Environmental Management Plan*, presents the EMP for the proposed intervention, including an environmental protection plan, an enhancement plan, a contingency plan during the construction period and a post-project environment monitoring plan;

- Chapter 10, *Organization, Management and Capacity Development*, presents a tentative project organization of the findings of a seminar held on institutional arrangements and cost recovery, the follow-up required for developing the capacity of government and stakeholders institutions, which will participate in the project, especially during the O&M phase, examples of river management, and

- Chapter 11, *Project Assessment,* evaluates the project's economics, and provides key economic indicators for project appraisal. It also assesses the economic viability of the proposed intervention and presents a financial analysis and a multi-criteria analysis.

The report also contains 13 Annexes, which have been prepared to provide detailed information to support the main report.

- Annex A - Sedimentation and Morphology;
- Annex B - MIKE-11 Hydrodynamic Model;
- Annex C - Engineering;
- Annex D - Social;
- Annex E - Economics;
- Annex F - Agriculture;
- Annex G - Navigation;
- Annex H - Fisheries;
- Annex I - Environmental Impact Assessment (EIA);
- Annex J - Pilot Dredging Project;
- Annex K - The O&M Phase: Institutional Arrangements and Cost Recovery;
- Annex L - Project Management Plan, and
- Annex M - Project Maps and Engineering Drawings.

1.5 Methodology

This investigation was carried out using an integrated multi-sectorial approach. The multi-disciplinary team included: water resource planning engineers and specialists in hydrodynamic modelling, river engineering, river surveying, environment, agriculture, fisheries, sociology, institutional development, gender, navigation and economics. The investigation also included new data collection.

Most of the aforementioned report chapters involved input from several members of the multi-disciplinary team, so it is appropriate at this point to summarize methodologies followed by each sectorial specialist, and to highlight the new data collected for this study. Details on the various methodologies used are provided in the feasibility study report annexes.

1.5.1 River Sedimentation and Engineering Studies

The scope of the sedimentation and morphologic investigations included:

- diagnosing the causes of recurring channel instability and sediment deposition;
- assessing future trends of river behaviour;
- predicting the physical impacts of proposed channel improvements, and
- assessing the ongoing maintenance required for the project.

A combined geomorphic-river engineering approach was used to forecast trends in river behaviour and to assess the impacts of proposed interventions. The investigations were carried out over the entire 300 km Kushiyara - Kalni -Dhaleswari - Meghna River system, with the work focussed on the 190 km reach between Fenchuganj and Dilalpur (Figure 1.1). The work included field investigations (primarily sediment sampling and morphologic surveys), as well as an analysis of historical maps and sediment transport modelling.

1.5.2 River Surveys and Mapping

NERP developed a fast, accurate method for preparing hydrographic charts of the river. This information was essential for the morphologic studies, for engineering design and costing of various alternatives, as well as for assessing project impacts. Underwater portions of the channel were surveyed using a Global Positioning System (GPS) and digital depth sounder in a boat. A GPS base station receiver on-shore was used to differentially correct the data. Ground topography was surveyed with an electronic total station. The survey information was produced in Auto-CAD format and presented as 1:10,000 scale charts.

1.5.3 Hydrodynamic Modelling Studies

A calibrated hydrodynamic model was developed to simulate various project scenarios and to determine the project's impacts on water levels, discharges and the extent of inundation in the region. The analysis was carried out using the MIKE-11 mathematical model developed by the Danish Hydraulics Institute and chosen by MPO and the Flood Action Plan (FAP under which NERP began) for hydraulic investigations in Bangladesh. The model simulates the passage of flood flows through a complex network of channels and the floodplain. Cross section surveys of the main channel and floodplain were carried out to gather the necessary data to represent the hydraulic geometry of the river system. Hydrometric measurements were conducted in 1995/96 to provide water level and discharge data to verify the model predictions.

A digital terrain model (DTM) was used to process the MIKE-11 output and to represent the depth of flooding and extent of inundation in the project area. This provided a very effective method for assessing the impacts of various development alternatives. These results were the basis for estimating the agricultural benefits of the proposed alternatives.

1.5.4 Agriculture

The data for agriculture were obtained from primary and secondary sources. The primary sources included: land use surveys, input use monitoring and field interviews. The land use survey provided a basis for the assessment of major and minor crops grown in the project area, crop sowing time, transplantation and harvest period, and yield levels both under normal and damaged conditions.

Ten sample sites, shown on Figure 1.2, were selected considering flooding characteristics, agro-ecological zones and sub-zones, soil association, land capability and land use association. The area of each sample site was selected to fully cover a number of *mauzas,* since the Bangladesh Bureau of Statistics (BBS) agricultural statistics are reported at the *mauza* level. The sample survey covered 32 *mauzas* within 10 *thanas*. Data were recorded on a structured questionnaire, and land use types, their location and areal extent were recorded on the corresponding *mauza* maps. The total area of the 10 sample sites represents 5% of the project area.

Input use and crop yields were determined from farm monitoring and crop cut samples using a separate questionnaire.

The secondary sources provided information on cultivated areas, land type, use, capability, soils, agriculture extension services, and previous data on crop area and production. The data were collected from several organizations. Views and findings of other studies have been used where applicable.

The net cultivable area (NCA) was determined from *thana* maps compiled from satellite imagery (1989-90), aerial photographs (1983-84), topographic maps developed by the Local Government Engineering Department (LGED) in 1994 under a UNDP/ILO project, BBS data and NERP land use survey.

The net cropped area on 34 *mauzas* were initially determined from NERP land use survey and then compared with 1983-84 BBS census data. Estimated cropped areas were then compared to BBS *thana* statistics (BBS, 1995a).

The total cultivated land was apportioned into 4 flooding depth ranges under present, future without and future with project conditions. It was then analyzed based on the flood depth maps produced by the MIKE 11 hydrodynamic model.

1.5.5 Fisheries

Monthly catch assessment surveys were carried out by a team of NERP fisheries field staff at 20 sites within the project area from February 1995 to December 1996. Under the direction of the NERP Fisheries Specialist, the surveys were carried out by three fisheries field biologists who completed questionnaires and gathered other information during sample site visits.

Information on fishing effort was collected by frequent field visits and direct census of the mode of operation of fishing gear, and the number of days of operation of the different gear at different sites and during different seasons. Data were also collected on the number of local fisher groups, the number of fishers aggregated by gear type, the number of units of each gear type, the number of units of each fishing craft type and the area of fishing ground harvested by individual fishers.

Nominal data on fish production were obtained from the *Annual Fish Catch Statistics of Bangladesh* published by the Department of Fisheries. Corporate fish purchase, production and export data were obtained through the courtesy of the directors of Ajmiriganj Fish Industries Ltd. and Kuliarchar Cold Storage Ltd.

1.5.6 Navigation

Field surveys were conducted in 1995 to gather data on the water transport fleet, its traffic and the volume of employment by boat crew. These data were collected through structured questionnaires at various market places and river stations on both *haat* (market) and non-*haat* days. The surveys were collected in both the dry and monsoon seasons to account for fluctuations in navigation activities. Traffic projections for future river water transport were formulated for various scenarios to estimate the project impacts and benefits.

The improvement of navigation in the Kalni-Kushiyara River system concentrates on trade generation and benefits on a 168 km reach between Fenchuganj and Astagram. This is called the "full river reach" in this report. A detailed traffic study was undertaken in 1995 along a 110 km reach between Madna and Sherpur which is defined as the navigation survey area (NSA).

The navigation analysis concentrates on a 10 km wide band (5 km on each side of the river). It is considered that this is the population and land area that will have the most influence on river traffic.

Note that the full river reach includes a section of the south bank of the Kalni Kushiyara River system that is outside the project area. Thus the navigation analysis utilizes crop areas, population and forecasts that are slightly different from those confined by the boundary of the project area.

1.5.7 Social

Material for the social, gender and community development study is based on both primary and secondary data. Primary data have been obtained from riverine and *haor* communities throughout the project area, through surveys, focus group discussions, community meetings and the in-situ experience of the Pilot Dredging Project. Secondary data have been amassed from the BBS and from other selected agencies and published sources. Following are the sources of data and information.

Village Reconnaissance Survey
In the 1995-1996 dry season, a village reconnaissance survey was done in 115 villages, on the riverside and the floodplain, along both banks of the Kalni-Kushiyara River, from Sherpur to Kochuagaon. A check-list format was used to collect material on village, union and *thana* location, population, flood occurrence, erosion history, and *khas* land availability.

Household Survey
A socioeconomic survey of households was carried out in April-June 1996. Based on the knowledge gained of villages in the Reconnaissance Survey, 6 villages, covering the Upper, Middle and Lower reaches between Sherpur and Kochuagaon were surveyed. Villages were selected to typify the pilot project communities, geographic diversity, village size, occupational and economic diversity, and water problems such as flood, erosion, and drainage congestion. In total, the male heads of 568 households were sampled with a pre-tested questionnaire to obtain

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data on population characteristics, land ownership, tenancy conditions, occupation, income and water and sanitation coverage.

Womens Status Survey
In the dry season of 1996, a women's status survey was conducted by female community organizers (COs) in 5 villages, representing 4 *thanas*, located along the river between Ajmiriganj and Madna. Villages were selected to sample women's participation in the pilot communities and to represent villages with a typical range of women's issues related to flood, erosion and homestead agriculture. The senior women in 408 households were surveyed with a structured questionnaire on household characteristics, marriage, education, literacy, land ownership, homestead production, income, wage and household decision-making.

Participatory Rural Appraisal
Participatory Rural Appraisal (PRA) is a research methodology, used by social scientists, to develop qualitative analysis on selected issues not captured in statistical surveys and hard data. Based on discussion, the analysis draws on people's experiences and knowledge of their life conditions. Over the past one and half years, the PRA method has been extensively used by the COs.

Having male and female COs living in the villages, over an extended period, has provided them with the acceptability needed to gain depth on village social relationships, as well as adding a seasonal and gender dimension to the material. At the pilot dredging sites, as well as in remote project areas, people's perceptions have been gathered to provide the social context on a wide range of issues including agriculture and fishing practices, land and tenancy relationships, traditional platform protection, labor and wage contracts, paddy gleaning, markets and navigation patterns. Historical accounts and selected studies on erosion, *khas* land, channel changes, river avulsions and disposal sites have contributed to the study team's knowledge of social issues in water resource management.

Government Statistics
Secondary data have been assembled using statistics from the Bangladesh Bureau of Statistics, and published material from the Bangladesh Institute of Development Studies (BIDS), the Bangladesh Agriculture Sector Review (BASR), UNDP and other government sources. Data on tubewell coverage has been obtained from the relevant *thana*-level offices of the Department of Public Health Engineering (DPHE), whereas material on health services and latrine coverage was obtained from the *thana* health offices and UNICEF, respectively.

1.5.8 Project Assessment

The economic methodology employed generally follows the FPCO *Guidelines for Project Assessment* (FPCO, 1992a) and internationally-accepted principles. All costs and benefits were valued in constant (non inflated) 1995 prices. NERP also updated the commodity conversion factors (CCFs) in terms of 1995 constant prices. These factors are required to convert the distorted market values of specific commodities into undistorted economic border price equivalents.

The economic project costs included capital costs and O&M costs.

The specific benefits evaluated in the economic analysis included the following:

- Agricultural Production;
- Socioeconomic Infrastructure;
- Fisheries, and
- Navigation.

Since the economic analysis is based on uncertain future events and imperfect data, a sensitivity analysis was conducted to assess systematically the reliability and robustness of the Base Case estimates.

A financial assessment was also carried out to investigate 3 particularly important financial considerations:

- Financial Impact on Project Beneficiaries;
- Poverty Alleviation Impact, and
- Financial Impact on Government.

The methodology used also included a multi-criteria analysis to provide a comprehensive basis for conducting a comparison of the expected impacts in economic, quantitative and qualitative terms.

1.5.9 Environmental Impact Assessment (EIA)

The methodology recommended in the EIA Guidelines and the EIA Manual of FPCO was followed (FPCO, 1992b). This Feasibility Study was initiated at a time when the Implementation Plan and the Environmental Management Plan (EMP) of the Pilot Dredging Project were prepared. This was followed by the implementation of the Pilot Dredging Project carried out at 2 locations in the study area. The experience of preparing and implementing the EMP for the Pilot Dredging Project was also used in conducting the EIA of the Feasibility Study, and in particular for collecting primary data, and selecting the Important Environmental Components (IECs). In addition, reconnaissance field visits and discussions with local communities were held.

Data collection methods included Rapid Rural Appraisal (RRA), Participatory Rural Appraisal (PRA), and other types of survey for collecting information on land use, vegetation, wildlife, fisheries, navigation etc.

The team developed an environmental baseline description for the study area, followed by a bounding exercise for determining temporal, spatial, impact and monitoring boundaries. The impacts of the project were predicted by assessing the difference between 'future-without-project' with a 'future-with-project' scenario.

Following the development of the EMP to enhance positive impacts and to mitigate negative ones, residual impacts of the project on the environment were evaluated.

1.5.10 Pilot Dredging Project

The pilot dredging project re-excavated 2 short reaches of the Kalni River downstream of Ajmiriganj and used the dredge spoil to construct two village platforms. The first platform (Kakailseo) was located on the left bank of the river in Kakailseo *Thana* of Habiganj District, while the second platform (Gazaria) was located on the right bank in Itna *Thana* of Kishoreganj District. The Kakailseo platform has an area of 3.1 ha and required 133,000 m^3 of spoil. The Gazaria platform has a combined area of 4.6 ha and required about 250,000 m^3 of spoil. The objectives of the project were:

- to evaluate dredging methods and disposal operations in terms of productivity, maintenance requirements, efficiency of operations, need for environmental management and cost;
- to develop, test and demonstrate the beneficial uses for the spoil, including the potential to develop new village platforms;
- to identify constraints that may affect the site selection and design of future dredging operations, and
- to develop a methodology for public participation activities in future dredging programs.

The experience from the pilot dredging project provided a wealth of knowledge related to almost all aspects of the proposed project, and proved invaluable in planning and designing many of the components proposed in this study.

2. BIO-PHYSICAL CONTEXT

2.1 Location

The Kalni-Kushiyara River Management Project (KKRMP) covers a gross area of 335,600 ha between latitude 24°56′ and 24°15′ N and longitude 92°05′ and 90°55′E. It extends over the districts of Sylhet, Sunamganj, Moulvibazar, Habiganj and Kishoreganj. The project area is bounded by the Kushiyara-Bijna-Ratna-Sutang River system on the south, the Old Surma-Dahuka River system and Jagannathpur-Sylhet road on the north, Old Surma-Baulai River system on the west, and the Sylhet-Kaktai village road on the east (Figure 2.1).

The focus of the river channel investigation is the 190 km reach along the Kushiyara and Kalni Rivers between the town of Fenchuganj and the junction with the Upper Meghna River near Dilalpur.

2.2 Climate

The project area experiences the sub-tropical monsoon climate typical of Bangladesh, with variations due to its location and topography. Mean annual rainfall increases from an average of 2,539 mm/year in the south (at Habiganj) to 4,209 mm/year (at Sylhet) in the north, or by 66% across the project area. This increase is mainly attributable to the presence of the Shillong Plateau to the north (Figure 2.2). The mean annual rainfalls during the period 1961-90 were 10% greater than those during the period 1901-30. The annual rainfalls during the period 1961-90 were 1.95 times as variable as those during the period 1901-30. It is possible that the indicated trends may reflect only a rise to the peak of some long-term climatic cycle, but they may reflect a monoclinal rise due to global climatic change. However, caution should be exercised in interpreting these results, due to the relatively high proportion of synthetic data (NERP, 1995a).

There are four more or less distinct seasons in the project area. They reflect the seasonal distribution of the annual rainfall (Table 2.1).

Table 2.1: Seasonal Distribution of Annual Rainfall

Season	Nature of Runoff	Calendar Period	% of Annual Rainfall in Project Area		
			South (Habiganj)	Middle (Markuli)	North (Sylhet)
Dry	Drought	Dec. - Mar.	4	3	2
Pre-monsoon	Flash Floods	Apr. and May	25	25	15
Monsoon	Flooding	June - Sept.	65	67	78
Post-monsoon	Drainage	Oct. and Nov.	6	5	5

The rainfall is heavily concentrated during the monsoon season, but more so in the north than the south. The dry season is slightly more pronounced in the north than the south.

The most distinctive climatic events of the year are the onset and withdrawal of the monsoon. In the project area, onset occurs 1 June plus or minus about 4 days on average. Withdrawal occurs 7 October plus or minus about 14 days on average. The average duration of the monsoon is 122 days, with a variation of 112 to 139 days.

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Maximum temperatures vary from 27.6 °C to 35.0 °C. The highest temperatures are experienced during the pre-monsoon period. Daily minimum temperature can fluctuate significantly during the year, ranging from about 9 °C to 23 °C. Mean monthly climatological data are illustrated in Figure 2.3.

2.3 Physical Setting

2.3.1 Topography

The land in the project area is generally low-lying and of low relief. Approximately 80% of the land lies below 7 m PWD and 50% of the land lies below 5 m PWD. The land generally slopes downward from east to west and from the Kalni-Kushiyara River banks towards the central depressions in the north and south. The highest land is found along the courses of the major rivers, while the lowest is found in the adjacent flood basins. Drainage is generally from northeast to southwest. Figures 2.4 (a) and (b) show respectively a generalized contour map and a digital terrain model of the project area. The elevation/area/storage relationship of the project area is given in Figure 2.5.

2.3.2 Physiography and Landforms

The landforms in the project area have formed as a result of alluvial sediment deposition on a slowly subsiding tectonic basin. Consequently, most of the area is underlain by Holocene-age alluvial, estuarine and lacustrine deposits. The project area is comprised of three main physiographic units: uplands, lowlands floodplain and flood basins (GSB, 1990 and Rashid, 1991). Uplands cover about 1% of the project area and are located in the northeast. They are comprised of merging alluvial fans that slope gently outwards from the foothills.

The lowland floodplain comprises about 34%, or 1,137 km^2 of the project area. The floodplain contains channel deposits such as meander scrolls and fills, overbank deposits such as natural levees and crevasse splays, flood basin and back-channel deposits. Levees are wedge-shaped ridges of sediment bordering stream channels and are most highly developed on the convex side of meander bends. Levees are generally socially significant landforms since they usually provide the highest (and only relatively flood-free) land for situating villages and settlements.

Flood basins cover about 65% of the project area. This physiographic unit is characterised by large, saucer-shaped depressions known as *haors*. *Haor* land is generally very low-lying and often contains permanent water bodies or *beels*. During the monsoon season, all of the *haor* areas are deeply flooded. The *haors* comprise the prime agricultural land of the project area, but seasonal inundation is a constraint to agriculture. In most areas only the *boro* (dry season) rice crop can be grown, but this is liable to flood damage in the pre-monsoon season. *Haors* and *beels* are also important habitat for fish and other wildlife.

Flood water often spills through distinct breaches or through formerly silted-in channels (*khals*) that cut across levees. These breaches or *dhalas* develop a drainage pattern into the adjacent low-lying flood basins and can cause major crop damage in the pre-monsoon season. These channels are also responsible for depositing large quantities of sediment (crevasse splays) into adjacent *beels* or lowlands. Figure 2.6 illustrates an active breach on the Kalni River at Koyer Dhala and shows the pattern of sediment deposition that has resulted.

Channel shifts and natural cutoffs produce ox-bow lakes, abandoned distributary channels and *beels* (Figure 2.7). These features may persist for many decades, but will eventually infill as a result of overbank sedimentation. Infilling is greatly accelerated when channel breaches erode large amounts of bank material and deposit the sediments in the first slack water that is encountered.

2.3.3 Agro-ecological Zones

The project area occupies five agro-ecological zones (AEZ) (Figure 2.8): the Old Meghna Estuarine Floodplain (AEZ 19), Eastern Surma-Kushiyara Floodplain (AEZ 20), Sylhet Basin (AEZ 21), Northern and Eastern Piedmont Plains (AEZ 22), and Northern and Eastern Hill (AEZ 29). All the zones excepting AEZ 20 are divided into sub-zones (Figure 2.8). The sub-zones are differentiated by relief and flooding characteristics.

Old Meghna Estuarine Floodplain

This land occupies the eastern part of Kishoreganj district and the western part of Habiganj district. It consists of nearly featureless flat land and shallow basins that were formed in earlier Holocene time by estuarine sedimentation. Elevation ranges from 3 to 5 m PWD. The sediments consist predominately of silty material. This unit borders the right (western) bank of the Kalni River below Kadamchal and the Baida Channel, as well as the floodplain east of Ajmiriganj. This old surface is being gradually re-worked by the Kalni River as it shifts through the earlier deposits. The existing land in this unit is stable and has not been subject to channel instability or alluvial sedimentation in recent geologic time.

Eastern Surma-Kushiyara Floodplain

This land lies mainly east of Sherpur, and occupies the relatively higher parts of the project area. Elevations are typically 10-15 m PWD. The land between the Surma-Kushiyara River consists of a low-lying inter-riverine flood basin that is drained by internal *khals*. Soils in this unit consist predominately of Non-calcareous Grey Floodplain deposits.

Sylhet Basin

This unit occupies 50% of the project area, and consists mainly of low-lying back swamp and flood basin land traversed by a maze of distributary channels and ox-bow lakes (Figure 2.9). The river channels are bordered by natural levees. Virtually all of the land lies below 6 m PWD, and is deeply flooded during the monsoon season. The main *haors* in this area include the Chanhai, Chaiar, Baram, Tangua, Bhanda, Chaptir and Naluar Haors. Sediments consist primarily of silt and silty sand on the ridges and silty clay in the basins. Extensive deposits of peat have been encountered 3-4 m below the surface on the north side of the Kalni River near Sullah.

2.3.4 Soils

Nine general soil types occur in the project area: Non-calcareous Dark Grey Floodplain, Non-calcareous Grey Floodplain and Acid Basin Clays are their major components. Non-calcareous Dark Grey Floodplain predominate in the southwestern part, Acid Basin Clays in central-southern part, and Non-calcareous Grey Floodplain in the western, northern and eastern parts. Varying proportions of Non-calcareous Alluvium, Peat, Non-calcareous Brown Floodplain Soils, Grey Piedmont Soils, Brown Hills Soil, and Deep Grey Terrace Soils occur in the project area.

Soils are relatively uniform. Grey, heavy, silty clay loams predominate the ridges with clay in the basins. Small areas of loamy soils, along with mixed sandy and silty alluvium, occur alongside rivers. Peat occupies some wet *haor* centres.

The soil reaction is mainly acidic. Topsoil reaction is moderately to very strongly acidic. Ridge soils have near-neutral subsoils, but upper subsoils in basins are medium to very strongly acidic. The soil approaches neutrality below about 50 cm.

Organic matter content in the cultivated layer ranges from 0.5-2.5% in most ridge soils and from 2.0-5.0% in basin soils. The soils that occupy *haor* centres stay wet for most or all of the dry season. They generally have 2.0-5.0% organic matter in the cultivated layer. Fertility level is medium to high.

2.3.5 Land Use/Land Cover

Table 2.2 shows the current land-use patterns in the project area. These figures are based on NERP's 1995 land-use survey and *thana* maps compiled from spot imagery (1989-90), aerial photographs (1983-84), and topographic maps done by the Local Government Engineering Department (LGED) in 1994 under a UNDP/ILO project. The land-use survey was carried out at 10 sample sites, and the information was recorded on *mauza* maps at a scale 1:3,960.

Table 2.2: Land Use

Land Use	Area (ha)
Cultivated Land	279,850
Settlement	14,779
Beels	13,340
Rivers	10,780
Channels	1,250
Ponds	2,466
Infrastructure	2,491
Khas/Grass Land	10,644
Total	**335,600**

2.4 Ecological Characteristics

2.4.1 Wetland

The project area supports two types of wetland: lowland permanent wetland and upland seasonal wetland. Permanent wetland includes rivers, canals, permanent water bodies (Figure 2.10), and fish ponds. Most of the project area supports seasonal wetland. The condition and duration of wetland is dependant on numerous factors such as land elevation, inundation, chemical and particulate concentrations and soil characteristics.

Wetland is key in the ecological cycle of the floodplain. It provides an important habitat to a multitude of species that in turn support the human population of the floodplain. Seasonal wetland links permanent wetland bodies allowing for migration and species recruitment, thus the water regime directly affects the flora and fauna that either inhabit or depend on the wetland. A list of principal wetland areas and their importance to wildlife is given in Table 2.3.

2.4.2 Terrestrial Environment

Table 2.3: List of Principal Wetland and Wildlife Ranking

Region	Wetland	Ranking
Northeastern	Damrir	B
	Dubrir	B
	Majail	B
	Muktarpur	D
North Central	Baram	B
	Chaptir	B
	Dhamalia	C
	Kaliagota	D
	Naluar	C
	Pagnar	B
	Pangasiar	B
	Tangua	B
South Central	Dabhanga	C
	Gardar	C
	Haitola	D
	Kodalia	C
	Mokar	B
	Matikata	B
	Puber	C
	Pipir	C
Western	Abdullahpur	C
	Garbhanga	B
	Ghagrar	D
	Raoband	C
	Shibpurer	B

Ranking:
A = Site of outstanding international importance for wildlife
B = Site of considerable national importance for wildlife
C = Site of local importance for wildlife
D = Not ranked

Terrestrial Flora

Terrestrial flora can be divided into two broad categories: natural vegetation and patterned vegetation. Natural vegetation habitats include forests, grass lands, roadside vegetation and other natural habitats. Patterned vegetation habitats include homestead gardens, orchards, plantation, cropland and any other form of planted habitat. Each habitat has a unique collection of plant species. In the project area, natural vegetation is minimal, comprising mostly small patches of grassland. Natural forest is totally absent.

Because of the absence of natural forest in the project area, homestead vegetation coverage is the critical terrestrial flora. In general, homestead vegetation includes two types of plants: those that are cultivated for their economic value and those that are self-propagating. The net settlement area in the project is 14,779 ha; about 40% of that (5,910 ha) is covered by homestead vegetation. The amount of the settlement area covered by homestead vegetation, however, varies widely among villages; some villages in the deep floodplain have virtually no vegetation cover at all.

Considering utilization and annual return, homestead vegetation land is the most productive in the project area. In addition to the regular supply of food, fodder, medicine and other household requirements, homestead land is the major source of timber and renewable biomass energy. The annual return from homestead vegetation stands at about Tk 57,275 per hectare, or Tk 338.5 million for the entire project area. The existing value of plant resources including trees, shrubs, and herbs is about Tk 314,468 per hectare, or Tk 1,858.5 million for the entire project area.

d2

Terrestrial Fauna
A total of 182 species were observed in the project area. Of these, 130 species are birds and 52 species are mammals, reptiles and amphibians. Habitat degradation and alteration has resulted in the elimination of all large mammals and has rendered other terrestrial fauna rare throughout the project area.

Terrestrial birds can be divided into two major groups: birds observed on the floodplain, and birds observed in dry habitats. Dry habitats include homestead forest, open woodland, secondary shrub and grassland. Birds of prey thrive in the project area. Other homestead birds are also prevalent and live mainly around the non-flooded portion of the project area.

Mammals are scarce. Small mammals such as the cat, civet, rat, fox, and bat comprise the major mammal wildlife population.

Among reptiles, the yellow land tortoise (Indotestudo elongata) is the only terrestrial chelonian known to occur in the project area. This species is very rare and on the verge of extinction.

There are several species of lizard that are common in the area. Snakes are uncommon in the vast floodplain, but are found in homestead groves. Amphibious species favour wetland and marginal dry areas.

Several species are listed in the IUCN Red Data Book (1994). These are Pallas' Fish-Eagle (Haliaeetus leucorhyphus), Marsh Babbler (Pellorneum palustre), Bengal Fox (Vulpes bengalensis), and Yellow Common Lizard (Varanus flavescens). In addition, some species are listed in the Schedules of the Convention on International Trade in Endangered Species of Flora and Fauna. These are *Baz pakhi* (Falco peregrinus), Bengal Gray Lizard (Varanus bengalensis), Small Indian Civet (Viverricula indica), Jungle Cat (Felis chaus), and Fishing Cat (F. viverrina).

2.4.3 Freshwater Environment

Aquatic Flora
Aquatic flora in the project area can be divided into several communities depending on the depth and duration of flooding. Generally, the western region of the project area floods deeply and aquatic plants grow sparsely due to low light and strong wave activity. In the eastern region, where land is shallowly flooded, water plants benefit from a very good substratum. Most of the rivers in the project area are devoid of any vegetation. The majority of the wetland is used as a source of irrigation water during the dry season. This practice destroys the seed beds and inhibits plant regeneration.

The communities of aquatic flora are as follows:

- Submerged - The submerged plant community is one of the most prevalent in the project area. This community is found in both permanent and seasonal wetland;

- Free-floating - Though they are not one of the dominant plant communities in the *haor* area, they comprise about 15 species of plant. Their abundance depends on the location of the wetland;

- Rooted-floating - The rooted-floating community is one of the most dominant plant types in the project wetland. This plant community is abundant in perennial wetland and deeply flooded seasonal wetland, but sparse in shallow seasonal wetland. This is due to inadequate time for growth;

- Sedges and Meadows - Sedges and meadows are ecotones consisting of amphibious plants. They have the highest species diversity among the communities. The vegetation type generally occupies the water margin and moves with the fluctuating water levels;

- Reed Swamp - The elevated areas with gentle slopes are occupied by tall grasses or reeds. The reeds also occur in the deeply flooded channel deposits locally known as *kanda*;

- Fresh Water Swamp Forest - This type of vegetation consists of evergreen trees forming a closed canopy. Mature trees are 10-12 m high. The lower parts of trees remain submerged 2-3 m for three or four months during the monsoon period, and

- Marginal - The community is composed of both wetland plants and small dry land herbs. Its composition depends on the degree of waterlogging in each particular area and the flood tolerance of each species.

Most of the wetland plant species are sensitive to seasonal water level fluctuations. In the permanent water bodies these plants can survive and regenerate for the whole year. In the seasonally flooded areas the rhizomes and seeds remain buried during the dry season and sprout with the arrival of water. As the water level rises, plant growth accelerates and attains its climax just after the peak flood. When the water starts receding, most of these plants flower and fruit very quickly, assuring offspring in the next year. Thus the growth period for most wetland plants is May-October.

Due to limited availability, human utilization of wetland plants remains low. Existing wetland plant products include food, fodder, medicine, thatching, fuel, and bio-fertilizer.

Aquatic Fauna

The life cycle of aquatic fauna is dependent on the river's natural fluctuations. In the dry season the flood plain is dotted with small *beels* and crossed by rivers. The water bodies are easily distinguished and generally unconnected. In the pre-monsoon season the major rivers begin to fill - reactivating dried *khals* and re-connecting the adjacent wetland. As the rivers and *khals* fill and overtop their banks during the monsoon, the floodplain eventually forms a single body of water dotted with islands of highland. By the end of the post-monsoon season, the flood waters recede from the plain eventually draining and drying through the dry season and starting the cycle again.

The fauna of the region are adapted to this hydrological cycle. During the pre-monsoon stage, fish leave their overwintering ground (*beel*s in the floodplain and *duar*s in the river) and migrate upstream to spawn. After spawning, as water level increases during the monsoon season, fry are dispersed all over the plain. As the monsoon progresses the production of plankton rapidly increases due to favourable temperature, sunlight, and oxygenation of the vast shallow areas. During this period, fish have access to a vast and rich grazing ground. This results in high fish production. In the post-monsoon season, as the water level drops, fish migrate towards overwintering grounds again.

A total of 72 species of fish have been recorded from the project area. Important groups are major carp, other carps, large catfish, knifefish, *ilish,* prawns, small catfish, small cyprinids, and other small species.

A total of 104 species of aquatic fauna (except fish) were observed in the project area. Of these, 68 species are totally dependent, and 36 are partially dependent on wetland (*beels*, rivers, ponds). The survey also showed a habitat preference for stretches abutting homestead backyards. There are few aquatic habitats for faunal species. Wetland are intensively exploited and the habitat is highly disturbed. Despite this, some species have adapted to the altered environment and others have even flourished.

Aquatic and water-dependent birds have been severely affected by habitat alteration. Wetland degradation has left virtually no sheltered space for waterfowl to roost. Compared to adjoining eastern parts of the Northeast Region, migratory waterfowl are scarce. They are restricted to the larger *haor* complexes. Wetland dependent birds such as kingfishers and other birds of prey have little scope for adaptation. Some species (mostly piscivorous) have moved to areas more favourable to their needs. Among the kingfishers, the storkbilled kingfisher (Pelargopsis capensis) was not seen, although the habitat is supposed to support them. It was felt that this species had migrated elsewhere.

There are few aquatic mammals. Common otter (Lutra) are present, but the population is quickly declining. The status of Smooth Indian Otter (Lutra perspicillata) is uncertain.

The riverine habitat of the project area is suitable for Gangetic Dolphins (Platanista gangetica). Gangetic Dolphins (P. gangetica) are listed in the IUCN Red Data Book (1994). According to fishermen, dolphins are found in the deepest parts of rivers. They feed on fish and benthos trapped in eddies. Dolphins dwell primarily in rivers. During the monsoon, they move onto the floodplain. In the dry season, they remain in *duars*.

2.5 Kalni-Kushiyara River System

The Kalni-Kushiyara River system originates from the Barak River in India. The Barak River drains 25,260 km^2 of land in the states of Assam, Manipur and Mizoram and crosses into Bangladesh near Amalshid. At Amalshid it splits into the northward-flowing Surma River and the southward-flowing Kushiyara River. Below Amalshid, the river undergoes several name changes along its course. For convenience, all locations along the river have been referenced to a chainage. The chainage is measured along the river centreline, and starts from the BWDB gauge on the Meghna River at Bhairab Bazar. Key locations are referenced in Table 2.4, and a map of the main river system is provided in Figure 2.11.

Table 2.4: Kushiyara River System

River Name	Reference Chainage (km)	Extent
Kushiyara	313 -163	Amalshid bifurcation to Bibiyana offtake near Sherpur
Suriya channel (Kushiyara)	163- 133	Bibiyana offtake to Markuli town
Kalni	133 -66	Markuli to Ratna/ Khowai junction
Dhaleswari	66 -20	Ratna River junction to Ghorautra River confluence
Upper Meghna	< 20	downstream of Ghorautra River confluence

The Sonai-Bardal River, Juri River and Manu River are the main left bank tributaries between Amalshid and Sherpur (Throughout this report, left and right river banks are when viewing downstream).

Downstream of Sherpur, the Kushiyara River flows in a westerly direction through the Suriya Channel until reaching Markuli. Before 1978, the Upper Kalni River collected runoff from the Surma-Kushiyara Inter-basin and drained southwards into the Kushiyara River at Markuli. In 1978, a closure was constructed across the Kalni River at Markuli and the flows from the Inter-basin were diverted into the Darain River system.

Downstream of Markuli, the river is called the Kalni. The Kalni River flows in a southerly direction until reaching Issapur, where it bifurcates, with the shorter western branch called the Baida River. The Kalni heads eastward through a series of bends and is joined by the Ratna/Khowai River near Madna (locally called Dhaleswari River). The Ratna River drains floodplain land south of Ajmiriganj, while the Khowai River is a major Piedmont stream that drains the Tripura Hills in India. Downstream of this confluence, the Kalni River is called the Dhaleswari River. This eastern branch has been gradually silting in, so that in the dry season most flow now is carried by the Baida channel which re-joins the Dhaleswari River south of Astagram. The Dhaleswari then joins the Ghorautra/Baulai River near Dilalpur and forms the Upper Meghna River.

2.6 Hydrology

2.6.1 River System Discharge

Discharge on the Kalni-Kushiyara River system is governed by inflows from the Barak River at Amalshid, tributary inflows (Juri, Manu, Khowai, and Sonai-Bardal), inflows or losses that occur through distributaries and spill channels and local rainfall drainage from the project area.

Figure 2.12 illustrates the long-term mean flow distribution along the river system. Based on water balance studies, the long-term discharge from the Barak River at Amalshid is 1,008 m^3/s, with the flow into the Kushiyara branch amounting to 656 m^3/s. The mean daily discharge increases to 1,100 m^3/s at Sherpur, and reaches 1,535 m^3/s in the lower Dhaleswari River at its confluence with the Meghna River. The contribution from the Kalni-Kushiyara River amounts to 27% of the total flow in the Upper Meghna River at Bhairab Bazar.

2.6.2 Ground Water

The estimated usable ground water recharge within the project area is 406 million m^3 based on MPO (WARPO) data. The majority of the ground water resource potential is located in Baniachang, Nabiganj, Biswanath and Jagannathpur *thanas*. About 269 million m^3 of recharge is available within the depth range that is accessible from force mode deep tube wells (DTW). Due to aquifer constraints, suction mode shallow tube wells (STW) can withdraw only about 7 million m^3. However, about 70 million m^3 could be withdrawn by deep-set suction mode technology (DSSTW).

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2.6.3 Seasonal Pattern of Flows

The seasonal distribution of discharge at Sheola and Sherpur is summarized in Table 2.5. Figure 2.13 shows the range in daily discharges that has occurred at these stations as well as hydrographs during a typical year (1989) and an extreme flood year (1991). These hydrographs illustrate the annual hydrological cycle of flash flooding during the pre-monsoon season, a longer term flood rise during the monsoon season, flood recession and drainage during the post-monsoon season, and low water during the dry season.

Table 2.5: Seasonal Distribution of Discharge

Season	At Sheola		At Sherpur	
	Discharge (m^3/s)	% of annual runoff	Discharge (m^3/s)	% of annual runoff
Pre-monsoon	472	11.5	1,152	17.4
Monsoon	1,415	69.4	1,952	59.0
Post-Monsoon	555	13.6	1,175	17.8
Dry Season	111	5.5	197	5.8
Year	682	100	1,101	100

2.6.4 Flood Hydrology

Three types of floods occur in the project area:

- winter floods;
- pre-monsoon flash floods, and
- monsoon season floods.

Winter floods, which occur between December and February, are caused by storms in the outlying hills and local rainfall. They rarely overtop the river banks, but water readily enters the *haors* through bank breaches and open *khals*. These floods do not occur every year and are very unpredictable.

The pre-monsoon season is characterized by unstable weather conditions, including the occurrence of intense tropical depressions and "Nor-Westers" which generate heavy, local rainfalls. Low magnitude pre-monsoon floods usually stay within the channel banks but may enter the adjacent flood basins and *haors* through open *khals*. Larger floods spill through bank breaching and by overtopping of low banks. The floods are relatively "flashy" and may last from a few days to about two weeks. The flood volumes are sufficient to fill the *haor* depressions and they cause major crop damage in the region.

Flooding in the monsoon season normally lasts from July to October. High water is caused by a combination of (1) large inflow volumes from external rivers (2) heavy local rainfall and (3) backwater from the Lower Meghna River. During extreme events, such as in 1988 and 1993, virtually all of the project area was inundated (Figure 2.14). Hydraulic modelling studies show most of the discharge is conveyed by the floodplain at these times, with the flow in the main channels amounting to less than 20% of the total. Table 2.6 shows that about 96% of the project area is inundated in a 1:2 year average flood during the monsoon season. From here on in this report the term "flood levels" and the land categories for depth of inundation will refer only to pre-monsoon levels.

Table 2.6: Depth of Monsoon Flooding (1:2 Year Annual Average Flood Level)

Flood Depth (m)	Land Category[1/]	Area (ha)	
		Gross	(%)
0.00-0.30	F0 (highland)	12,651	4
0.30-0.90	F1 (medium highland)	32,698	8
0.90-1.80	F2 (medium lowland)	73,532	22
>1.80	F3 (lowland)	216,719	66
Total		**335,600**	**100**

Note 1/: MPO classification

2.6.5 Frequency and Magnitude of Floods

Trends

Figure 2.15 shows the range of annual maximum daily discharges and maximum daily pre-monsoon discharges at Sheola and Sherpur. The last decade has clearly experienced unusually high flows, with major flood events occurring in 1988, 1991 and 1993. The average maximum daily discharge at Sheola in the pre-monsoon season increased from 804 m^3/s in 1964-1973 to 1,227 m^3/s in 1982-1993 (Table 2.7). The average annual maximum discharge at Sheola increased from 1,816 m^3/s in 1964-1973 to 2,619 m^3/s in 1982-1993. Two factors have contributed to this pattern:

- the unusual sequence of wet years produced a clustering of extreme flows, and
- the increased discharges have coincided with reduced discharges in spill channels on the Upper Kushiyara floodplain due to confinement effects from embankments and closure of distributary channels.

Concerns have been expressed that the increased channel changes at the Amalshid bifurcation have caused the Kushiyara River to capture flow from the Surma River. Field investigations by NERP indicated that recent deposition on the Surma River at Amalshid has caused most of the flow in the dry season to be carried by the Kushiyara River. However, water balance studies and hydraulic investigations have shown that the flow split has remained virtually constant over the last 30 years during the pre-monsoon and monsoon season, and is not a significant factor in changing flood flows.

Table 2.7: Pre-monsoon Flood Discharges on Kushiyara River

Period	Amalshid (172)		Sheola (173)		Sherpur (175.5)	
	average (m^3/s)	maximum (m^3/s)	average (m^3/s)	maximum (m^3/s)	average (m^3/s)	maximum (m^3/s)
1964 - 1973	930	1,500	804	1,580	-	-
1974 - 1981	921	1,640	785	1,680	-	-
1982 - 1993	1,484	3,781	1,227	3,250	1,790	3,471
1964 - 1993	1,145	3,781	965	3,250	-	-

Figures 2.16 and 2.17 show the trend in maximum daily pre-monsoon and annual maximum water levels at Sherpur, Markuli, Ajmiriganj and Madna. Markuli, Ajmiriganj and Madna represent, respectively, the upper, middle and lower end of the Kalni River. Pre-monsoon flood levels at Markuli and Ajmiriganj have increased by an average 1.2 m and 1.0 m respectively since 1975. At Markuli, the maximum daily pre-monsoon water levels have been increasing in a remarkably consistent fashion since the 1950's, at an average rate of 8.5 cm/year over the last 25 years. By comparison, pre-monsoon water levels at Madna show no consistent trend. The trend of increasing pre-monsoon flood levels has been attributed to three main factors:

- increased discharges in recent years on the Upper Kushiyara River;
- closure of distributary channels at and below Markuli, which effectively increased the discharges in the lower reach of the river, and
- sediment aggradation below Markuli causing reduced channel conveyance.

The minimum recorded water levels at Ajmiriganj and Markuli have also increased consistently since 1964. They rose an average of 1 m in 25 years (4 cm/year) until 1988, then rose abruptly by nearly 1 m since then. The corresponding minimum discharges showed no systematic change up until 1988, after which the flows have nearly doubled. The 4 cm/year rise between 1964-1988 is believed to reflect morphologic changes (since the discharge was approximately constant during this time), while the increase since 1988 is believed to be caused mainly by the increased flows that have been experienced.

Flood Frequency Analysis
The available data have certain limitations for frequency analysis.

1. At Sherpur and Sheola, the gauge discharge measurements represent the flow in the main channel only. However, the floodplain and secondary channels carry part of the total flood flow, which the data series do not take into account. As a result, the frequency curves tend towards upper asymptotes. In such cases, flood frequency predictions underestimate the true flood potential that could develop if the overbank spills are confined by embankments.

2. The data series are short, with the longest at Sheola covering only 30 years. This means that tests for statistical anomalies are very weak, and not useful for assessing the data's homogeneity. Consequently, predictions for longer return periods tend to have low reliability.

3. Some data series, especially pre-monsoon water levels at Markuli and Ajmiriganj, are non-homogeneous and non-stationary - that is, the data do not reflect consistent physical conditions of flood generation. In such cases flood frequency estimates derived from the whole record represent an average of historic conditions and are not necessarily applicable to present or future conditions.

Given these limitations, the available data were analyzed to estimate flood frequencies by using the General Extreme Value (GEV) distribution. There are 30 years of records (1964-1993) available at Sheola, 14 years of records (1982-1995) at Sherpur and 30 years (1964-1993) at Ajmiriganj. Both pre-monsoon season and annual maximum floods were analysed. The results are presented in Table 2.8.

Table 2.8: Flood Frequency Analysis

Location	Return Period				
	1:2 year	1:5 year	1:10 year	1:20 year	1:50 year
Discharges (m^3/s)					
Sherpur- Pre-Monsoon	1,694	2,398	2,834	3,228	3,709
Sherpur-Annual Maximum	2,579	2,977	3,225	3,451	3,729
Water Levels (m PWD)					
Sherpur-Pre-Monsoon	7.45	8.42	8.80	9.04	9.24
Ajmiriganj-Pre-Monsoon	4.50	5.10	5.45	5.75	6.11
Sherpur-Annual Maximum	8.97	9.16	9.31	9.39	9.50
Ajmiriganj-Annual Maximum	7.42	7.49	7.78	7.95	8.20

Some key results relative to historical floods are summarized in Table 2.9. Based on the estimates at Sherpur, the largest recent floods (1993 and 1991) had annual return periods of 75 years and 35 years respectively. However, the highest water levels at Ajmiriganj occurred in 1974 and 1988, and these floods had return periods of 50 years and 25 years. The largest pre-monsoon flood occurred in 1991, and had an estimated return period of 25 years at Sherpur and 15 years at Ajmiriganj. In 1994, the pre-monsoon flood level at Ajmiriganj approached the 1991 value, even though the flood discharge at Sherpur had a return period slightly over 1:2 years.

Table 2.9: Frequency of Historic Floods

Flood Type	Year	Discharge (m^3/s)	Return Period (years)
Kushiyara River at Sherpur			
Annual Maximum	1993	3,843	75
Annual Maximum	1991	3,632	35
Pre-Monsoon	1991	3,471	25
Pre-Monsoon	1994	1,850	2
Kalni River at Ajmiriganj			
Rank	**Year**	**Water Level (m PWD)**	**Return Period (Years)**
Annual Maximum	1974	8.21	50
Annual Maximum	1988	8.02	25
Pre-Monsoon	1991	5.8	15
Pre-Monsoon	1994	5.6	≈ 15

The unusually high water level at Ajmiriganj in 1994 was caused by downstream morphologic changes at a natural loop cut near Katkhal village. This channel shift raised the pre-monsoon flood level at Ajmiriganj by approximately 1 m.

2.7 River Channel Characteristics

2.7.1 General

The Kushiyara River flows in a single, irregularly meandering sand-bed channel bordered by natural levees that reach up to 3 m above the adjacent flood basins. Channel dimensions at Sherpur are 240 m wide x 9.1 m deep at bankfull stage. Based on sediment transport measurements in 1995 and 1996, the long-term suspended sediment load at Sherpur was estimated to be 18 million tonnes/year, of which around 5.4 million tonnes consists of fine sand and coarse silt. The remaining 12.6 million tonnes/year consists of finer silt and clay-sized sediments.

Downstream of Markuli, the Kalni River flows through the low-lying Sylhet Basin and is controlled by backwater from the Meghna River during the monsoon season. The river has an irregular channel pattern in this reach, occasionally splitting into a single main channel and a smaller distributary branch. The bed material size decreases abruptly downstream of Markuli. It becomes much more variable in composition, ranging from fine sand to silty sand and sandy silt. During the pre-monsoon season and dry season, the water surface slope averages around 0.00008 (8 cm/km). Under these conditions, with a low tailwater from the Meghna River, the water surface profile exhibits a characteristic M-2 "drawdown" profile (Figure 2.18). During floods in the monsoon season, backwater from the lower Meghna River causes the water surface to become virtually flat. The entire region is deeply submerged (Figure 2.14). Hydrodynamic model results show that under these conditions, most of the flow and fine suspended sediment is carried onto the floodplain. Field surveys show that this reach undergoes a seasonal pattern of scour and fill, with a blanket of fine sediment deposited in the main channel in the monsoon season and degradation occurring during the post-monsoon season, dry season and pre-monsoon season in response to the steeper water surface slope and increased channel velocities (Figure 2.18). Therefore, in spite of the depositional nature of this reach, the river is able to maintain a rough channel equilibrium by two main processes:

- by distributing much of the flow and fine suspended sediment onto the floodplain in the monsoon season, and

- by scouring out finer channel deposits during periods when the slope is relatively steep.

Downstream of Madna, the name changes to the Dhaleswari River. The channel has a split pattern, and adjacent to it are frequent abandoned channels and ox-bow lakes. The channel cross section enlarges and deepens as it approaches the junction of the Baulai River near Dilalpur.

2.7.2 Channel Stability

Over the last 40 years, the river has responded to man-made interventions and natural processes by undergoing a number of changes. The resulting changes have had a major impact on the socioeconomic conditions and pattern of land-use along the river. Table 2.10 and Figures 2.19

(a) and (b) summarize the long-term rate of bank erosion that has occurred over the 105 km reach between Sherpur and Issapur during the period 1963-1995. Approximately 1,788 ha of land has been destroyed, 1,581 ha from channel shifting and 207 ha from channel widening, an average loss of 56 ha/year. The rate of erosion appears to have remained relatively steady over this period. However, the location of the erosion has gradually shifted further downstream.

Table 2.10: Historical Erosion Rates

Erosion due to Channel Shifting

River	Reach	Km	Erosion 1963-1995 (ha)	Erosion Rate 1963-1995 (ha/year)
Kushiyara	Sherpur-Bibiyana offtake	177-163	176	5.5
Kushiyara (Suriya Channel)	Bibiyana offtake - Markuli	163-133	555	17.4
Kalni	Markuli-Ajmiriganj	133-107	246	7.7
Kalni	Ajmiriganj - Kadamchal		269	8.4
Kalni	Kadamchal - Issapur		335	10.5
Kalni-Kushiyara	Sherpur-Issapur		1,581	49.4

Erosion due to Channel Widening

Location	Km	1955-1963		1963-1995		1955-1995	
		Avg. Width Change (m)	Eroded Area (ha)	Avg. Width Change (m)	Eroded Area (ha)	Avg. Width Change (m)	Eroded Area (ha)
Suriya channel	160-132	+52	135	+57	159	+109	294
Katkhal channel	96.5-92.5	-	-	+120	48	+120	48

Table 2.11 highlights some of the most important channel changes that have occurred. Most of the channel stability problems can be traced back to the river's shift from the Bibiyana channel into Suriya Khal in the early 1960s. This shift was initiated accidentally in 1955 by local authorities when a pilot channel was excavated just downstream of Sherpur, re-directing the river's flow into Jalalpur Khal (Figure 2.20). This *khal* enlarged over a period of years and gradually established a new route through a series of minor distributary channels and *haors* until re-joining the Kalni River 30 km downstream near Markuli. The shift destroyed several villages along the new channel's route, including Jalalpur, Modipur and Alkadi.

After this shift, pre-monsoon flooding problems increased downstream of Markuli and in the low-lying *haors* areas north of Markuli that were drained by the Kalni River. In April 1977, flood water from the Kushiyara River entered the Kalni River and devastated *boro* crops in several of the major *haors* in this area. Substantial sediment deposition was also reported to occur throughout portions of Derai, Sullah, and Jagannathpur *thanas*. In 1978, local officials decided to construct a closure across the mouth of the Kalni River to prevent spills from entering these lowlands. By 1982 this work was completed, against the advice of some BWDB engineers who expressed concern about closing an active flowing channel. This closure appears to have reduced inflows to the low-lying basins north of Markuli, but also raised water levels on the Kushiyara River and increased discharges and suspended sediment loads downstream of Markuli.

Table 2.11: Important Events on Kalni-Kushiyara River

Date	Location	Event
1955	Sherpur	Loop cuts constructed, triggers erosion in Jalalpur Khal
1958-1970	Sherpur-Markuli	River shifts from Bibiyana channel into Suriya Khal
1978	Downstream of Markuli	Loop cuts constructed to mitigate pre-monsoon flood problems
1978	Markuli	Closure of Kalni River causes major change to drainage pattern
1988	Regional	Major flood
1991	Regional	Major flood
1992	Ajmiriganj	Bheramohona closure constructed to reduce pre-monsoon spills
1993	Regional	Major flood
1993	Katkhal	Natural cutoff destroys Shahebnagar village and initiates enlargement of Cherapur Khal

These changes were accompanied by substantial channel aggradation in the reach downstream of Ajmiriganj. Figure 2.21 shows longitudinal profiles of the river in 1963, 1975 and 1988. Comparison of these surveys showed that up to 5 m of deposition has occurred at Ajmiriganj, mostly since 1975. Comparison of cross sections established by BWDB showed that near Ajmiriganj, the channel's cross sectional area decreased from 1,457 m^2 in 1980 to only 556 m^2 by 1993. The amount of aggradation decreased downstream of Ajmiriganj, indicating the deposition developed in the form of a 50 km long sediment wedge between Ajmiriganj and Kalma on the Dhaleswari River. Based on the available surveys from both BWDB and BIWTA, approximately 25 million m^3 of sediment has been deposited downstream of Ajmiriganj since the Bibiyana avulsion. This value is comparable to the amount of material eroded from Suriya Khal during the original avulsion.

The deposition has produced a downstream progression of channel instability along the Kalni River that continues to this day. In the 1980s, sediment deposition near Katkhal caused the northern main channel to be abandoned, and the course shifted into the smaller *khal*. This channel gradually enlarged until 1993 when it caused a natural loop cut to develop, destroying the village of Shahebnagar (Figure 2.22). This shift caused the river to impinge into another *khal* (Cherapur Khal), which has subsequently widened and diverted more water from the Kalni River into the Baulai River system. This development could eventually lead to a new avulsion into the Baulai River, and the abandonment of the lower Kalni River channel.

Further downstream, ongoing deposition near Madna has gradually blocked the eastern branch of the river in the dry season, causing more flow to be diverted into the Baida channel. Consequently, the Dhaleswari branch is gradually "dying". The developments at Cherapur Khal appear to be hastening this process, since as more dry season flows are lost to the Baulai River system, there is less flow available to maintain the Dhaleswari branch.

These historical observations illustrate three characteristic styles of channel instability on the river.

Avulsions
Avulsions are rapid channel shifts which result in the development of a new river course and the abandonment of former channels. The shift from the Bibiyana channel into the Suriya channel and the ongoing shift into Cherapur Khal represent two examples of this process. Avulsions occur in reaches where the river has an anastomosing channel pattern, with one or more dominant channels and a number of branching distributaries or *khals*. Changes in channel alignment, downstream aggradation or erosion at the *khal's* junction can all trigger the sudden shift from the main channel into the *khal*.

Breaches
Dhalas form at the outer (convex) banks of bends, when the river breaches its natural levee and cuts a spill channel into the adjacent low-lying flood basin. These breaches cause large amounts of sediment to be eroded from the bank and deposited in the nearby *beels* and *haors*. These features are mainly found upstream of Ajmiriganj. This is probably because the flows are still confined in the pre-monsoon and monsoon seasons, so that when a breach occurs there is sufficient head difference between the river and floodplain to generate high velocity spills. Downstream of Ajmiriganj, backwater effects reduce the head difference between the main channel and floodplain so that spills do not have sufficient velocity to scour a new *dhala*. Figure 2.6 illustrates this process at Koyer Dhala, 10 km upstream of Ajmiriganj.

Meander Migration
Progressive meander migration is driven by secondary currents in bends, with point bar deposition on the inner (convex) bank and scour along the outer (concave) bank. Figure 2.23 illustrates the common types of meander shifting and loop cut formation that occur on the river.

The rate of shifting has been found to depend on several factors:

- bend geometry - the radius of curvature of the bend (R) and the channel width (W);
- hydraulic conditions (discharge, shear stress on the bank, scour depth);
- geo-technical properties (bed and bank materials, pore water pressure in bank), and
- local conditions (vegetation, local protective works, structural loading of the slope).

Estimates of bank erosion rates were made at each bend between Sherpur and the Meghna River confluence using the historic mapping between 1964 and 1995. The radius of curvature, average top width and distance of bank retreat was estimated at each bend. Figure 2.24 shows the erosion rate is largely governed by the bend radius / channel width ratio (R/W). The erosion rate was found to increase rapidly when $R/W < 3$. Furthermore, at R/W ratios < 2, the probability of developing a neck cutoff becomes very high.

Bank erosion in meanders was often observed to take place during the declining stages of the flood (post-monsoon season), when the water level in the river was dropping quickly and the banks and floodplain were still saturated. The sudden draw-down triggered slope failures in the over-steepened silty-clay bank materials. Bank erosion was also observed to occur during the months of April-May, when the water surface slope was steepest and the channel velocities were highest.

Table 2.12 and Figure 2.25 identify sites of active bank erosion along the river. There are three reaches where the risk of channel instability and the threats from erosion are particularly high.

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Table 2.12: Erosion Hazards on the Kalni-Kushiyara River

#	Name	Km	Bank	Process	Comments
1		168.5-165	LB	Mf	Bank erosion along outside of bend threatening to make chute cutoff
2		161-156	LB	Mf	Bank erosion threatening to make chute cutoff, spills & breaching into Itakhola Nadi
3	Raniganj	153	RB	Mc	Rotation of meander bend threatening to erode Raniganj town
4	Balisri	149.5	LB	Ma	Extension of meander bend creating erosion along outside of bend. Spills in 1991,93 & 95
5		144	RB	B	Spill and breaching through *khal* in 1985,89,91,92,93,94 &95
6	Akkilshah Bazar *Dhala*	139	LB	B	Breach at sharp bend into Katma Beel. Major spills in 1985,89,91,92,93,94 & 95
7	Markuli	133	LB	Ma	Extension of meander bend eroding outer bank and threatening to destroy Markuli town
8	Fayjullapur	129.5	RB	B	1991 breach formed 200 m wide *dhala,* closed successfully by BWDB in 1993
9	Tangua Dhala	119	RB	B	1988 flood formed *dhala,* spills in 1989,90,91, closed by BWDB in 1991
10	Koyer Dhala	115	LB	B, Ma	*Dhala* formed after loop cut constructed. re-recurring spills in to Kaia Beel since 1988 flood, extension of meander bend is increasing bank erosion & threatening to enlarge spills
11	Pituakandi	114.5	RB	B, Ma	Breaches in 1984,85, 88,89,90,91. Closed by Union Parishad in 1992. Extension of meander bend continuing to create new erosion.
12	Bheramohona	109	RB	B	Artificial canal constructed in 1987, enlarged into *dhala* after 1988 flood, spills caused major flood damage in 1990, 91,92. Permanent closure in 1992/93.
13	Shantipur	97	RB	Mb	Downstream translation of meander+ channel widening has caused erosion on right bank
14	Cherapur Khal	90	RB	A	Channel shift near Kadamchal has re-directed flow into Cherapur Khal, initiating channel widening and diversion of flow into Baulai River
15	Anwarpur	83	LB	Ma	Point bar deposition on right bank is causing meander extension, resulting in erosion on left bank and threatening the town of Anwarpur
16	Issapur	72		A	Deposition in Dhaleswari Channel is encouraging flow diversion into Baida River channel

Legend:

A=Avulsion
B=Breach
Mx=meanders migration (see Figure 2.23 for definition of meander migration types)

Kushiyara River - Raniganj to Markuli
The meander pattern is still adjusting to the increase of discharges and top width that has occurred along the Suriya channel. As a result, many of the smaller radius bends are in the process of developing natural loop cuts. Cut offs at Km 168 (site 1) and Km 161 (site 2) appear

inevitable, and may actually end up producing a more stable channel pattern. Active erosion is also occurring along the outer (concave) banks in most meander bends, and is seriously threatening villages such as Raniganj and Markuli. Active breaching and *dhalas* are also occurring at sites such as Akkilshah Bazar.

Kalni River near Koyer Dhala
There is a high risk of continued breaching and spills along the right bank (through Pituakandi Dhala) and on the left bank (through Koyer Dhala). If Koyer Dhala breaches again, boro crops in the entire area of Ajmiriganj and Baniachang *thanas* and one third of Nabiganj *thana* would be damaged.

Cherapur Khal and Baulai River
The natural cutoff downstream of Katkhal has increased flow losses into Cherapur Khal. Now, 35% of the flow is being diverted into the Baulai River system in the pre-monsoon season. This is triggering channel widening and erosion along the *khal*, and is hastening sediment deposition along the lower Kalni River. If this *khal* continues to enlarge and capture more of the flow, it could seriously affect a 50 km reach along the Baulai River system as well as the lower Kalni-Dhaleswari system.

2.8 River Hydraulics

2.8.1 Bankfull Conditions

Field studies and hydrometric measurements were carried out in 1995 and 1996 during high water conditions to assess the existing discharge capacity of the channel and to document the location of major spills. Estimated bankfull discharge capacities along various reaches are summarized in Table 2.13. Near Sherpur, the bankfull stage coincides closely to the mean annual flood during the monsoon season. Downstream of Markuli, the channel can convey up to a 1:2 year pre-monsoon flood without exceeding bankfull conditions. During higher floods, a substantial portion of the flow spills onto the floodplain, or through *khals* and distributary channels into adjacent flood basins. For example, a 1:10 year pre-monsoon flood inflow at Sherpur exceeds the bankfull capacity at Ajmiriganj by about 950 m^3/s.

Table 2.13: Bankfull Discharge Pre-monsoon Season

Location	Distance (km)	Discharge (m^3/s)
Sherpur	177	2,500
Markuli	133	1,950
Ajmiriganj	107	1,750
Shantipur	96	1,500
Kadamchal	85	1,350

Past experience has shown that, due to bank breaching and spills through open *khals*, flood damage may start to occur at stages well below the average bankfull level. Several important spill sites have been identified upstream of Ajmiriganj (Figure 2.25). These include Koyer Dhala (km 115), Paharpur (km 124), Markuli (km 133), and Bhanda Beel (km 134). These spills divert pre-monsoon flood flows from the Kushiyara River into the north and south flood basins. They can cause substantial damage to *boro* rice cultivation and infrastructure. In most cases the spills occur at the outside of meander bends through an opening in the bank (*dhala*) or through an inactive *khal*. Once the river starts to attack these weak spots, the erosion rate accelerates and the occurrence of bank breaching and spilling becomes more frequent and damaging. In most cases, some temporary mitigative works are already in-place at these sites. During minor floods they may be adequate to prevent breaching until after the pre-monsoon season. During more severe pre-monsoon floods, they will breach.

Downstream of Ajmiriganj, pre-monsoon floods can overtop the channel's average bankfull level by up to one metre. Flooding is caused by general inundation rather than local spills. Portions of the project area are also subject to flooding from other external inflows, principally the Khowai/Barak/Ratna River system in the south and the Surma/Baulai River system in the north.

2.8.2 Flood Extent - Present Conditions

The MIKE-11 hydrodynamic model was successfully calibrated and verified using hydrometric measurements and surveys from 1991, 1993 and 1995. The model was then used to estimate the water levels, discharges and extent of inundation in the project area for various flow conditions using hydrological time series from 1991 and 1993. The frequency of occurrence of the pre-monsoon flood conditions were referenced to the discharge at Sherpur (BWDB gauge 175-5). These discharges represent the main inflows affecting the study reach.

Table 2.14 summarizes the extent and depth of inundation in the project area under present conditions for three different pre-monsoon floods at Sherpur (1:2 year, 1:5 year and 1:10 year).

Table 2.14: Pre-monsoon Flooded Areas

Flood Condition	Return Period	Non Flooded (ha)	Gross Flooded Area (ha)				
		< 0.3 m	0.3 to 0.9 m	0.9 to 1.8 m	> 1.8 m	Total Flooded Area	Flooded/ Project Area (%)
Pre-monsoon	1:2	266,100	35,890	26,494	7,116	69,500	21
	1:5	117,471	67,609	103,770	46,751	218,130	65
	1:10	45,527	48,358	131,710	110,005	290,073	86

Figures 2.26 to 2.28 show the extent of inundation over the project area. During a 1:2 year flood, about 21% of the project area is inundated, with flooding occurring primarily in the following areas:

- north of Markuli;
- south of Koyer Dhala;
- north and west of Ajmiriganj;
- west of Katkhal along Cherapur Khal, and
- along the Barak-Ratna floodplain north of Madna.

During a 1:10 year flood, when spills and overtopping of banks become widespread, up to 86% of the area is inundated.

2.9 Wave Erosion

Wave erosion can seriously damage exposed structures, village platforms and embankments. Generation of high waves depends on the occurrence of extreme winds, the presence of long, exposed fetches and deeply flooded conditions in the fetch zone.

The normal wind pattern in the project area is governed by the onset and withdrawal of the monsoon. For about four months in the summer (June - September), the south-west monsoon brings moist air into the Northeast Region from the Bay of Bengal along a circular route over the Chittagong area. This produces a dominant south-westerly to south-easterly wind system during the monsoon season.

Two severe weather disturbances can generate extreme high winds in the project area. "Nor-Wester" thunderstorm squalls usually occur between March and June, and are caused by outbreaks of cold air from Central Asia. High winds, thunderstorms and even tornados are generated along the interface of the advancing cold air and the warm air already in the region. The passage of a "Nor-Wester" typically lasts only for an hour or two, and the extent of extreme winds is usually localized. Furthermore, since these occur primarily in the pre-monsoon season when the extent of inundation on the floodplain is low, the occurrence of a "Nor-Wester" may not necessarily generate high waves.

Extreme winds can also be generated with the inland incursion of tropical cyclones from the Bay of Bengal. These events typically occur in the pre-monsoon (April-May) and post-monsoon (October-November) season. Once the cyclones cross over the mainland, they degenerate into intense tropical depressions which can move into the NE Region and generate heavy rainfalls and floods for periods of up to two or three weeks. Thus, after its landfall near Kutubdia Island, the cyclone of 29 April 1991 moved into the Northeast Region and generated some of the most extreme flooding on the Kushiyara River and the Tripura border area in recent memory.

Monthly extreme wind speed and direction data from the anemometer at Sylhet were collected from the Bangladesh Meterological Department. This station operated for 23 years between 1966 and 1988. The published wind extremes are the maximum three minute average speeds, measured every eight hours during the day. The wind data were analyzed to estimate an appropriate design wind speed that could be used for wave hind-casting purposes. The monthly wind extremes were analyzed by computing the number of occurrences in each specified wind speed class and direction. The analysis was carried out only for the period May - October, since this is the only time that the floodplain would be deeply flooded. This analysis showed the most frequent directions for extreme winds were from the east, north-east, south-east and south. The maximum observed wind speed reached 84 knots (from the north-east) in May 1979.

Given the relatively short period of record and the nature of the reported wind records, it was decided to combine all of the winds and not to develop a separate wind frequency relation for different wind directions. Initial calculations indicated that a duration of 15 minutes would be required in order for the waves to become fully developed. Therefore, the corresponding wind speeds for a 15 minute duration were estimated. The three parameter log-Pearson distribution was used to fit a curve to the observations. The resulting wind speeds represent extreme values measured over a duration of 15 minutes. The estimated extreme wind speeds for various return periods are summarized in Table 2.15.

Design wave heights and wave periods were estimated using hind-casting procedures recommended by the US Army Corps of Engineers for shallow lakes and reservoirs. In these equations, the wave height and period are expressed as a function of (1) wind speed, (2) water depth, (3) wind duration and (4) fetch length. In the deeply flooded *haor* areas, the average water depth over the floodplain will reach up to around 3 - 4 m during floods.

Table 2.15: Adopted Design Wind Speeds

Return Period (Years)	Wind Speed (15 minute duration in knots)	Wind Speed (15 minute duration in m/s)
10	23	12.5
20	33	17
50	50	25

Tables 2.16, 2.17 and 2.18 summarize the significant wave heights (Hs) and wave periods (Ts) that will be generated for various fetch lengths and water depths.

This hind-casting analysis showed the wave heights that can be generated are limited by the water depths in the fetch area. However, even when the water depths reach up to 4 m, the wave height cannot increase much after the fetch exceeds about 15 km in length.

Table 2.16: Estimated Wave Heights For 1:2 Year Storm

Fetch Length (km)	Depth = 1 m		Depth = 2 m		Depth = 3 m		Depth = 4 m	
	Hs (m)	T (sec)	Hs (m)	Ts (sec)	Hs (m)	Ts (sec)	Hs (m)	T (sec)
2	0.3	1.7	0.3	1.8	0.3	1.8	0.3	1.8
5	0.3	2.1	0.4	2.3	0.5	2.4	0.5	2.4
10	0.3	2.4	0.5	2.7	0.6	2.8	0.6	2.9
20	0.3	2.6	0.5	3	0.7	3.2	0.8	1e+200

Table 2.17: Estimated Wave Heights For 1:20 Year Storm

Fetch Length (km)	Depth = 1 m		Depth = 2 m		Depth = 3 m		Depth = 4 m	
	Hs (m)	T (sec)	Hs (m)	Ts (sec)	Hs (m)	Ts (sec)	Hs (m)	T (sec)
2	0.4	1.9	0.4	2.1	0.5	2.1	0.5	2.1
5	0.4	2.4	0.6	2.6	0.7	2.7	0.7	2.8
10	0.4	2.7	0.6	3	0.8	3.2	0.9	3.3
20	0.4	2.9	0.7	3.4	0.9	3.7	1.0	3.9

Table 2.18: Estimated Wave Heights For 1:50 Year Storm

Fetch Length (km)	Depth = 1 m		Depth = 2 m		Depth = 3 m		Depth = 4 m	
	Hs (m)	T (sec)	Hs (m)	Ts (sec)	Hs (m)	Ts (sec)	Hs (m)	T (sec)
2	0.5	2.3	0.7	2.4	0.7	2.4	0.8	2.5
5	0.5	2.8	0.8	3	1.0	3.1	1.1	3.2
10	0.5	3.1	0.9	3.5	1.1	3.7	1.3	3.8
20	0.5	3.4	0.9	4.0	1.2	4.3	1.4	4.5

The most severe wave action in the project area will occur at sites bordering one of the major deeply flooded *haors*. At these sites, the wave heights will be governed mainly by the size of the *haor* and the floodplain water level at the time of the storm. Accounts from local villagers showed that many exposed villages have experienced severe erosion from wave action. The worst erosion occurred in 1988 when strong winds coincided with extreme flood levels. In that year, exposed villages experienced losses of up to 30-40% due to erosion of the platform.

3. SOCIOECONOMIC CONTEXT

3.1 The People

3.1.1 Area and Population

The Kalni-Kushiyara River Management Project covers an area of 3,356 km^2 and includes parts of the greater Sylhet and Mymensingh regions. Greater Sylhet accounts for as much as 80% of the total area. The project extends over five districts within these two regions (Table 3.1). It includes Ajmiriganj and Baniachang *thanas* in their entirety and parts of 17 other *thanas*.

According to the latest census, the population was 1,766,338 in 1991. The project area accounts for 2.27% of the country area and 1.58% of the population of Bangladesh. The average project area population density is 526/km^2, much lower than that of the NERP area (707/km^2) or of Bangladesh (755/km^2). This is because large tracts of land are not suitable for dwelling due to very low elevation. The average population density gradually decreases from east to west. However, the population density along the main river bank is 1,000/km^2 since the main river channels are contained by natural levees projecting some 3 m above the surrounding lowlands. As a result, the population density on inhabited lands is one of the highest in the country.

Table 3.1: Project Area and Population

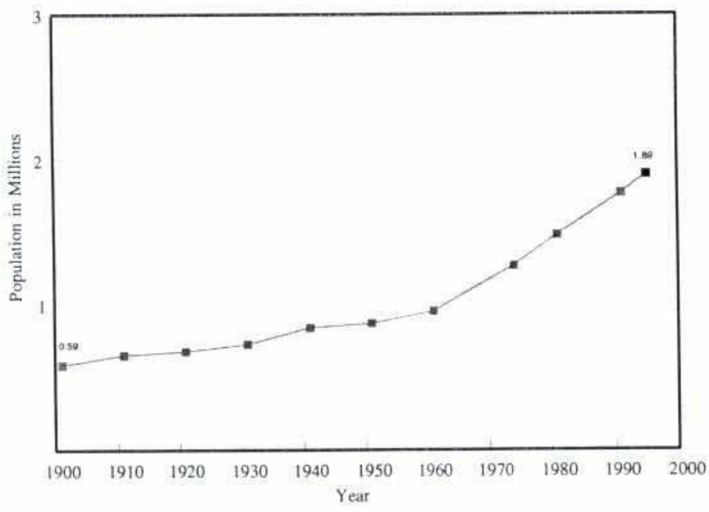
District	Share in the Project (%)	
	Area	Population
Habiganj	35.7	34.7
Sylhet	22.2	31.6
Sunamganj	22.8	19.0
Kishoreganj	18.9	14.2
Moulvibazar	0.4	0.5
Total	**100.0**	**100.0**

Source: Estimates based on the 1991 Population Census, BBS, 1994.

3.1.2 Demographic Characteristics

From 1901 to 1991, with an average annual growth rate of 1.3%, the population more than tripled. During this period, the national growth rate was 1.5%. Population growth was relatively slow in the early part of the century, then began to experience a more rapid increase from the 1960s. During the intercensus period 1981-1991 population increased at an annual rate of 1.8%. According to projections, population in the project area was 1.89 million (563/km^2) in 1995 (Graph 3.1). The low growth rate in the 1901-1991 period implies that net out-migration is a contributing factor to the population dynamics.

Graph 3.1: Population Growth



In 1991 the sex ratio (males/100 females) in the project area was 102.7, slightly lower than the rest of the country. A high sex ratio indicates that women are disadvantaged in the society. Data since 1951 show that the sex ratio has been declining. The average household has 5.7 members; this is slightly higher than the national average (5.5). The Demographic Dependency Ratio, that is the ratio of the dependant population (<14 and >64 years of age) to the population of the working age, is estimated to be 45%.

3.1.3 Urban Population

The area is comparatively less urbanized than the rest of the country. Urban population in the project area increased at an annual rate of 5.4% during the inter-census period 1981-1991. According to the 1991 census, 8.9% of the project area's population is urban. This is much lower than the urban population of Bangladesh as a whole (20%). Among urban centres are the district and *thana* headquarters.

3.1.4 Rural Settlements

The project area is characterised by open agricultural lands dotted with village settlements (Figure 3.1). There are an estimated 2,412 villages in the project area. A village is composed of several *paras* or clusters of households. The settlement of a *para* (or *hati*) often reflects a particular set of social relationships.

The Village Landscape
Historically, villages developed along the banks of rivers that were and remain the lifeline of most rural settlements (Figure 3.1). In the project area most villages are located between the river and the *haor*. There are villages, however, surrounded by *haors*. In the monsoon season the raised village settlements look like small islands in a great sea.

A river or *haor* settlement is a cluster of homesteads. Larger villages have several irregular "rows" of houses. Medium and large-sized villages have a weekly or daily market place. There are usually raised pathways (*gopats*) along the bank of the river or through the village. Sandy, newly emerged *khas* land along the bank of the river (*char*) is used for the cultivation of ground nut and sweet potato. *Haor* land has different names and uses related to its elevation and the inundation and drainage of monsoon water. Village homesteads are linked with the *haor* by unraised earthen roads. These roads are used only in the dry season to transport the harvested rice. Much of the *haor* land is used for crops. Irregular earth cuttings from the cropland, or *bondh*, form the ditches often used for domestic water sources. Ditches and other low plots of the *bondh* are used as seed beds for rice. Over the years, the earth which has been cut from the *bondh* is replaced with coarse alluvial deposits. The lowest parts of the haor contain *beels*, some of which drain early enough in the dry season to be used for rice cultivation, but the lowest *beels* remain as fishing grounds throughout the dry season.

There are narrow patches in the *haor* with relatively higher elevation. This is called the *kanda* and is considered to be *khas* land for use by the community. The *kanda* is used for cattle grazing and, in the early monsoon season, for the cultivation of *dhaincha* (sesbania sp.), a water-tolerant plant used for fuel. If it is close to their existing homestead platform, people raise *kanda* land to extend their homestead.

The Homestead Platform

To protect their settlement from flooding people build their homesteads on raised earthen platform called *bhita*. Depending on the household's economic status, their homestead consists of a house for dwelling and grain storage, a kitchen, a cattle-shed, a courtyard space for straw storage and a latrine hanging off the platform. Slightly elevated land adjoining the homestead platform (*chara bisra*) is used for growing vegetables. Towards the end of the dry season, the *chara bisra* is levelled, glazed with mud and used as a rice threshing platform. The size of a *bhita* is generally larger in highland areas and smaller in *haor* areas. For example, the average size of a *bhita* in the villages along the Kalni-Kushiyara River between Markuli and Sherpur is 0.05 ha, while it is only 0.02 ha in the villages downstream of Markuli (NERP, 1995-96a).

In most villages, homestead platforms are eroded either by river currents in the pre-monsoon season or by waves from the *haor* in the monsoon season. The configuration of a village, its location on a river bend and its exposure to a large *haor* affects the frequency and extent of platform erosion. To dampen the effects of monsoon wave erosion, shrubs and grasses are cultivated along the outer slope and toe of the platform. Earth to extend or rebuild an eroded village platform is obtained from cropland near the homestead. A survey of riverside villages from Sherpur to Kalma shows that over 5% of the platform area of vulnerable villages is eroded each year.

In the project area, 19% of households do not have a *bhita* of their own. Erosion has rendered many of them homeless. In *haor* areas, raising a village platform is difficult and costly. The cost for one household to purchase land and raise a homestead platform of two decimals (0.008 ha) in Shahebnagar of the lower Kalni reach is Tk 36,000. Once a platform is eroded, families from poor households find it impossible to raise a new one. Such families often live on low agricultural land during the dry season and on others' homesteads during the monsoon season. When platform space is no longer accessible, people migrate to other areas.

Living Conditions

Lack of space and inadequate sanitation on homestead platforms create unhealthy living conditions, which become worse during the monsoon period. A description of human settlements narrated in 1905 by B.C. Allen in the Gazettees of Sylhet (1970) is indicative of the physical living conditions in that era. With the exception of available tubewell water, the present-day living situation does not vary significantly from this depiction (Text Box).

THE DWELLING

The conditions under which the majority of the people pass their days are far from conducive to a long term of life. Their houses are small, dark, and ill ventilated, and the rooms in summer must be exceedingly close and oppressive. They are built upon the plinths, and are in consequence extremely damp, and the poorer people instead of sleeping on beds or bamboo platforms, which would cost but little to provide, often pass the night on a mat on the cold floor. The houses are buried in groves of fruit trees and bamboos which afford indeed a pleasant shade but act as effective barrier to the circulation of air, and increase the humidity of the already over humid atmosphere. Of sanitary arrangements there are none, the rubbish is swept up into a corner and allowed to rot with masses of decaying vegetation, and the complete absence of latrines renders the neighbourhood of the village a most unsavoury place. The water supply is usually bad and is drawn either from rivers or from tanks in which the villagers wash their clothes and persons.

Source: District Gazettees of Sylhet, Government of East Pakistan, 1970

3.1.5 Social Stratification

Land holding is the main determinant of social stratification in the project's rural area. The distribution of households by cultivable holding is presented in Table 3.2.

Many landless and small farmers need to cultivate others' land through a share-cropping or leasing arrangement to subsist.

Table 3.2: Household Distribution by Cultivable Holding

Class	Percent of Households (%)	Percent of Land (%)	Average Farm Size Owned (ha)	Average Annual HH Income (Tk)
Landless	42.6	0		22,371
Small Farms	35.7	14.3	0.4	32,943
Medium Farms	13.9	23.0	1.8	55,491
Large Farms	7.8	62.7	8.8	174,977
TOTAL	**100%**	**100%**	**1.1**	**42,577**

Source: Household Survey, (NERP, 1996a)

The estimated total number and average farm size actually cultivated (i.e. hectares owned + rented) is presented in Table 3.3.

Table 3.3: Farm Size Profile

Class	Total Rural Households	Owned Land (ha/HH)	Rented Land (ha/HH)	Total Land (ha/HH)
Landless	109,760	0.00	0.21	0.21
Small	92,075	0.43	0.00	0.70
Medium	35,830	1.80	0.08	1.88
Large	19,955	8.80	(2.53)[1]	6.27
TOTAL	**257,620**	**1.10**		**1.10**

Note: 1. Figures in parenthesis are for land rented out to smaller landless farmers.

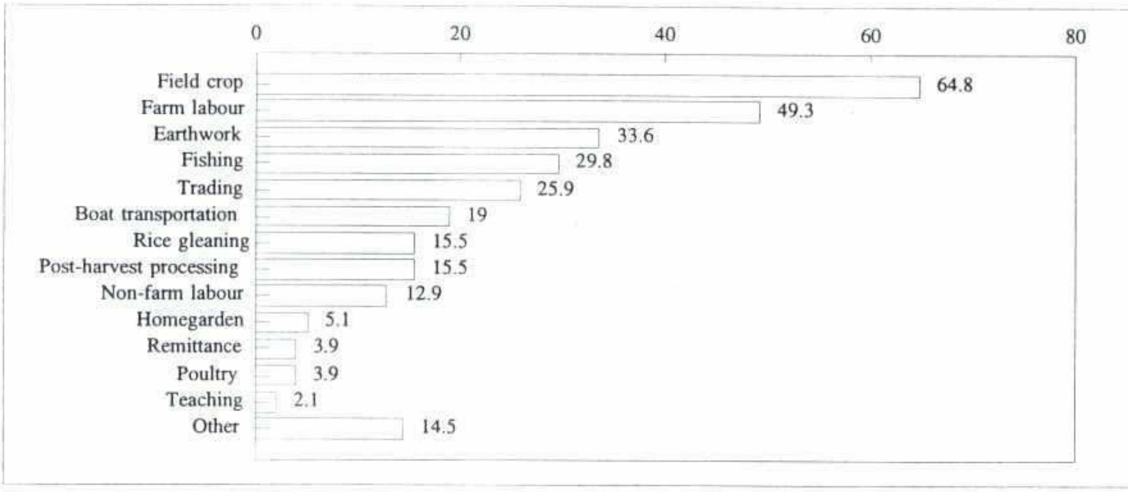
A woman's status in the society is determined by the position of her household, and specifically through the status of her male guardian. Even in land-owning families, women seldom have control as head of household. In landless families, where *purdah* is less rigorously applied, women have greater control in decision-making about income-earning. Poor and destitute female heads of household are obliged to work in the public sphere and consequently are viewed as having a lower social status (NERP, 1996b).

3.1.6 Livelihood Sources

People are generally dependant on agriculture as their source of livelihood, either as land owners or as wage laborers (Graph 3.2). Earthwork, fishing and trading are important occupations, while for women, post-harvest rice processing and gleaning are important sources of income in poor households. The majority of households survive by having more than one source of income.

The undeveloped infrastructure, absence of industrial labor opportunities and low level of urbanization in the project area results in few alternatives to agricultural labor as a source of livelihood for the landless.

Graph 3.2: Livelihood Sources (% of Households)



Source: NERP Household Survey

3.1.7 Education

In the study region, there are less than six primary schools and one secondary school per 10,000 people. Compared to the rest of the country, the ratio of schools for population is relatively higher at the primary level and lower at the secondary level (NERP, 1994).

Table 3.4: Level of Schooling

Schooling	Both sexes (%)	Male (%)	Female (%)
No schooling	72.3	67.4	77.5
Primary	19.4	21.3	17.5
Secondary	6.9	9.1	4.5
Above secondary	1.4	2.2	0.5
Total	**100.0**	**100.0**	**100.0**

Source: Household Survey, (NERP, 1996a)

Survey data indicates that about three-fourths of the population have never attended school (Table 3.4). School dropout rates are high and increase in each successive grade. For example, in primary school the average number of students enrolled in grade one is 52, while it is only 15 in grade five. At successive stages of schooling, the dropout rate is relatively higher for female students (NERP 1996a).

3.1.8 Health

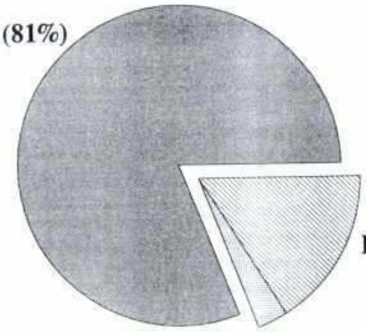
Public health infrastructure in the project area includes one health centre-cum hospital in each *thana* headquarters with limited laboratory facilities and a few beds for indoor patients. At the union level, one Family Welfare Centre provides limited mother and child health services, supplies contraceptives, and provides immunization to children and pregnant women. People suffer mainly from water-borne diseases; about half of all the patients treated in government hospitals come with diarrhoeal problems. The incidence of all diseases, including diarrhoea, is highest in the post-monsoon season. Many people in the village still depend on traditional healers for their day-to-day health care needs.

3.1.9 Water and Sanitation

Water

Hand tubewells are the main source of drinking water in the project area (NERP, 1996a); 81% of households drink tubewell water. Others fetch drinking water from open water sources such as ponds, rivers and ditches (Graph 3.3). Data from Balaganj, Jagannathpur, Ajmiriganj, and Mitamain *thanas* show that 4% of public tubewells are inoperable. On the average, there are 112 persons (20 households) per functioning tubewell. For bathing, laundry and dish-washing, most households use water from near-by rivers, *khals* and ditches.

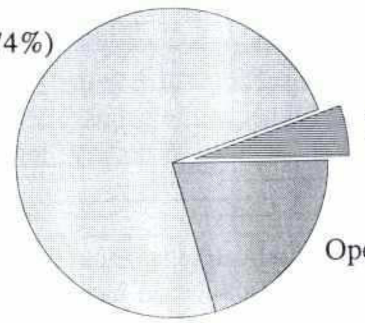
Graph 3.3: Source of Drinking Water



Sanitation

The sanitation facilities used by 95% of households in the project area are below the acceptable standard for a sanitary latrine (water-seal and pit latrines). Only 5% of households use pit latrines, 1% possess a *pucca* pit latrine (concrete rings and slab with brick walls), while 4% of households use an earthen pit toilet in the wet season (Graph 3.4).

Graph 3.4: Type of Latrine Used in Wet Season



In the project area, 74% of households use a hanging latrine in the wet season. Constructed on a bamboo frame, with walls of banana leaf or burlap, these latrines are situated over ditches or canals into which the untreated waste drops. Twenty one percent of households have no latrine. Defecation in open fields during the dry season and in open water bodies during the monsoon season is common practice for the families of these households.

3.1.10 Relationships in Agriculture Production Systems

Agricultural practices are inextricably related to the social setting of "the man behind the plough". The traditional farmer forms the nucleus of the agrarian society. The typical traditional farm family owns some cows and bullocks and cultivates a parcel of land.

Tenancy Systems

With division of land into smaller parcels and increasing landlessness, various share-cropping and land leasing systems have evolved. *Barga*, *chukti* and *rangjoma* are the major tenancy systems in the region. *Barga* is a system of sharecropping where the cultivator and the landowner equally share the cost of seed, fertilizers and water. Labor costs are borne by the cultivator. The produce is equally shared. *Chukti* is a type of leasing system for single-cropped land where the cultivator pays a fixed amount of rent after the harvest. The rent is normally 4-5 *maunds* (37 kg/*maund*) of rice per *kare* (0.11 ha). *Rangjoma* is a type of leasing system where the cultivator pays a fixed rent in cash at the time of contract. The rent is Tk 1,000/*kare* for single-cropped land and Tk 1,200-1,500/*kare* for double-cropped land (1996 rates).

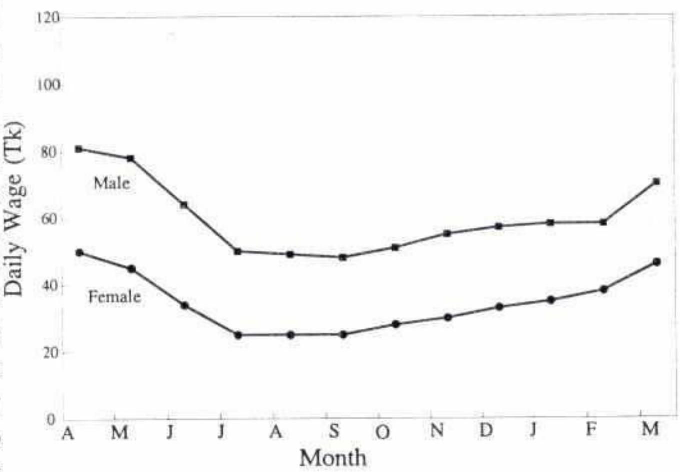
In the *haor* area, these specialized systems of share-cropping and leasing are indicators of a high percentage of landlessness (42% of households) and of land concentrated in the hands of a few large landowners. Large landowners rent out land under different systems, while small landowners sharecrop or rent land. The proportion of land taken on sharecropping (*barga*) and land leased-in under fixed rent (*rangjoma*) is almost equal.

Labor Arrangements
The dry season is the peak agricultural period in the area. Cultivation of a single *boro* crop is characterized by a high demand for labor during the peak periods of transplantation and harvesting. Daily wages fluctuate with the seasons (Graph 3.5). Loss of crops through pre-monsoon flood represents a serious loss in annual earnings for agricultural labor.

Earnings through agricultural labor vary, depending on the type of contractual arrangement and on labor demand. Harvesting labor may be engaged either on a daily basis or by contract and is either local or migrant. With the ever-present danger of early flood, a timely harvest is essential. Many farmers prefer to contract migrant labor rather than to depend on local labor. Farmers are willing to pay migrant labor 10% of the harvest as wage in order to secure their harvest before pre-monsoon floods.

Credit Arrangements
The credit market, once dominated by a small group of traditional money-lenders, has changed and usury is now a common practice. In the *haor* areas, the demand for credit reaches its peak between mid-December and mid-March, when farmers start preparing land for *boro* cultivation, negotiate with labor, transplant rice, buy fertilizers and pay for irrigation. Most of the poor and medium farmers borrow money from the professional money-lenders (*mohajans*). They repay the loan after harvest. The common practice is to pay 8 *maunds* of rice for borrowing Tk 1,000 for the six months of a cultivation season (mid-November to mid-May). In case of a crop failure for whatever reason, the common defaulting practice in the area is to extend the repayment period by another year and write off the interest for the first year.

Graph 3.5: Wage Rates in Agriculture



Division of Labor

Traditionally, tasks in agricultural production are gender-delineated. Field activities for rice cultivation, such as preparation of seed-beds, ploughing, transplantation and harvesting are men's domain, while home-based activities like seed preservation, post-harvest processing and storing of grains are performed by women. For women of middle-class farm families, working in the field is an unacceptable breach of *purdah*, related to diminishing the social status of respectable families. With increasing poverty, poor and destitute families can no longer afford to retain the social status related to keeping women in *purdah*.

Changes in the traditional division of labor are a reflection of the deteriorating economic conditions. In the project area, women from poor households now work as agricultural laborers in rice transplantation, weeding and harvesting on small plots near the household. As well, they are engaged in all stages of cultivating minor crops like sweet potato, ground nut and chili.

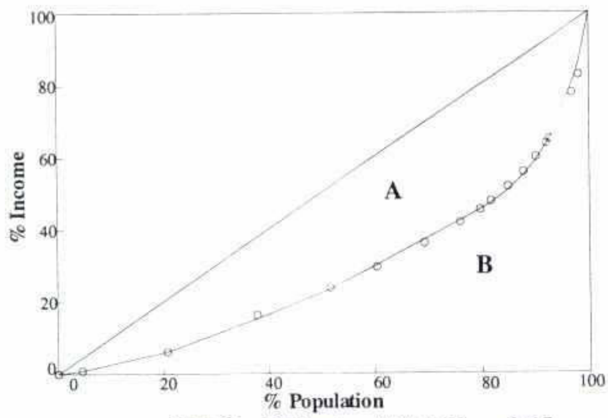
3.1.11 Income and Poverty

To assess poverty alleviation, various macro-indicators of poverty and income distribution characteristics at a given points in time are typically employed and include the following (BBS, 1995; ADB, 1994; UNDP, 1997):

Head Count Ratio: Fraction of the people who are poor. The Absolute Poverty Line in Bangladesh (as defined by WHO/UNICEF) is a calorie intake of 2,122 calories per capita per day. The Hard Core Poverty Line is defined as 85% of the required level, that is 1,805 calories per capita per day.

Gini Coefficient: A measure of the degree of income inequity which compares the percentage of income with the percentage of the population. The value of the coefficient ranges from zero to one. If the coefficient is zero, the income distribution is equal while one indicates perfect inequity (Graph 3.6).

Graph 3.6: Gini Coefficient of Project Area



Gini Coefficient= A/(A+ B) = 0.45

Poverty Gap Ratio: Average income shortfall of the poor expressed as a percentage of the poverty line.

Sen Index: A distributionally sensitive poverty measure that takes into account all 3 of the above measures: the poverty headcount ratio, Gini coefficient, and poverty gap ratio.

Human Development Indicators: Various indices developed using measures of life expectancy, adult literacy, school enrollment ratios, and real gross domestic product (GDP) in purchasing power terms.

Although the Sylhet basin is a rice surplus area, characterizing relative prosperity, the project area is one of the poorest regions of Bangladesh. Large scale landlessness, limited labor opportunities owing to low intensity of cropping and frequent crop failures coupled with a feudal social power structure have created a poverty trap which has accelerated the process of pauperization and marginalization.

Poor communication linkages and difficult living conditions have resulted in the limited presence of NGOs in the area, with the result that targeted poverty alleviation programs have not been developed to any significant extent.

Average per capita annual income in the Kalni-Kushiyara River region has been estimated at Tk 7,470/year (US$ 187/year). Household income is not sufficient to maintain a decent life for most of the households. As much as 65% of the households are below the "absolute poverty line" in terms of caloric intake while the extent of the "hard core poor" is estimated at 50%. These rates are much higher than that of the country as a whole (Table 3.5).

Table 3.5: Percentage of Households below Poverty Line

Poverty Line	Households Below Poverty Line (%)	
	K-K Region	Bangladesh
Absolute	65	48
Hard Core	50	28

At the same time, the income distribution is highly skewed and this is highly correlated to land ownership patterns. It is estimated that the bottom 20% of households only have an income share of 6% while the top 10% have an income share of 40%. And, again, this degree of income inequity is much higher than for the country as a whole. The Gini Coefficient, for the Kalni-Kushiyara River region, is estimated to be 0.45 compared to 0.39 in Bangladesh and 0.37 in rural Bangladesh, based on 1991-92 data (Graph 3.6).

Other analyses (Hossain, 1994) identify the principal determinants of this poverty and help identify sustainable poverty-alleviating interventions, namely:

- Land Ownership/agricultural technology;
- Number/education of household members;
- Non-agricultural employment opportunities, and
- Infrastructure (transportation & electricity).

But these constraints, in turn are made more acute by the existing environmental conditions. Existing annual flood conditions accentuate (and perpetuate) existing poverty levels in the Kalni-Kushiyara region. Measurable sustainable development in the Kalni-Kushiyara River region is practically precluded without changing the over-arching socioeconomic and physical environment (Jalal, 1993).

The poor depend mainly on wage labor for survival, however labor opportunities are limited. Rice cultivation in the dry season is the main economic activity in the region. A host of labor contracting systems with varying wage rates has evolved, characterized by a fluctuating demand for labor at different stages of rice cultivation.

Well-to-do farmers employ one or more laborers on a seasonal or yearly basis. Farmers with surplus land usually engage one laborer per 1.5 ha of cultivable land. A male laborer contracted for the crop season (November to mid-June) earns, in addition to three meals a day, 30 *maunds* of rice or Tk 6,000 - 8,000. Small farmers generally engage labor only for the harvest. In addition to two or three meals a day, such a laborer earns 15 *maunds* of rice for two months of work. The monthly wage rate for certain activities, such as boat operation and operation of low lift pumps for irrigation, is about Tk 800-900 plus three meals a day. During the monsoon season, the demand for labor drops and wages decrease.

The main source of income for women is in agriculture labor, limited by the constraints of a single crop that is vulnerable to frequent pre-monsoon flooding (NERP, 1996a). Women's wage in agriculture is less than that of men's. On a contracted basis, women work for seven weeks and earn five to six *maunds* of rice, three meals a day and a saree (wage equivalent to Tk 2,700).

Women have limited access to earning in the fishing industry. Women's earning capacity in homestead production (vegetable cultivation, rice, livestock rearing) is significantly limited by lack of space on the crowded village platforms.

During the four-month monsoon season, the lack of local labor opportunities and the low wage rates cause severe hardship for households dependant on women's wage labor. Seasonal out-migration to *thana* and district centers in search of jobs is part of the survival strategy of such poor households.

3.2 Physical Infrastructure

3.2.1 Water Resources Projects

There are 11 flood control and drainage projects in the study area: 4 on the left bank and 7 are on the right bank of the Kushiyara River (Figure 2.1). The gross area of these projects is about 80,180 ha, and the net cultivable area is about 55,270 ha.

Projects on the Kushiyara Left Bank
Two of the projects, the Sutki River Embankment Project and Sutki River FCD Project, have a gross area of about 13,560 ha and are designed to protect *boro* crops from pre-monsoon flooding. The remaining two projects, Jhingari Nadi Scheme and Bashira River Re-excavation, were designed to improve drainage and increase winter season irrigation. All these projects are located around Baniachang Thana.

Full flood embankments exist along the left bank of the Kushiyara River between Nalua Gang and Manumukh. These are part of the Manu River Irrigation project, that was constructed in the early 1960s. Recently, a road has been constructed from Sherpur to Enayetganj, that also serves as an embankment.

Projects on the Kushiyara Right Bank
There are 7 projects on the right bank of the Kushiyara River, with a total gross area of about 55,200 ha. The 6 Kushiyara River right bank projects, around Markuli, are submersible embankment projects that provide pre-monsoon flood protection to *boro* crops. The total length of embankments for the 6 submersible embankment projects is about 208 km. The seventh project is the Damrir Haor project which is a drainage project only. It is located near Fenchuganj.

Embankments also exist along the right bank in Balaganj Thana (opposite the Manu River Irrigation Project). These embankments were originally constructed as submersible embankments, but have been gradually raised so that they are only occasionally overtopped during the monsoon season.

3.2.2 Other Infrastructure

About 76 km of the Dhaka-Sylhet National Highway runs through the project area. There is also about 23 km of railroad that connects Fenchuganj and Sylhet. Feeder roads connect Habiganj to Baniachang, Nabiganj and Sherpur Thana headquarters. The Balaganj Thana is also connected by a paved feeder road from the National highway at Tajpur. There are two feeder roads that form the project boundary: Habiganj-Lakhai and Sylhet-Jagannathpur. The total length of feeder roads within the project area is about 471 km, of which 205 km is paved. The elevation of these roads is about the same as the annual average flood level and they are damaged almost every year.

There are about 2,002 km of village roads in the project area that connect all the *thana* centres and market places. Most of these roads are impassable during the monsoon season due to flooding. The flooded roads are damaged annually.

3.3 Agriculture

3.3.1 Land Use

The net cultivated area within the project area is 279,850 ha. Of this, over 94% is single cropped, about 3% is double cropped and 3% is fallow. The total cropped area is 281,787 ha, resulting in a low cropping intensity of 101% (Table 3.6). This indicates that each unit of cultivated land in the project area supports the equivalent of one crop per year.

Table 3.6: Distribution of Cropped Area

Crop	Percent of Total Cropped Area
Rice	98.3
Oilseeds	0.4
Vegetable/Spices	0.7
Other[(1)]	0.6
Total	100
Total Cropped Area (ha)	**281,787**

Note: 1. Potato, wheat, pulse etc.
Source: Land use Survey (NERP, 1995-96b).

Land use was initially determined based on the NERP sample survey and then reviewed with the trend of development of district statistics (BBS, 1983-84). Estimated cropped area was finally reviewed and verified with *thana* statistics (BBS, 1995a).

3.3.2 Cropping Pattern and Crop Area

A wide range of crop patterns are practiced in the project area, but the major patterns are rice based, accounting for over 98% of the net cropped area. Vegetables, spices, sweet potato and ground nut are the major non-rice crops. They account for about 1.3% of the total cropped area (Table 3.6). The patterns of the major crops are presented in Annex F. These patterns are based on a NERP land use survey conducted in 1995-96.

Generally in Bangladesh rice is grown throughout the year with one crop grown in each of the three seasons (*Kharif* I, *Kharif* II, and *Rabi*) of the year (Table 3.7). However, in the project area, flash floods and deep seasonal flooding limit agriculture significantly. In *Kharif* I, heavy rainfall and flash floods limit crop production to only a small area. During *Kharif* II, about 96% of the project area is submerged more than one meter (Table 2.6). Thus, almost all the production occurs during the *rabi* season.

Boro is the major rice crop in terms of area. It is grown principally during the *rabi* season, but is harvested in April-May. *Boro* covers over 84% of the total cropped area. Transplanted *aman* (t. *aman*), or monsoon rice, occupies 2.7% of the total cropped area. *Aus*, or pre-monsoon rice, occupies 2.6%. Deepwater *aman*, which is sown in the pre-monsoon season and harvested with t. *aman*, accounts for 9% of the total cultivated area.

About 27.4% of the total cultivated rice area is a local variety. The HYVs (high-yield varieties) cover about 72.6% of the total rice area, and are mainly cultivated during the *boro* season. The HYVs account for about 82% of the total area under *boro* rice, and 99% of the total area under t. *aman*. The *aus* and deepwater *aman* varieties are local.

HYV *boro* is grown on floodplain ridges. During the flood period, deepwater *aman* is grown along the flood periphery. T. *aman* and wheat are grown on high ridges adjoining rivers in the east. The t. *aman* is followed by HYV *boro*. Groundnut, sweet potato, vegetables, and spices are grown along the ridges of river banks.

Table 3.7: The Seasons of Bangladesh

Month	Crop Season	Meteorological Season
April	**Kharif I**	**Pre-monsoon**
May	*aus* rice crop	
June		**Monsoon**
July	**Kharif II**	
August	*aman* rice crop	
September		
October		**Post-monsoon**
November	**Rabi** (*boro* rice crop)	
December	Traditionally no rice was grown in this season. *Boro* cropping is a recent practice, thus the *boro* season does not correspond perfectly with the *rabi* season, as *boro* is harvested in May.	**Dry season**
January		
February		
March		

3.3.3 Crop Yields and Production

The analysis of crop yields shows that the average yield of rice is 4.1 tonnes/ha in flood free lands compared to 2.5 tonnes/ha in flood-damaged lands. These figures as well as the subsequent ones are for paddy rice.

Annual rice production varies from 0.82 million to 1.05 million tonnes, with HYV rice accounting for 84% of the rice production. About 97% of HYV rice is produced in the dry season, the remainder during the monsoon season.

Compared to rice, the production of non-rice crops is minuscule with an annual production of the order of 28,000-30,000 tonnes. The production of wheat as a substitute for rice is insignificant at 300 tonnes/year. Land suitability studies indicate that the land is mostly suited for the cultivation of rice, in particular dry season rice, because of widespread and extended flooding which precludes extensive cultivation during the monsoon season.

The present per capita crop food availability is 0.94 kg/day for rice and 0.04 kg/day for non rice crops. By comparison, the average per capita daily intake at the national level in rural areas for 1991-92 was 0.52 kg/day for cereals including 0.48 kg/day for rice, and 0.19 kg/day for non-cereals (BBS, 1995b). This indicates that the area produces a rice surplus but suffers a deficit for non-cereal crops. However, the study area is both a rice exporter when most farmers sell their crop in the wet season, and importer during the dry season.

3.3.4 Crop Damage

Crops get damaged in a variety of ways. *Boro* rice (HYV and local) is damaged by flood when it is at the reproductive or ripening stage. Yields are also much reduced when the rice is planted early in the post-monsoon season in the lower lands, despite unsuitably cold temperatures, in order to harvest it before the advent of pre-monsoon floods. T. *aman* rice is damaged by floods and drainage congestion in the late monsoon season.

Annual rice losses are estimated to vary from 100,000 tonnes to more than 400,000 tonnes. Annual HYV *boro* losses range from 44,000 to 330,000 tonnes and from 26,000 to 57,000 tonnes for local *boro*.

Annual losses of non-rice crops are estimated to be from 100 tonnes to 3,000 tonnes.

3.3.5 Crop Cultivation Practices

Farmers practice sole-stand cropping for the major crops, and a system of mixed cropping for vegetable cultivation. Agricultural production technology is based almost exclusively on manual labor. The country plough, ladder, rake, hoe, and sickle are the most important and sometimes the only agricultural tools. Exceptions are LLPs and tubewells for irrigation, and power sprayers for pesticides and fungicides.

3.3.6 Input Use

Modern Crop Varieties
A major part of the cropped area is under modern, high yielding varieties (HYVs) of rice. The spread of HYVs began with the availability of irrigation. BRRI has developed and released 16 *boro* season HYVs. High yielding varieties of wheat and improved varieties of pulses, oilseeds, spices and vegetables are also available. These varieties were developed by BARI.

Seeds
Seed use and availability vary widely. Usually, farmers save their seeds from the harvested crop and sometimes they exchange seeds among themselves. Seeds of HYVs or improved varieties are available at *thana* BADC seed centres. However, the total amount of seeds distributed to farmers is lower than the average requirements for the cultivation of most crops. Problems with seed distribution often lead to late plantation.

The average seed used for broadcast rice cultivation is 90 kg/ha. It is 25 kg/ha for transplanted rice cultivation. For wheat cultivation, the seed used is 130 kg/ha. The average seed requirement for potato, pulses, and ground nut is 1,600 kg/ha, 35 kg/ha and 150 kg/ha, respectively.

Irrigation
A contributing factor to the spread in cultivation of modern rice varieties is the increased availability of irrigation water. Fertilizer responsive HYVs perform well in areas with good irrigation facilities. Most irrigation development in the project area has taken place through use of LLPs. Low lift pump irrigation accounts for 73% of the irrigated area. About 2% of the irrigated area is fed through ground water. Traditional irrigation methods account for 25% of the irrigated area. These traditional methods include swing baskets and *doons*, and are generally practised in depressions and in flood basins, where surface water is available at a level of 1 to 2 m below the cultivated land in the dry season.

Fertilizer
Chemical fertilizers are an important input for HYV rice production in the *rabi* season. Nitrogen is the most common and widely-used nutrient, and urea is the major source of nitrogen. In the project area, annual consumption of urea is about 30,000 tonnes. Phosphate is second only to nitrogen in total volume of use as a fertilizer. The most widely used phosphate fertilizer is Triple Super Phosphate (TSP). Annual consumption of this fertilizer is about 15,500 tonnes. Potash is the third most widely used nutrient, and Muriate of Potash (MP) is the only source of potash. The project area consumes about 5,000 tonnes of MP annually. The fertilizer application is poorly balanced, with a low actual-to-recommended ratio. Fertilizers are available in the local markets. The price of fertilizer increases in the *rabi* season when most of the cultivated land is cropped.

Labor
Labor requirements for the various farm activities vary according to the crop. There is high demand for labor during the *boro* rice transplantation and harvest. Farm monitoring study shows that average labor requirements per ha for HYV production in *boro* and *aman* seasons are 215 person-days and 150 person-days, respectively. The production of local rice varieties is less labor intensive. The labor requirement per ha is 117 person-days for b. *aus*, 101 person-days for b. *aman*, 107 person-days for local t. *aman* and 154 person-days for local *boro*.

Vegetable and spice production is more labor-intensive than rice crops, requiring an average of 181 person-days/ha. Potato and groundnut require 187-188 person-days/ha; sweet potato, 116 person-days/ha; oilseeds, 115 person-days/ha. Wheat and pulse production require less labor with requirements of 99 person-days/ha and 45 person-days/ha respectively.

Pesticide
Mainly granular pesticides are used in the project area. Other pesticides include conventional pest complex, acaricide, fungicides and rodenticide. Pesticides are mainly applied on HYV *boro* rice. It was estimated from the farm monitoring survey that about 12% of the total cropped land in the project area is treated with pesticides. The application rate is significantly below the recommended rate. In HYV *boro* cultivation, the average application rate is 1.4 kg/ha compared with the recommended dose of 16.8 kg/ha. The application rate for other crops varies from 0.5 kg/ha to 1.5 kg/ha.

Draught Animal Use
The availability of draught animals is not adequate. Traditional land preparation for crop production involves ploughing, puddling and laddering, all of which require substantial draught power. Timely tillage, as well as proper tillage depth are not achieved due to the shortage of draught power: cattle being the main source. The present draught animal requirement is 41-45 bullock days/ha in transplanted HYV rice, 40-42 bullock days/ha for transplanted local rice, 39-41 bullock days/ha in local broadcast rice, 50 bullock days/ha for vegetables and 40-46 bullock days/ha for other non-rice production.

3.3.7 Marketing

Small scale intermediaries are generally involved in moving crops from producers to consumers, especially in areas with poor road communications and high transport costs. There are many primary markets in villages and secondary markets in commercial centres. Generally farmers sell surplus crops after retaining an adequate amount for family consumption until the following harvest. Small farmers, although they have no surplus, nevertheless sell a portion of their harvest immediately after threshing, to repay loans or meet other needs.

3.4 Fisheries

3.4.1 Ecological Characteristics

The project area is characterized by the presence of high quality fisheries habitats. The most important habitat, constituting 95.8% of the total, occurs on the extensive floodplain, in *beels* and ponds. The remainder of the fishery habitat includes the Kalni-Kushiyara River mainstream channel (which contains important river *duars*), other active rivers (the Baulai, Old Surma and Khowai rivers) and open and closed distributaries. Data on the principal aquatic habitat types in the project area are presented in Table 3.8.

A total of 72 species of fish have been recorded in the project area. Important groups are major carp, other carps, large catfish, knifefish, *ilish*, prawn, small catfish, small cyprinids and other small species.

Fish abundance in the project area was determined by NERP catch assessment surveys at 20 representative sites. The most fish-rich natural habitats were *beels*. All other natural habitats had significant lower standing crops (Table 3.8). Variation of standing crop within a habitat was generally moderate, except for *beels* which ranged from 118.5 to 1,294.3 kg/ha/yr. This may be due to the degree of sedimentation of individual *beels*.

Table 3.8: Areas and Fish Production by Habitat Type - Present Conditions

Habitat group	Habitat type	Area (ha)	Area (%)	Standing Crop (kg/ha/yr)	Production (tonnes)	% of Total
Riverine	Kalni-Kushiyara River	3,955	1.4	201.8	798	1.5
	Other flowing rivers	3,104	1.1	273.2	848	1.5
	Closed and dead rivers	3,721	1.3	121.7	453	0.8
	Distributaries	1,250	0.4	121.7	152	0.3
	Subtotal	**12,030**	**4.2**	**187.1**	**2,251**	**4.1**
Floodplain	Floodplain	260,200	90.3	159.7	41,554	76.2
	Beels	13,340	4.6	503.1	6,711	12.3
	Ponds	2,466	0.9	1,636.5	4,036	7.4
	Subtotal	**276,006**	**95.8**	**189.5**	**52,301**	**95.9**
	Total	**288,036**	**100**	**189.4**	**54,552**	**100**

Standing crop and species composition show seasonal variations for individual habitat types (Annex H). *Beel* and riverine habitats generally have peak catches during winter months, while floodplain habitat peaks during the mid-monsoon.

Mainstream River Channel
The Kalni-Kushiyara River is a principal migration route for certain high value commercial fish species (major carp, large catfish, *ilish* and *golda chingri*) in the Northeast Region. Biomass peaks during April and May in the Kushiyara River while further downstream in the Kalni, the highest biomass is observed in December, January or February. One interpretation is that migratory fish may congregate in the lower river section during the dry season, and then swim upstream during the pre-monsoon for spawning purposes. Peak month catches show a high proportion (30% - 88%) of large species (carp, catfish, *ilish*).

Mainstream Duars
Highest biomass in *duars* was recorded in the month of December and February. This suggests the use of *duars* as overwintering grounds. Peak month catches are heavily dominated by large species (83% - 100%) such as carp and catfish.

Other Rivers
Biomass peaks were highly variable among other rivers. This is probably due to the impact of river closures, connections to different remote mainstream channels and variations in timing of fish movements over a large floodplain basin area. Biomass peaks were recorded in January, June, August and November. Assuming that the other rivers act as transit routes, these differently timed peaks probably represent migration episodes to and from spawning, grazing, and overwintering grounds. Peak month species composition is dominated by small fish (58% - 76%). *Golda chingri* can be of some importance as well (5% - 11.2%, when present).

Floodplain
Fish only occur on flood lands when the habitat is flooded, thus floodplain production is entirely dependent on in-migration from other aquatic habitats (rivers and their *duars*, *beels*, *khals*). This paradox - that the most productive habitat in the project area is completely non-self-sustaining is a central and critical concept for analyzing and interpreting the potential project impact on fish production in the project area.

Highest biomass on the floodplain was recorded in August. Species composition in peak months is usually dominated by small finfish species (in most cases, 60% to 73%). Large catfish are also of some importance (14% - 36%). In one instance *golda chingri* accounted for 52% of catch.

Beels
Highest biomass was recorded during the dry season (December to March). Carp are especially important in peak month catches (14% - 48%). Small fish form the largest component (34% - 68%), but both large catfish (18%) and *golda chingri* (10%) are significant.

The results of the field survey highlight the importance of the river *duars* and *beels* as critical overwintering habitats for carp and catfish broodstock. Moreover the productivity of the extensive floodplain habitat is entirely dependent on annual restocking with 'seed' from riverine and *beel* habitats.

Ponds
There are an estimated 29,399 ponds in the project area (Annex H) covering an area of 2,466 ha out of which nearly 25.2% are cultured, and 32.6% are culturable (may be used for fish culture without any major investment). In addition, 42% are derelict, these are not presently used and are lying fallow, in most cases they are covered with water hyacinth. The cultured ponds are generally larger and deeper than other ponds and are used for wild fish stock and fingerlings of cultured species. Those are mostly located in flood-free areas. Culturable ponds are shallow and are often located in areas subject to flooding.

3.4.2 Fish Production

Total fish production in the project area is estimated at 54,552 tonnes (Table 3.8). Breakdown by habitat indicates that 76.2% of all fish production originates from floodplain. *Beel*s contribute about 12.3%, and ponds of all types contribute 7.4%. Riverine habitats yield comparatively minor contributions to catch: the Kalni-Kushiyara River mainstream channel yields only 1.5%; other active rivers, 1.5%; closed and dead rivers, 0.8%, and distributaries only 0.3%. *Duar*s in the mainstream channel contribute about 40% of the total mainstream channel catch. In other rivers, *duar*s contribute about 9.4% of the catch.

3.4.3 Fishing Practices

Diverse fishing practices are used in the region's floodplain and *beels*. During the dry season when fish are confined to the *beels* and in the drainage channels, there is very active fishing with a wide variety of nets, traps and other fishing methods. The specification of the gear depend on the type of habitat, target species, hydrological conditions, portability, labor-intensiveness, capital costs, availability of materials and profitability. The intensity of fishing varies inversely with the amount of water retained in the depressions. Fishing boats used to operate the gear and transport fish also vary greatly in size, and are predominantly non-mechanized country boats using sail, paddle or pole propulsion.

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3.4.4 Fishing Community

The traditional fishers of the project area are Hindus and belong to several castes, the most important being the *Kaibarta, Barman, Das, Rajbongshi, Malo*. There are also Muslim fishers who are predominantly landless or poor people with a low standard of living. Women in the fishing industry are employed mainly in fish processing and net making and repairing.

Fishers generally own the gear and boat either individually or as a group; wages are paid on a catch sharing basis. The distribution of catch, however, varies depending on the nature of the fishing effort and the water body type.

3.4.5 Fisheries Management

The open water fisheries of the project area are being managed by the owners to earn revenues from fishers and fish traders operating in the waters. In the past, the ownership of the rivers, *beels* etc. rested with private landlords. The rivers are divided into arbitrary segments, each known as a fishery or *Jalmohal*. Similarly each seasonal or perennial *beel* is also a *jalmohal*. Presently, ownership of all *jalmohal* rests with the Ministry of Land and are leased out through auction. The lessees then allow fisher access for a fee. Running rivers have been declared open fisheries since 1996.

Although a licensing system (termed the New Fisheries Management Policy) was introduced in selected fisheries in the project area, the traditional leasing system is still the dominant management mechanism.

The revenue-oriented management system tends to encourage over-fishing of the fish stocks as both fishermen and lessees are motivated by the desire to maximize profit in the short-term. The lessees, during the tenure of lease, exercise monopoly privileges in so far as control and exploitation of real fishermen. The lessees charge exorbitant rents or fees for different fishing gear and units belonging to fishermen. In addition, the lessees also take the bigger share of the catch from the fishermen. Thus the role of lessees in the management of the fisheries of the project area has been exploitative and fishers working in the fishing grounds remain deprived and perpetually poor.

3.4.6 Fish Processing and Marketing

A small portion of the fish catch in the project area is processed and exported. There are two processing plants situated in and around the area.

Ajmiriganj Fish Industries Ltd., Ajmiriganj
The plant started operation in 1980. It is a large fish processing plant with a daily freezing capacity of 4 tonnes. The ice plant has a capacity of 10 tonnes/day. The plant exported fish products within the range of 175 to 507 tonnes/year with an average of 327 tonnes/year during the period 1985 to 1992. About 70% of the supply of fish to the plant is harvested from the project area.

Kuliarchar Cold Storage Ltd.
This is a large fish processing plant that was established in 1985. The maximum production capacity is 11.2 tonnes/day, but only 4 to 6 tonnes of fish and prawns are produced per day. The ice plant has a production capacity of 11.2 tonnes/day. The capacity of the cold store is 300 tonnes.

The major export items are prawns (65%) and table fish (35%). The plant exports about 2,660 tonnes per year to Belgium, Germany, Italy, UK, USA, and the Netherlands. About 80% of the fish are collected from the project area, particularly from Ajmiriganj, Sullah, Baniachang, Itna, Mitamain, Lakhai and Astagram.

There are also eight ice plants in the project area for fish preservation and marketing.

Sun-dried *(Sutki)* and fermented fish *(Sidal)* are the most common form of processed fish product. Ajmiriganj, Kakailseo, Khaliajuri and Derai are important dried fish marketing centres. Both the products are marketed to other parts of the country from November to May.

3.5 Navigation and River Transportation

3.5.1 Population and Market Centres

The total population in the project area is estimated at 1.89 million (1995). However, the population that can be considered as directly river-served is estimated at 0.75 million (Annex G - Navigation). The rest of the population lives south of the Kalni-Kushiyara River and is road and/or rail served, although seasonally accessible by water. There is also a large population between the Kalni-Kushiyara and the Surma-Baulai which cannot be considered river served at present, and which does not have modal alternatives either.

Major market centres are given in Table 3.9. The population that has access to the river is generally concentrated in these towns and unions (Figure 3.2). The estimated population density is in the range of 2,500-3,000 people/km^2, which is a significantly higher density than for the region as a whole. The average population density in the project is 526/km^2 (1991), while the concentration within a 1.5 km band on either side of the river is in the order of 1,000/km^2.

It should be noted that there are other major centres adjacent to the 10 km wide band (5 km on each side of the river) of the river that could be considered at least partially river-dependent. These are:

- Beanibazar — upstream of Fenchuganj, left bank;
- Derai — right bank of the Kalni River, north of Markuli, and
- Lakhai — left bank of the Dhaleswari River, below Madna.

The boxed section in Table 3.9 refers to the Market centres within the Navigation Survey Area (NSA).

Effective navigation on the Kalni-Kushiyara River system may well increase river trade to and from those centres.

The major market centres also summarize the modal access to these communities. Only Fenchuganj has both perennial road and rail access. Downstream of Sherpur, the only effective year round access would be via the river. Figure 3.2 also provides summary information on road and rail access to different communities on the river.

In general, poor transportation and communication, either in terms of reliability and/or cost, will be major inhibiting factors in economic development. Within the Northeast Region, particularly the *haor* areas, roads are expensive to build and maintain through successive floods. As a consequence, rivers are the most cost effective mode in that they serve a multiple role of transportation, irrigation water supply, and post-monsoon drainage.

Table 3.9: Major Market and Urban Centres on the Kalni-Kushiyara River System (Boxed section relates to the NSA)

Name	Description	Km	Population		Road	Rail
			Town	Union		
Fenchuganj	Major urban centre; fertilizer plant; tea and rubber	95	15,000	31,650	P	Yes
Balaganj	Regional market	115	13,000	18,450	P	No
Sherpur	Regional market; bridge over Kalni-Kushiyara	135	10,000	38,950[1]	P	No
Enayetganj	Regional market	150	-nd-	20,000	S	No
Raniganj	Regional market	155	7,000	27,000	S	No
Markuli	Regional market	180	5,000	65,000[2]	No	No
Paharpur	Regional market; duck rearing/eggs	189	5,000	14,500	S	No
Ajmiriganj	Regional market	205	10,000	20,400	S	No
Kakailseo	Regional market; fertilizer distribution	211	6,000	21,350	S	No
Katkhal	Regional market	219	5,000	17,530	No	No
Kadamchal	Local market	223	2,000	- [3]	No	No
Abdullahpur	Regional market	233	5,000	28,750	No	No
Adampur	Regional market	242	6,000	19,500	S	No
Astagram	Major urban centre	260	-nd-	30,500	P	No
	TOTAL		94,000	372,100		

Notes:
1. Sherpur is in two unions: Aushkandi and Khalipur.
2. Markuli is at the junction of three unions.
3. Kadamchal is in Abdullahpur Union.

Km: Distance downstream of Amalshid
Town Population: Estimated by 1995/96 survey team
Union Population: From 1991 Census
Road: P=perennial S=seasonal

3.5.2 Kalni-Kushiyara River Conditions

Each year a tremendous volume of sediment enters the Kalni-Kushiyara River. As a result, the Kalni-Kushiyara navigation channel has deteriorated from a class I (LAD=3.6 m) perennial navigation route, which it was in the early 1960s, to a class IV (LAD <1.5m) seasonal river route. The river bed contains many shoaled patches.

An examination of the most recent navigation charts produced by the Bangladesh Inland

Waterways Transportation Authority (BIWTA) shows that there is very limited access to river communities above Ikardia. The communities of Shibpur, Noorpur, Madna and Adampur on the Dhaleswari River are virtually inaccessible during the dry season due to river siltation (Figure 3.2). Indicative LADs are about 1 m until Madna, and then 0.6 m to Adampur. As a result, through-traffic now takes the Baida channel (western loop), which offers better depths, or is diverted via the Baulai River and Dhakey Khal (locally called Cherapur Khal) to the Kalni River above Kanchanpur. The reach above Issapur is reasonably accessible, although there is a shallow area below Abdullahpur which would limit boats to 1-1.25 m draughts. The river reach between Kanchanpur and Kadamchal is accessible but deteriorating fast due to the Cherapur Khal diversion (Chapter 2).

There are many shallow stretches along the river between Kanchanpur and Ajmiriganj which inhibit navigation during the dry season for anything other than a small country boat. The river is effectively blocked by a major drying shoal below Manumukh at Km 159, and there are other limiting shoals at Omarpur as well as just below Fenchuganj. Thus, the river is not currently navigable to through-traffic during the dry season.

3.5.3 River Navigation Network

In the extensive low lying lands of the Kalni-Kushiyara River Project, the waterways are the backbone of the transportation system. The main river with its many tributaries, distributaries, *khals* and *haors* provides a dense navigation network (Figure 3.3). The important connections in this network are identified below:

- Ajmiriganj-Bhairab Bazar/Ashuganj via the Upper Meghna River;
- Ajmiriganj-Habiganj via the Old Kushiyara River, Ratna River, and Jhinri Khal;
- Dhanpur-Bheramohona (Gudi) River route;
- Chamraghat-Joykolos route via Samarchar;
- Chamraghat-Habiganj route via Dhakey-Kanchanpur Khal;
- Kanchanpur-Dhakey Khal route;
- Khowai River-Dhaleswari River route;
- Derai-Ajmiriganj route via the Old Surma River;
- Derai-Markuli via the Old Kalni (Old Surma) River, and
- Sunamganj-Dhanpur through the Old Surma River.

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Table 3.10 shows the 1,037 km of the Kalni-Kushiyara River system network. The total navigable length in the dry season is 551 km.

Table 3.10: Navigability of the Kalni-Kushiyara River System, 1995

River	Total Length (km)	Navigable[1] (km)	Non-Navigable (km)
Kalni-Kushiyara	285	250	35
Khowai/Barak	87	37	50
Juri	62	10	52
Sonai Bardal	25	10	15
Langla/Ratna	116	20	96
Manu	80	20	60
Darain	24	15	9
Kalni (Old Surma)	30	15	15
Beramohana Khal	10	10	0
Kanchanpur/Dhakey	30	30	-
Bibiyana	15	10	5
Sutang	77	15	62
Dhalai	59	15	44
Singli	12	8	4
Old Kushiyara	28	18	10
Jingri Khal	15	8	7
Dhaleswari	37	30	7
Old Surma (Dhanpur to Sunamganj)	45	30	15
Total	**1,037**	**551**	**486**

Note: 1. The navigable stretches of the feeder rivers mostly occur in small segments, and their discontinuity hampers navigation.

Source: NERP Navigation field survey of 1995 supplemented by figures from the FAP 6 pre-feasibility report 1994. The total navigable length of waterways in the Kalni-Kushiyara River basin has been taken at 551 km: 250 km for the Kalni-Kushiyara main river and 301 km for other tributaries.

3.5.4 Bench Mark Statistics on Water Transportation

Official statistics on water transport for the Kalni-Kushiyara River are not available. The primary data were collected by the NERP Navigation Survey in 1995. The survey was done at 12 important river stations along a 110 km reach between Madna and Sherpur - this is the navigation survey area (NSA). Based on population, the statistics were extrapolated for the 165 km reach between Fenchuganj and Astagram. This is called the "full river reach" in this report. The navigation analysis concentrates on a 10 km wide band (5 km on either side of the full river reach). This is considered the population and land area that will have the most influence on Kalni-Kushiyara River traffic. The survey produced data on the water transport fleet, the river traffic and the volume of employment of boat crews.

Water Transportation Fleet

The total number movements/trips done in 1995 can be seen in Table 3.11. The total number of incoming and outgoing movements/trips for each of the river stations is given in Annex G.

Table 3.11: Number of Trips at 12 River Stations on the Kalni-Kushiyara River in 1995

Types of Boats/Launches	Dry ('000 trips)	Monsoon ('000 trips)	Annual ('000 trips)
Mechanized Boats (MB)	99	222	**321**
Non-Mechanized Boats (NMB)	32	425	**457**
Launches	17	28	**45**
All Types	148	675	**823**

Note: River stations are: Madna, Paharpur, Kadamchal, Adampur, Abdullahpur, Katkhal, Kakailseo, Ajmiriganj, Markuli, Raniganj, Enayetganj, and Sherpur.
Source: Navigation Survey (NERP, 1995b).

Volume of Employment of Boat Crews
The volume of employment of boat/launch crews in the Kalni-Kushiyara River area in 1995 came to 2,514,000 person-days (PDs) and 4,170,000 PDs for the NSA and full river reaches respectively (Table 3.12). A breakdown of the employment by mechanized boats (MB), non-mechanized boats (NMB) and launches is given in Annex G.

Table 3.12: Volume of Employment of Boat Crews in the Kalni-Kushiyara River Area in 1995

Season	NSA ('000 PDs)				Full River Reach ('000 PDs)			
	MB	NMB	Launch	Total	MB	NMB	Launch	Total
Dry	396	63	120	579	656	104	199	959
Wet	889	850	196	1,935	1,473	1,408	324	3,205
Annual	**1,285**	**913**	**316**	**2,514**	**2,129**	**1,512**	**523**	**4,170**

Note: Number of Crew per boat is: MB=4, NMB=2, Launch=7.
Source: Navigation Survey (NERP, 1995b)

Water Transportation Traffic
The cargo and passenger traffic have been derived based on data gathered by a structured questionnaire. The questionnaire was conducted at twelve river stations in the NSA. A summary of the results is shown in Table 3.13. The details of the cargo and passenger data for each river station, broken down into incoming and outgoing traffic, is given in Annex G.

Table 3.13: Water Transport Traffic at 12 River Stations, 1995

Seasons	Cargo ('000 tonnes)	Passenger ('000 nos)
Dry Season	149	3,333
Monsoon Season	292	6,355
Annual	**441**	**9,688**

Itemized Cargo Traffic

The important traffic items of the area are paddy and rice (21%), fertilizer (19%), house building materials including boulders, sand, cement and rods (19%), fruits and vegetables (10%), and consumer goods (4%). The estimated itemized cargo traffic, broken down into the dry and monsoon seasons, is given in Annex G.

3.5.5 Indian Transit Traffic

Table 3.14 gives available data on Indian transit traffic over the past 35 years. Transit traffic via the Jamuna and Kalni-Kushiyara River system was suspended in 1965, when a war broke out between Pakistan and India. It also remained suspended during the period 1965-73, until Bangladesh revived the inter-country transportation agreement. Transit traffic has never recovered. During the 8 years of suspended activities, India was forced to make alternative arrangements to serve its Eastern States. This included creating rail linkages between Calcutta and Assam as well as improving road access.

It is apparent from the traffic data that although the Jamuna/Brahmaputra river link to Assam may be the most cost-effective, India prefers to handle trade via alternate all-India routes. Consequently, it is expected that, even if an economic case could be made for greater river traffic via the Kalni-Kushiyara River system, there may not be any significant increase with improved LADs.

It is, therefore, presumed that India will maintain its transit traffic pattern. They will pay conservancy dues based on a need to maintain the rights to an alternate system to serve the Eastern States and as a means of maintaining a strategic capability for deployment of materials and equipment in the event of an emergency.

3.6 Trade and Industry

At a macro-economic level, the project area has a surplus of rice and fish. These commodities are exported to other regions. Rice is mainly transported to Bhairab, while Bhairab and Kuliarchar are the most important outlets for fish.

The region has a very poor industrial base. Although it accounts for more than 2% of the total area of Bangladesh, it contains only about 1% of the manufacturing enterprises of the country. The highest proportion of enterprises are food processing units, followed by units involved in timber processing, wood products, and brick manufacturing. Most of the manufacturing units are located in highland areas of Sylhet and Fenchuganj. In some *thana*s (Itna, Mitamain, Astagram, Baniachang, and Sullah) there is not a single manufacturing establishment.

Most of the household essentials and consumer goods are brought from outside the region, mainly Bhairab. Ajmiriganj is the biggest trading centre in the region. Among other trading centres of considerable importance are Adampur, Markuli, Derai, Raniganj, and Sherpur.

Table 3.14: Indian In-Transit Traffic on the Jamuna and Kalni-Kushiyara Rivers

Year	Total Traffic ('000 tonnes)	Jamuna River Share ('000 tonnes)	K-K River system Share ('000 tonnes)
1960-61	891	790	101
1961-62	1,000	887	113(1)
1962-63	844	765	79
1963-65	-na-	-na-	-na-
1965-73	Indian in-transit traffic remains suspended.		
1973-75	-na-	-na-	-na-
1975-76	-na-	-na-	-na-
1976-77	4	4	-
1977-81	-na-	-na-	-na-
1981-82	50	33	17(2)
1982-83	65	43	22
1983-84	60	40	20
1984-85	78	52	26
1985-86	97	65	32
1986-87	98	65	33
1987-88	100	67	33
1988-89	95	63	32
1989-90	55	37	18
1990-91	65	43300	27
1991-92	50	33327	17
1992-93	43	22494	21
1993-94	55	29	26
1994-95	-na-	-na-	23(3)

Notes:

1. Total of 1,000,000 tonnes in traffic is split in ratio of 7.85:1 as found for the year 1960-61 to obtain traffic share via Jamuna and Kalni-Kushiyara River systems.

2. Traffic figures for Jamuna and Kalni-Kushiyara River systems for the years 1981-82 through 1990-91 were derived as per advice of BIWTA at ratio 2:1 from the total in-transit traffic figures shown in BIWTA Annual Traffic Report, 1991-92 year.

3. The in-transit Indian traffic 23,000 tonnes for 1994-95 via the Kalni-Kushiyara River system was obtained from custom officer Zakiganj.

4. INSTITUTIONAL CONTEXT

There are a variety of institutions in the project area. Many of them will work directly on the proposed KKRMP. Others will influence the execution of the project and the distribution of its benefits. This chapter describes the key institutions that are currently involved in the project area.

4.1 Institutions in the Bio-Physical Context

Table 4.1 identifies the institutions, agencies, organizations and groups that are relevant to the bio-physical context of the KKRMP.

Two national agencies have the main responsibility related to development and management of water resources in the project area. The Bangladesh Water Development Board (BWDB), under the Ministry of Water Resources (MOWR) is the key agency in the water sector. It is involved in the planning and the implementation of flood control, drainage and irrigation projects. The Bangladesh Inland Water Transport Authority (BIWTA) under the Ministry of Shipping (MOS) is responsible for the development, maintenance and control of inland water transport and certain navigable waterways.

Ministry of Water Resources
The Ministry of Water Resources (MOWR) has overall responsibility for the development and the management of the water sector. While policy decisions are taken at the Ministry level, planning and implementation of sectoral projects are undertaken by two semi-autonomous agencies within the MOWR, the Water Resources Planning Organization (WARPO) and the BWDB.

Water Resources Planning Organization
WARPO is a constituent under the MOWR responsible for water resources assessment and planning. The Flood Plan Coordination Organization (FPCO), responsible for the execution of the Flood Action Plan (FAP), was recently merged into WARPO. The organization is headed by a Director General.

Bangladesh Water Development Board
The BWDB is a key national agency under the jurisdiction of the MOWR and is basically a water resource engineering organization. It is involved in the planning and implementation of Flood Control, Drainage and Irrigation (FCDI) projects, and town protection works. It also has its own fleet of dredges that are often contracted to private firms. The dredges used in the Pilot Dredging Project were contracted from the BWDB.

The BWDB has an internal structure that does not correspond to administrative boundaries. The BWDB is managed by a Board comprising a Chairman and several Members who are appointed by the Ministry. Planning is done under the auspices of the Chief Engineer, Planning, who reports directly to the Board. This office includes several Directorates, each headed by a Director who is at the level of Superintending Engineer. The KKRMP project feasibility study is under the jurisdiction of the Directorate of Planning Schemes-I. Implementation of projects is done under the auspices of the Chief Engineer, Implementation.

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Under the Board and at the field level, there are several layers of management that are responsible for project implementation and O&M. The structure is as follows:

Zone: Covers a region which includes several districts headed by a Chief Engineer. The KKRMP project is within the jurisdiction of the Northeast Zone and the Central Zone of the BWDB having their offices in Comilla and Dhaka respectively.

Circle: Part of a Zone covering one or more district(s) headed by a Superintending Engineer. The KKRMP project includes parts of three Circles with headquarters in Sylhet, Moulvibazar and Mymensingh.

Division: Part of a Circle covering one or more district(s) or part of a district headed by an Executive Engineer. The KKRMP project includes O&M Divisions of Moulvibazar, and Habiganj under Moulvibazar Circle, Sylhet and Sunamganj O&M Divisions under Sylhet Circle and Kishoreganj O&M Division under Mymensingh Circle.

Sub-Division: Sub-Division is part of a Division covering a specific project or a component thereof headed by a Sub-Divisional Engineer (SDE).

Also of interest to the KKRMP is the Land and Water Use Directorate of the BWDB, responsible for extension work related to BWDB projects.

Bangladesh Inland Water Transport Authority

BIWTA is an agency under the Ministry of Shipping. It is mainly responsible for development, maintenance and control of inland water transport and inland waterways.

BIWTA activities include river conservancy works, dissemination of navigational and meteorological information, maintaining pilotage and hydrographic survey service, channel maintenance, and development and O&M of inland river ports and terminal facilities. BIWTA has dredges that do periodic general dredging to remove obstructions to river traffic.

The organization is headed by a Chairman and two Members, all appointed by the Ministry. The main office is that of the Member Engineering, which includes the following departments:

- Engineering Department headed by a Chief Engineer;
- Hydrography Department headed by a Director;
- Planning Department headed by a Director;
- Dredging Unit headed by a Deputy Chief Marine Engineer;
- Conservancy & Pilotage Department headed by a Director, and
- Ports & Traffic Department headed by a Director.

It has several field offices, none in the KKRMP area. But BIWTA launch stations with pontoon and ferry facilities exist at Abdullahpur, Ajmiriganj, Raniganj, Sherpur, Markuli and Fenchuganj under the administrative jurisdiction of the Senior Deputy Director of Ports and Traffic, Narayanganj Port.

The BIWTA also has a fleet of dredges that are often contracted out to private sector firms. BIWTA is considering increasing the contracting out of dredges and dredging responsibilities.

Table 4.1: Institutions in the Biophysical Context Relevant to Sustaining KKRMP Benefits

Sector	Ministry	Institution	Mandate
Government	Ministry of Water Resources (MOWR)	Water Resources Planning Organization (WARPO)	Water resources assessment and planning
		Bangladesh Water Development Board (BWDB)	Planning, implementation and O&M of FCDI projects and town protection
	Ministry of Shipping (MOS)	Bangladesh Inland Water Transport Authority (BIWTA)	Hydrographic survey, channel maintenance, control of inland water transport, development and O&M of inland ports and terminal facilities
	Ministry of Local Government, Rural Development & Cooperatives (MLGRD&C)	Local Government Engineering Department (LGED)	Development and O&M of rural physical infrastructure
	Ministry of Land (MOL)	District Administration	Land acquisition, disposal of khas land, leasing *jalmohal*
	Ministry of Environment and Forest (MOE&F)	Department of Environment (DOE)	Formulation and enforcement of environmental regulations, environmental planning, training and management
NGOs & Grass-Root Groups		NGOs	Assist villagers in construction of dykes, berms, village platforms
		Village groups	protection & maintenance of village platforms

Local Government Engineering Department

The Local Government Engineering Department (LGED) is a constituent within the Local Government Division of the Ministry of Local Government, Rural Development and Cooperatives (MLGRD&C). Headed by a Chief Engineer, it is mainly responsible for rural physical infrastructure including construction and maintenance of growth centre connecting roads, development and maintenance of selected growth centres and small-scale water management structures. It provides technical support to *thana* and district-level organisations in design, construction, and O&M of local civil infrastructure.

The LGED has an office in each *thana* headed by a Thana Engineer. At the district level, works are coordinated by an Executive Engineer. LGED has also developed effective mechanisms for community participation in ongoing maintenance of roads, ditches and embankments relevant to flood control.

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Ministry of Land
Ministry of Land (MOL) is the custodian of all *khas* land. It is responsible for management and disposal of *khas* land as per the law. At the district level, the DC represents the Ministry of Land and exercises the authority through the Additional Deputy Commissioner, Revenue (ADC Revenue) at the district level and through the Assistant Commissioner, Land (AC Land) at the *thana* level.

The MOL also gives final clearance for private land acquisition required by water resources and other projects.

Department of Environment
The Department of Environment (DOE) is a national agency within the Ministry of Environment and Forest. It is headed by a Director General. Its main activities are formulation and enforcement of environmental regulations, training and environmental education. It does not have offices at the district level or below the district level.

Non Governmental Organizations
Non Governmental Organizations (NGOs) assist the local population in the construction of dykes, berms and village platforms. CONCERN, an NGO who targets the poor has been active in the project area in assisting villagers in extending or consolidating their village platforms under Food for Work Programs, tree plantation and poor women income generation. They are also cooperating with NERP on the Pilot Dredging Project for tree plantation.

Grass-Root Groups
Villagers have traditionally had responsibility for maintaining and protecting their settlement platforms and the dykes, levees and embankments around their fields. With NERP support, Village Committees were formed in the villages of Gazaria and Kakailseo during the Pilot Dredging Project to assist in organizing work related to the maintenance and protection of the newly-constructed platforms.

4.2 Institutions in the Socioeconomic Context

Table 4.2 identifies the range of institutions, agencies, organizations and groups that are relevant to the social context of the KKRMP.

BIWTA
In addition to its responsibilities related to the bio-physical context and described in section 4.1, BIWTA at the moment also has responsibilities associated with assessing and collecting fees for licensing, tariffs etc. from large vessels using the river. The Government is considering shifting its responsibilities through contracting out to private sector for collection of river transport fees. The Government does not attempt to collect tariffs or taxes for river usage by villagers whose operations barely meet their basic needs. The vessels they target for some form of "taxation", are those that use the river for operations that yield profits beyond basic human needs.

Department of Fisheries
The Department of Fisheries (DOF) is a development and extension agency within the Ministry of Fisheries and Livestock (MOF&L). It is responsible for conservation, management and development of fisheries resources, both inland and marine. It is mainly involved in providing extension services to the fisher population, formulation and implementation of fisheries laws,

management of water bodies used as fisheries, training and socioeconomic development of the fishers. The Department is headed by a Director General. It has offices at the district and the *thana* level headed by the District Fisheries Officer (DFO) and the Thana Fisheries Officer (TFO) respectively.

Bangladesh Fisheries Research Institute

The Bangladesh Fisheries Research Institute (BFRI) is a research organization within the MOF&L. It is located in Mymensingh headed by a Director General. It has Research Stations at different locations. For riverine fish, KKRMP is under the jurisdiction of the Research Station at Chandpur headed by a Chief Scientific Officer, while for aquaculture, KKRMP is under the jurisdiction of the Mymensingh BFRI office.

Bangladesh Fisheries Development Corporation

The Bangladesh Fisheries Development Corporation (BFDC) is another autonomous organ under the MOF&L with headquarters in Dhaka under a Chairman. It has several fish landing stations. A fish landing station has been proposed in Sunamganj district which is part of the KKRMP region. This station is not yet operational.

Department of Public Health Engineering

The Department of Public Health Engineering (DPHE) is a national agency within the MLGRD&C. It is the key government agency in the field of drinking water and sanitation. It is mainly responsible for installation and maintenance of rural potable water supply systems based on a network of hand tubewells. It also provides extension services for the installation of waterseal latrines. It has offices at the district and the *thana* levels headed by a District Public Health Engineer and a Thana Public Health Engineer respectively.

Bangladesh Rural Development Board

The Bangladesh Rural Development Board (BRDB) is a national agency within the Ministry of LGRD&C. It is headed by a Director General. Its main activity is to promote a two-tier cooperative structure. *Krishi Samabaya Samity* (KSS) is a farmers' cooperative society sponsored by the BRDB at the village level. At the *thana* level, all KSSs are federated to the Thana Central Cooperative Association (TCCA). BRDB also forms destitute women's group at the village level. It has an office in each district under a Deputy Director and also in each *thana* under a Rural Development Officer.

Public Administration

Public Administration (PA) is done at the district level and at the *thana* level. Appointments and transfers are controlled by the Ministry of Establishment.

<u>District Administration</u>: The district is the major geo-administrative unit under the central government. Public administration is the responsibility of the Deputy Commissioner (DC) at the district level. The DC also coordinates inter-Ministry/agency affairs at the district level. The DC is the custodian of *khas* land within the district and is authorized to lease it out either temporarily or on a permanent basis. The DC is also authorized to acquire land for the purpose of development activities. Land acquisition is done through the Land Acquisition Officer (LAO), while *khas* land administration is done by the Additional Deputy Commissioner, Revenue (ADC Revenue).

Table 4.2: Institutions in the Socioeconomic Context

Sector	Ministry	Institution	Mandate
Government	Ministry of Fisheries and Livestock (MOF&L)	Department of Fisheries (DOF)	Fisheries extension
		Bangladesh Fisheries Research Institute (BFRI)	Fisheries research
		Bangladesh Fisheries Development Corporation (BFDC)	Fish marketing promotion
	Ministry of Local Government, Rural Development & Cooperatives (MLGRD&C)	Department of Public Health Engineering (DPHE)	Drinking water and sanitation
		Bangladesh Rural Development Board (BRDB)	Rural development
		Union Parishad	Local self-government
	Ministry of Establishment	Deputy Commissioner (DC)	District level public administration. Exercise land acquisition authority at District level
		Thana Nirbahi Officer (TNO)	*Thana* level public administration
		Upazila Parishad	Abolished in 1991, recommended for reinstatement to operate at the *thana* level
	Ministry of Agriculture (MOA)	Department of Agricultural Extension (DAE)	Agriculture extension
	Ministry of Shipping (MOS)	Bangladesh Inland Water Transport Authority (BIWTA)	Fees for vessel licensing, tariffs
	Ministry of Planning	Bangladesh Bureau of Statistics (BBS)	Census, demographic and socioeconomic survey
		Bangladesh Institute of Development Studies (BIDS)	Socioeconomic research consultancy
	NGO group		Village level social development self-help activities
NGOs/ grass-roots groups	Krishi Samabaya Samity (KSS)		Village level farmers' cooperative society
	Labor Contracting Society (LCS)		Earthwork on contractual basis
	Stakeholder Committee		Beneficiary mobilization for planning, construction and O&M activities
	Samaj		Informal village structure providing arbitration

Recently a Commission appointed by the government has recommended a four-tier local government structure. According to the recommendations of the Commission, public administration and development activities at the district level will be supervised by a District Council with an elected Chairman, while the DC will be the "executive officer" accountable to the Council. A structure of District Council was in existence in the country since the colonial period. The system is expected to be revived with more authority and responsibility in the hand of the Chairman and the Council.

Thana Administration: *Thana* is a subordinate geo-administrative unit under a district. Public administration is the responsibility of the Thana Nirbahi Officer (TNO) at the *thana* level. The TNO coordinates inter-Ministry/agency affairs at the *thana* level. *Khas* land administration is done through the Assistant Commissioner, Land (AC Land). The TNO reports to the DC.

Upazila Parishad: The *Upazila Parishad* functioned at the *thana* level throughout the 1980s. It was abolished in 1991, but in 1996 a government commission recommended the reinstatement of an Upazila Parishad at the *thana* level with an elected Chairman. It is likely to start functioning within a year or two.

Union Parishad

Union Parishad (UP) is the lowest-level local self-government council under the Ministry of LGRD&C. The UP is constituted with one Chairman and nine Members directly elected under the universal adult franchise. Its tenure is four years. UPs in a *thana* now report to the TNO. UPs play an important role in the management and maintenance of rural markets, roads and small water bodies.

Department of Agricultural Extension

The Department of Agricultural Extension (DAE) under the Ministry of Agriculture (MOA) is responsible for agriculture extension, under a Director General. It has district offices, each under a Deputy Director and *thana* offices, each under a Thana Agriculture Officer (TAO).

Bangladesh Bureau of Statistics

The Bangladesh Bureau of Statistics (BBS) is the agency of the Statistics Division of the Ministry of Planning responsible for the compilation and publication of Bangladesh statistical information. The BBS is in charge of conducting the national Population Census, Agricultural census, Census of manufacturing Industries, Census of Establishments and other national level surveys in the field of labor force, demographic situation, agriculture, household income and expenditure, health and nutrition, education and so forth. Selected social indicators and socioeconomic information relating to all sectors of national economy are also compiled and published.

The Secretary of the Statistics Division is concurrently the head of the BBS designated as the Director General. BBS has an office headed by a Regional Statistical Officer in every district and in every *thana*, headed by a Thana Statistical Officer.

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Bangladesh Institute of Development Studies
The Bangladesh Institute of Development Studies (BIDS) is an autonomous agency constituted by the Ministry of Planning, based in Dhaka and headed by a Director General. It does not have any field office. Its main activity is to undertake socioeconomic research. It provides research consultancy to the government and the private sector. It publishes a journal on theoretical economics and development.

Non Governmental Agencies
NGOs organize village based groups which are often federated at the union and *thana* levels. Among the NGOs and agencies of similar nature working in some parts of the KKRMP region are BRAC, Grameen Bank and CONCERN. NGOs mainly perform a promotional role, particularly awareness building, grass roots capacity development and group management. Some of them also provide services in selected fields like credit and vocational training.

Grass-roots Institutions
There are a host of formal and informal institutions and groups at the micro-level. Among these, some are sponsored by catalytic agencies such as farmers' cooperative societies sponsored by the BRDB and the different village groups sponsored by NGOs and other agencies. Other groups have evolved gradually through social processes and dynamics (eg. *samaj*). Following are some of those grass-root institutions:

Labor Contracting Societies (LCS): Earthworkers' groups usually lead by a *sardar* (group leader). Several women LCS worked in the Pilot Dredging Project. If formalized, the LCSs function as class D contractors.

Stakeholder's Groups: Forum of the project affected population. This may assume the form of a Platform Society at a disposal site for dredged materials or a Beneficiary Committee around a water management structure, such as, a regulator, a fishpass or a dyke. Within the framework of the Pilot Dredging Project, the stakeholders of Kakailseo and Gazaria formed village committees which were involved in planning, design, implementation and O&M of the homestead platforms.

Samaj: A traditional social institution at the village level that exerts significant influence over its members and regulates their social and economic life. There are traditional social institutions at the village level named as *samaj*. A *samaj* leader generally belongs to the social power structure with substantial kinship lineage and political following.

4.3 Institutions Directly Relevant to KKRMP

Table 4.3 shows the structure and location of existing institutions which are considered directly relevant to KKRMP. These include both biophysical and socioeconomic contexts. These institutions represent the existing institutional framework within which KKRMP would be implemented and managed.

4.4 Institutional Coordination Among the Biophysical and Socioeconomic Institutions

There are currently no specific institutions in Bangladesh with responsibility for managing water resources according to river or other basins as the Asian Development Bank (ADB) recommends in its Emerging Principles for Water Resources Management. Such management would span both biophysical and socioeconomic organizations. What coordination is done is primarily the responsibility of BWDB which is reported as having about 20,000 employees and a recurrent budget to support about half of them. It is currently undergoing considerable re-structuring to reduce costs and staff size and to contract more of its work out to the private sector. The MOWR has overall responsibilities for water resources development and management nationally, and this ministry would be appropriate for coordination within the Kalni-Kushiyara River Basin or other basins. The participation of MOE&F, with its responsibilities relevant to environmental impact assessment and planning, is also critical to any effort at coordinated cross-sectoral management. Divisional Commissioners and their Deputies at District level in the KKRMP area have some responsibilities relevant to such broad coordination and specifically they execute the authorities of the MOL for land acquisition in their Districts. The MOWR and MOS have joint responsibilities for negotiating international agreements with India and establishing appropriate local legislation associated with the use of the river by Indian vessels.

Table 4.3: Structure of Directly Relevant Institutions

Ministry/ sector	Institution	Mandate	Focal Point				
			National	District	*Thana*	Union	Village
Ministry of Water Resources		Water policy	Secretary				
	BWDB	Water Management	Chairman	SE (Circle), Executive Engineer (Division)	Sub-Divisional Engineer (Sub-division)		
Ministry of Shipping	BIWTA	Navigation	Chairman				
Ministry of LGRD&C	LGED	Rural physical infrastructure	Chief Engineer	Executive Engineer	Thana Engineer		
	DPHE	Drinking water and sanitation	Chief Engineer	District Public Health Engineer	Thana Public Health Engineer		
	Local Government Division	Local government	Secretary	Chairman, District Council (proposed)	Chairman, *Upazila* Council (proposed)	UP Chairman	
	BRDB	Rural development	Director General	Deputy Director	Rural Development Officer/ TCCA		KSS
Ministry of Fisheries and Livestock	DOF	Fisheries extension	Director General	District Fisheries officer	Thana Fisheries Officer		
Ministry of Environment and Forestry	DOE	Formulation and enforcement of environmental regulations	Director General				
Ministry of Planning	BBS	Census and survey	Director General	Regional Statistical Officer	Thana Statistical Officer		
Ministry of Establishment		Public administration	Secretary	Deputy Commissioner	*Thana Nirbahi* Officer	UP Chairman	
Ministry of Land		Land administration	Secretary	Deputy Commissioner	*Thana Nirbahi* Officer	UP Chairman	
Ministry of Agriculture	DAE	Agricultural Extension	Director General	District Agriculture Officer	Thana Agriculture Officer		
Non-Government Sector	Grass-roots groups/ informal institutions	Economic and social development					NGO LCS, stakeholder committee, samaj

5. RIVER MANAGEMENT PROBLEMS AND ISSUES

5.1 Background

This chapter describes the key problems and water management issues facing the project area. These issues have been identified by NERP in consultation with the people of the area. The Kalni-Kushiyara River system is the life-line of the people, the resource base for their livelihood and the vehicle of their survival. Agriculture, fisheries, transportation, and the region's environmental sustainability are all dependant on the hydrological and geomorphic characteristics of this system. At the same time, most of the problems faced by the people are inextricably linked to changes in the river's hydrologic regime. A substantial portion of the project area is subject to flooding and spills through breaches in the river banks, channel shifting, bank erosion, and sedimentation due to the recurring instability along the river. These events have reduced crop yields, caused loss of productive agricultural land and settlements, impaired navigation in the dry season and contributed to the loss of valuable fisheries habitat. Deteriorating production from all resources was impacted on the economic security and life quality of the river's people.

Flooding and sedimentation are natural processes in this region, and people have developed great skill in adapting to these processes. However, the river system has been de-stabilized as a result of past interference and upstream channel changes. To-date, water management and flood control initiatives have not addressed the underlying causes of these problems, and in some cases have probably worsened the situation in the region. People of the area find it increasingly difficult to cope with the river's deteriorating condition.

The following sections highlight the impacts of the river on people's lives. Past approaches to flood control and water management practices are then reviewed. Finally, conclusions are drawn on the key problems that have been identified. A set of photographs (Photos 1-8) has been included at the end of this chapter (Section 5.6) to help illustrate some of the critical issues that are discussed.

5.2 Impacts of the River on People Over the Year

The hydrological events occurring in each season shape the nature of people's lives. The people's settlements, their work and the day to day rhythm of their activities are centred around the river and the *haor*. The annual monsoon flood is the heart and pulse of the year's activities. The dominating nature of the monsoon can be appreciated by comparing the site conditions shown in Photo 3 (taken in September 1991) with those in Photo 4 (taken in April 1994). The region varies in nature from a vast shallow lake during the flood season to a fertile plain in the dry months. Table 5.1 summarizes the hydrological events and their significance to people's lives through the year.

5.2.1 Pre-monsoon Flood Season

Pre-monsoon floods are the major cause of damage to the *boro* rice crop, the principal food grain grown in the project area. Low yields and complete loss of the *boro* crop leads to unstable food production and causes economic insecurity for the people. Recurring pre-monsoon flood damage has accelerated the process of pauperization among farm families. This is depicted through a case study of Kuloncho village (Text Box).

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Table 5.1: Impacts of Hydrological Processes on Peoples Lives

	Season			
	Pre-monsoon	Monsoon	Post-Monsoon	Dry Season
Hydrological Processes	• flash-flooding • overbank spills • bank erosion • bank breaching	• deep flooding by backwater from Meghna River	• drainage from floodplain to river	• drought
Human Activities	• *boro* harvest • rice processing, sale & storage • platform flood protection • household flood preparation (fuel, food)	• people confined to high land • fishing • distress sales of livestock	• planting non-cereal crops • preparation of rice seed beds • fishing • repair of earthen platforms • sale of surplus crops • purchase of crop inputs	• plantation, weeding, irrigation of *boro* rice • harvest of non-cereal crops • fishing
Impact of river processes on Agriculture	• spills damage *boro* crop before harvest • overbank sand deposition reduces soil fertility	• *aus* and *aman* crops restricted to limited flood-free areas	• slower drainage delays planting *boro* crops	• surface irrigation supply dries up due to reduced storage capacity in *beels/ haors*
Impacts of river processes on Fishing	• spills and sediment deposition degrade habitat			• shallow depths restrict over-wintering ground
Impacts of river processes on Water Transport			• shoals restrict boat traffic	• shoals and shallow channel restricts boat traffic and increase cost of commodities
Impacts of river processes on Human Settlement	• economic loss of the year's main crop • economic loss of homestead land and buildings	• damage to homestead platform from from bank & wave erosion • damage to grain, fodder & livestock when platforms are overtopped	• increased risk for economic loss of the following year's *boro* crop	• traders incur business losses

5.2

The inundation is widespread as shown on Figures 2.26 to 2.28. Much of the pre-monsoon flood damage is caused by bank breaching along the outer bank in meander bends. The resulting spill channel or *dhala*, may damage crops and cultivated land, even though the water level in the river does not exceed the top of the river bank. The breaches scour large amounts of sediment from the floodplain and re-deposit the material in nearby *beels* and *haors*. These sediment "splays" can greatly accelerate overbank sedimentation and infill wetlands and permanent water-bodies. This reduces the amount of water available for surface irrigation and the availability of valuable aquatic habitat.

Channel shifting and bank erosion are mainly governed by flows in the pre-monsoon season. Bank erosion has destroyed several villages along the river and has turned many peasant families into day laborers. Field studies have documented many examples where people have had to move from one place to another as a result of bank erosion. Homestead erosion has created a large population of internal refugees in the area.

5.2.2 Monsoon Flood Season

During the monsoon, most of the project area is deeply flooded and people's living space is restricted to their homestead platform (*bhita*) and the higher natural levees (*kanda*) along the river (Photo 2). Movement to schools, markets and neighbouring platforms is hampered by flooded, low areas in the village. The homestead courtyard is congested with livestock, straw piles and often other families, who seek living space on a flood-secure platform. Inside the house, the family's living space is cramped with stored grain supplies and often poultry and animals. Earthen homestead platforms are usually not raised above extreme flood levels and up to 0.6 m of water may inundate the courtyard. If the flood water enters the house, the family may live for weeks on a raised bamboo platform (*macha*), sustained by dry food. When flood conditions become life-threatening, households will shift to higher spaces within the village. In addition to the severe dislocation of people's lives, monsoon floods cause economic hardship when livestock, fodder and stored grain supplies are lost or damaged and have to be disposed of fat distress sale prices.

Downstream of Ajmiriganj, village platforms, roads and embankments are subject to severe wave attack during the monsoon season. Damage to such infrastructure entails annual replacement or re-construction. The most exposed sites are located adjacent to major *haors*. Local people may not have sufficient resources to adequately maintain and protect their platforms in all years.

THE IMPOVERISHMENT OF KULONCHO

Kuloncho is situated about four kilometres off the right bank of the Kushiyara River near Raniganj. The farmers of Kuloncho have their cultivable land in Tangua Haor. Since 1971-72, their *boro* crops have been ruined by early flooding. The water of the Kushiyara River usually enters Tangua Haor through spills at Akkilshah Bazar and Uttar Shuriarpar. The people tried to prevent such overflow by constructing dykes at these locations. However, in some years the river spills have breached the dykes and destroyed the crops.

The land slopes downwards from the riverbanks towards the *haor*. The gradual erosion of riverbanks allows the river to move into progressively lower areas. For this reason, overbank spilling from any point over the right bank of the Kushiyara River enters Tangua Haor and adjoining areas, damaging *boro* crops.

Over the past eight years, farmers have suffered heavy economic losses as a result of frequent pre-monsoon floods. In 1991 and 1992, farmers partially harvested inundated crops. It was only in 1995 that they were able to take the entire *boro* harvest home. However, many farmers had not cultivated all their fields that year because crop loss in the preceding years had financially crippled them.

Crop loss in successive years has exacerbated the impoverishment of Kuloncho through loans, mortgages and the distress sale of land and livestock. Medium farmers have become poorer and small farmers became landless. Many owner-cultivators have had to resort to share-cropping on other's land. Landless households now depend on many sources of income, including wage labour and fishing in the *haor*.

As part of their survival strategy, families have had to sell their cattle, poultry, trees and even their boat, the only means of transport during the monsoon season. Ten years ago, there were only a few landless; now, as many as eighty Kuloncho families have become impoverished.

Gazaria's village platform was dramatically eroded in the monsoon flood of 1988. With crop loss and poor harvest over the following five years, Gazaria homesteaders lacked resources to provide traditional platform protection. Furthermore, traditional methods of wave protection may not be adequate to protect against a severe storm event. In a participatory rural appraisal (PRA) study conducted in 6 villages of the project area, Chandipur people recall the monsoon flood of 1974, when waves off the southwest *haor*, eroded their entire village. In August 1988, when high winds coincided with extremely high water levels, 35% of the villages of Shibpur and Srihail were eroded by 1.5 m waves.

5.2.3 Post-Monsoon Season

After October, water levels in the project area usually start to decrease, and the water drains from the floodplain back to the main river channels. The timing of this recession is very important, since it governs when *boro* rice cultivation can begin, provided temperatures have raised sufficiently. If drainage is delayed or obstructed, farmers can not transplant *boro* seedlings. The longer the delay in planting, the greater the risk of incurring damage from pre-monsoon floods before the next harvest.

Many of the long-term drainage patterns on the floodplain have been disrupted or blocked as a result of channel shifting or construction of closures across open channels. Consequently, much of the post-monsoon drainage is now forced through other channels such as the Darain River, and the Old Surma River which ultimately flows into the Baulai River system. As a result, problems of post-monsoon drainage congestion are perceived to have worsened over time.

5.2.4 Dry Season

Irrigation and Water Supplies
Surface water from *beels*, *haors* and the river are the main source of irrigation water supplies in the dry season. Overbank sedimentation has filled-in many of the *beels* and *haors* adjacent to the main channel. As a result, water for irrigation must be drawn from the main channel. This requires construction of long canals and additional pumping costs. Approximately 200 low lift pumps (LLPs) have been installed in the last two years along the river and about 20% of the LLPs must pump water along canals more than 2.5 km in length.

Constraints to Navigation
Shoals and shallow reaches restrict navigation between January and March, particularly in the 40 km reach between Kalma and Ajmiriganj. The available depths have decreased by over 2 m since 1963 in response to channel aggradation. As a result, portions of the main river such as the Dhaleswari reach between Kalma and Madna, do not even meet a Class III navigation standard (1.8 m least available depth). This effectively isolates some communities from normal river transport routes during the dry season. As a result, trading goods for such market towns as Adampur Bazar and Madna, must be off-loaded onto lighters or transported at higher costs by roads.

5.3 The Impact of Channel Instability

The problems associated with flooding and sedimentation have been exacerbated by recurring channel instability along the river. Table 5.2 summarizes the three main styles of channel instability that occur and their associated hydrological effects. Table 5.3 summarizes the resulting impacts on people's livelihood in the region. Channel avulsions (such as the shift from the Bibiyana River to Suriya *Khal*) produce the greatest impacts to flooding and sedimentation patterns and the greatest disruption to people's lives. Although these events occur infrequently, their effects can persist for many years. Furthermore, they accelerate other kinds of channel instability such as meander shifting and bank breaching.

Table 5.2: Types of Channel Instability on Kalni-Kushiyara River

Style of Channel Instability	Description	Physical Impacts	Hydrological Impacts
Avulsion	• Sudden channel shift resulting in abandonment of former channel and development of a new channel	• Channel widening and accelerated shifting along the new channel • Degradation along the new channel • Aggradation in lower reach • Former channel silts-in	• Pre-monsoon flood levels may be increased during the development of the new channel system • Post-monsoon drainage may be reduced due to disruption of the drainage system • Increased magnitude of flows along new channel system
Breach or *Dhala* Formation	• Breach at outside of bend causes spill channel to form	• Erosion along spill channel • Increased overbank sedimentation in adjacent *beels* and *haors*	• Increased pre-monsoon flood spills • Reduced post-monsoon drainage due to local siltation of drainage channels.
Meander Shift	• Progressive migration of meander pattern	• Bank erosion along concave (outer) bank, deposition along convex (inner) bank. May eventually lead to natural cutoff	•Usually minor

The following factors are believed to have contributed the most to de-stabilizing the Kalni River:

- the accidental diversion of the Bibiyana channel into Suriya khal by local authorities;
- construction of the closure across the Kalni River at Markuli, and
- the occurrence of an unusual number of large floods in the period between 1982 to 1993.

It is believed that the Suriya avulsion has had the largest single impact to the river system and has been the main cause of aggradation in the reach downstream of Ajmiriganj.

An impact of recent channel shifting is provided in the example at Shahebnagar. Shahebnagar is located on the left bank of the Kalni, across the river from Katkhal (Figure 2.22). The destruction of Shahebnagar's homestead and agricultural land was caused by the abandonment of a former main channel and the subsequent enlargement and shifting of a former *khal*. The people of Shahebnagar vividly remember the dramatic event of April 1994 when overnight erosion along the Kalni's right bank removed the last piece of land separating the Kalni and the Old Kalni Rivers. After this cutoff, the contiguous villages of Katkhal and Shahebnagar were separated, the homesteads of Taragazir Hati were submerged and Shahebnagar, as it was originally settled, was lost to the river.

Table 5.3: Impacts of Channel Instability

Style of Channel Instability	Impact on Agriculture	Impact on Human Settlements	Impact on Aquatic Habitat	Impact on Navigation
Avulsion	• Increased frequency of pre-monsoon flood damage along entire new channel system • Loss of cultivable land due to bank erosion • Delayed *boro* plantation due to post-monsoon drainage congestion	• Increased damage to homesteads along new channel route due to bank erosion and channel widening	• Major displacement and/or alteration to habitat characteristics along river • Former *duars* may be filled-in, new *duars* will be created in other locations	• Navigation routes disrupted in dry season during formation of new channel • Navigation routes along former main channel may be permanently obstructed
Breach	• Frequency of pre-monsoon flood damage increases in localized areas affected by spills • Reduced crop yields due to overbank sand deposition • Reduced irrigation water supply from *beels* due to over bank siltation	• Usually minor unless village is located along path of spill channel	• Overbank sedimentation causes infilling of *beels* and *haors* which are important habitat for many species of fish and wildlife	• Local sedimentation in *khals* blocks connector routes between main channel and floodplain areas
Meander Shift	• Loss of cultivable land due to bank erosion	• Erosion damage to villages and infrastructure	• Ongoing creation and destruction of habitat such as *duars* and *beels*	• Natural loop cuts may disrupt navigation routes

Over the forty year period of river devastation, 95% of Shahebnagar's 500 homesteads have been eroded at one time or another. For their survival, the people of Shahebnagar have developed patterns of seasonal labor migration and temporary homestead shifting. Landlessness has increased from 15 to 35% of households. Of the 200 Shahebnagar families eroded in 1994, half of them also lost their agricultural land. They now survive on wage labor, working as agriculture labor during the dry season, and migrating during the monsoon, to find work in Dhaka and Sylhet.

The cost of relocating homesteads has also contributed to the impoverishment of many Shahebnagar families. PRA field studies report that many households have re-settled and re-built as often as four times over the past 25 years. At an average cost of Tk 36,000 to raise low *haor* land and build a new homestead, even medium-sized farmers have become life time debtors to banks and money lenders. Those unable to construct a flood-secure homestead, live on their flat *haor* land during the farming season and shift to live temporarily on others' homesteads during the monsoon.

Over time, the river's shifts and erosion has affected the quality of land on the *haor*. In addition to the economic insecurity caused by erosion of homesteads and agricultural land, Shahebnagar farmers report loss of yield and high production costs for *boro* rice, cultivated on sandy lands.

Impact of Channel Changes on Flood Levels
The cumulative effect from past aggradation and channel changes has been to increase the magnitude and frequency of pre-monsoon flood levels between Sherpur and Madna. Measurements at Ajmiriganj show the pre-monsoon flood levels have risen by approximately 1.5 m over the last 20 years. Figure 2.16 illustrates that pre-monsoon floods at Sherpur and Markuli are approaching the levels that occur during the monsoon season.

An example of how local channel instability and sedimentation can affect pre-monsoon flood damage was documented in 1994. In that year, significant crop damage was experienced throughout the project area (Table 5.4 - The location of *thanas* is shown on Figure 5.1). Furthermore, the pre-monsoon flood level at Ajmiriganj was the second highest on record, reaching nearly the level of the 1991 flood. However, the actual pre-monsoon flood discharge (measured at Sherpur) had a return period of only about three years. Field observations showed that unusually high water level occurred after a channel shift below Katkhal produced a channel constriction, which raised the water levels upstream.

Table 5.4: Crop Damage by Early Floods in 1994

Thana	Union	Affected Area (%)
Jagannathpur	Pilegaon	50
	Raniganj	50
	Holdipir	80
Derai	Kuloncho	90
	Tarol	75
	Jagdol	60
	Rajnagar	50

5.4 Water Management

5.4.1 Past River Management Practice

To-date, the main priority of water management authorities has been to develop pre-monsoon flood protection schemes around individual *haors* on the floodplain. These *haor* development projects were constructed with the assumption that the areas could be treated in isolation from each other and from channel instability problems on the main river system. However, the recurring spills and breaches from the main river and the need for raising the submersible embankments to keep up with the constantly rising pre-monsoon flood levels shows the limitations of this approach. So far, responsible agencies such as BWDB or BIWTA have not had the resources to carry out systematic channel maintenance or stabilization measures on the main river. As a result, some of the works that have had the greatest impact to the river system were carried out by local groups with virtually no detailed engineering investigation or planning.

Works carried out in this manner included:

- construction of the Quesba pilot channel which triggered the Suriya avulsion;
- closure of the Kalni River channel at Markuli, and
- construction of loop cuts between Markuli and Ajmiriganj.

Although these works may have benefited some areas, they also produced substantial adverse impacts along other portions of the river system and have continued to affect the channel's overall stability to this day. They have certainly increased the need for maintenance work on the river and made it more difficult for local people to cope with the hydrological regime. There is no indication that the stability problems will fade away. In fact, there is strong evidence that the problems are continuing to propagate downstream along the river. Future work on the river needs to be planned to minimize adverse impacts and should include mitigation measures to compensate for any residual impacts. Furthermore, the work needs to be carefully coordinated so that the greatest overall benefits can be realized.

5.4.2 Institutional Structures

Existing Institutional Setting
One of the characteristics of the existing institutional setting related to the water resources projects is that the administration is highly centralized with most major decisions made in the capital city, Dhaka, resulting in limited coordination between line ministries at the local level. Moreover, there is no existing institution that can effectively coordinate the work of various ministries and local organizations involved in water management at a project level.

Operation and Maintenance
Another aspect which is to be considered in order to ensure the success of the water management project is an effective O&M. In Bangladesh, water management projects do not achieve their intended purpose because of lack of effective O&M. BWDB frequently cites inadequate O&M resources as the major constraint which prevents proper follow-ups once the project is completed. The funds allocated for O&M are mainly used to cover BWDB's establishment costs and only a small proportion is available to provide for operation and repair of completed projects.

Bangladesh Government desires that the beneficiaries at least should contribute to the O&M cost of the project. There is a general belief that one of the key requirements for achieving this objective is the increased beneficiary participation in project development and O&M activities (MOWR, 1994).

Community Management Capacity
Interests of many social groups lie with the management of water resources in the project area. As such, it is required to integrate them, especially the affected water resource user groups, in the project management so that the development does not sacrifice the interests of any of the groups.

Although they are not unlike other committees in rural Bangladesh, the village committees in Gazaria and Kakailseo (NERP Pilot Dredging Project) did not perform well in matters where they were required to serve civic interests beyond their own economic or political interests. Nevertheless in the future, a committee selected by the community will be necessary for the management of platforms.

The committee will only be functional when it can command support from the village's politically influential leadership.

Absence of NGOs in the Project Area
Water resource management in the 1990's requires a strong community development component, often lacking in traditional projects implemented from a purely technical perspective. Increasingly, NGOs are called upon to implement the soft components of such infrastructure projects. However, unlike most other areas of rural Bangladesh, there are no national NGOs actively serving communities in the remote project areas. The only NGO which has some presence on the right bank of the Kalni-Kushiyara River is CONCERN (Chapter 4). Although national NGOs like BRAC and Proshika worked in some *haor* communities in an earlier period, they left the project area in the late 1980's. NGOs with a credit program targeted to landless and small farmers find loan recovery difficult in a one-crop area, where the annual harvest is frequently lost to pre-monsoon flood. Improved water resource management in the project area will provide enhanced opportunities for people's socioeconomic development. During the course of implementing a future project, support should be provided to NGOs and government institutions who are willing to direct their development efforts to landless groups and targeted poverty alleviation programs.

The roles and weaknesses of existing institutions which have been identified to participate in the KKRMP are described in Table 5.5.

5.5 Land Acquisition

In the acquisition of land, a distinction is made between private land and *khas* land.

5.5.1 Private Land Acquisition

Based on the experience of other water management projects, land acquisition for construction of civil works is identified as one of the major constraints facing the KKRMP. In the project institutional setup Executive Engineers of BWDB Circles are required to process the land acquisition case through the Deputy Commissioner's Office for the approval of the Land Ministry. The GOB land acquisition process, as given in Table 5.6, shows that after submission of the land acquisition plan to the Deputy Commissioner's Office by the BWDB Executive Engineer, it takes some one and a half year to acquire the land.

5.5.2 Khas Land Acquisition

In the Pilot Dredging Project, NERP's experience was positive in obtaining private land for use as disposal sites on a temporary basis. Landowners readily understood the benefits of dedicating their land for its development as a flood-secure, homestead platform. However, the idea of obtaining a *khas* land site, suitable both for disposal of river spoil and as a village platform for landless people was abandoned as the land was occupied by local elites. Achieving the settlement of landless households on *khas* land will require the support of political leaders at all levels, as well as the government's national and regional executive bodies. Experience on other projects has also shown that issues related to land acquisition and compensation need careful forward planning in order to avoid delays. An effective institutional collaboration was reported on the Khulna-Jessore Drainage Improvement Project, where the Ministry of Land Administration was provided financial and equipment support to carry out ownership surveys, land acquisition and settlement.

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Table 5.5: Roles and Weaknesses of Institutions Relevant to Sustaining KKRMP Benefits

Agency, Institution, Organization	Mission, Mandate, Roles and Responsibilities	Weaknesses in Relation to KKRMP
Biophysical: Water Resources Development and Management		
MOWR-Ministry of Water Resources	Overall responsibility for water resources development and management in Bangladesh.	Weak co-ordination with other ministries & departments.
BWDB-Bangladesh Water Development Board	Key national agency in water sector. Semi-autonomous under the jurisdiction of the Ministry of Water Resources; planning, implementation, design, construction, maintenance of flood control, drainage and major irrigation works.	Cumbersome procedures. Weak user participation. Weak responsiveness to users. Start-up & implementation delays.
Land-Land and Water Use Directorate	Responsible for extension work related to BWDB projects.	Weak coordination with DAE.
MOS-Ministry of Shipping BIWTA-Bangladesh Inland Water Transport Authority (Autonomous national agency under MOS)	Responsible for development, maintenance and control of inland water transport and certain inland navigable waterways, river conservancy works, dissemination of navigational and meteorological information, maintaining pilotage and hydrographic survey service, channel maintenance, development and O&M of inland river ports and terminal facilities.	Weak implementation of procedures for collecting approved charges (tariffs etc.) from river traffic.
MOE&F-Ministry of Environment and Forest	Formulation and enforcement of environmental laws and regulations, training and environmental education, environmental planning management, and monitoring.	
DOE-Department of Environment	Environmental Impact Assessment; providing advice to line agencies on their activities affecting soil and water conservation, forests, wildlife and other natural resources.	Unable to carry out many of its responsibilities, due to insufficient institutional resources such as staff, equipment and so on.
The Ministry of LGRD&C LGED - Local Government Engineering Department	Responsible for rural physical infrastructure including construction and maintenance of growth centre connecting roads, development and maintenance of small-scale water management structures, provides technical support to district and *thana* level in design, construction, operation and maintenance of local civil infrastructure.	Weak mechanism for coordination with other Ministries and sector departments.
MOL-Ministry of Land Administration and Land Revenue	Owner of all *khas* land, responsible to manage and dispose of *khas* land as per the law. Acquires land needed in the construction of civil works.	Few staff and delays in land acquisition applications.

Agency, Institution, Organization	Mission, Mandate, Roles and Responsibilities	Weaknesses in Relation to KKRMP
Socioeconomic: Food and Agriculture		
MOF&L-Ministry of Fisheries and Livestock	Responsible for fisheries resources management, conservation, development, enforcement, statistics, quality control, extension and training for both inland and marine.	
DOF-Department of Fisheries		DOF suffers from short-comings in planning, project implementation, design of extension activities and inter-agency coordination. Absence of a clear mandate for the DOF results in "confusing and/or overlapping divisions of responsibility" between DOF and MOWR, MOL, FRI, BFDC and *thana* administration. Committed donor assistance cannot be fully utilized.
FRI-Fisheries Research Institute	Does research on aquaculture, riverine fisheries, marine fisheries and brackish-water fisheries.	There is a need for involvement of DOF in program prioritization of FRI research activities.
MOA-Ministry of Agriculture		
DAE-Department of Agricultural Extension	1982: Disseminates crop production information to farmers.	Extension service lacks links to other agencies involved in the sector; communications are poor especially in the northeast and hinder delivery of extension services to remote areas.

Agency, Institution, Organization	Mission, Mandate, Roles and Responsibilities	Weaknesses in Relation to KKRMP
Socioeconomic: Community Development		
Deputy Commissioner (under Ministry of Establishment)	Exercise land acquisition authorities at district level for development activities.	Delay in land acquisition process.
TNO- Thana Nirbahi Officer	Public administration at the *thana* level.	
UP-Union Parishad (lowest-level local self-government council under the Ministry of LGRD&C.	Play important role in the management and maintenance of roads, rural markets and small water bodies.	
Upazila Parishad	Not yet functional only recommended by a commission, set up by the government, to operate at the *thana* level.	
DPHE-Department of Public Health Engineering (A national agency within the Ministry of LGRD&C)	The key government agency in the field of drinking water and sanitation and is mainly responsible for installation and maintenance of rural potable water supply system based on a network of hand tube wells. It also provides extension service for installation of water seal latrines.	Lack of resources for expansion of programs.
NGOs	They follow a "target group approach", where the landless and women are the target audience. They are broadly grouped into 2 categories in terms of their activities: service delivery and catalytic. Social mobilization, rural development, capacity building and institutional development of the vulnerable groups, through the formation of village-based groups or cooperatives by the "conscientization process"; health and family planning services, particularly community health education; non-formal education, particularly for adults; rural credit; promotion of employment, in the field of livestock, poultry, fisheries, and sericulture; training for income generating activities.	There is very little NGO activity in the project area due to the difficult conditions. In particular there is no NGO active in micro-credit because re-payment of loan are unreliable.
Grass-roots Institutions:		
LCS- Landless Contracting Society	A group centred around a *Sadar*, involved in earthwork.	
Others	Traditional social institutions at the village level named as *samaj* who exerts influence over its members and regulates their social and economic life.	

Agency, Institution, Organization	Mission, Mandate, Roles and Responsibilities	Weaknesses in Relation to KKRMP
Socioeconomic: Census and Survey		
Ministry of Planning Bangladesh Bureau of Statistic	Responsible for Census surveys and publications, and statistics on Bangladesh.	Backlog of work, delays in publications.

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Table 5.6: GOB Land Acquisition Process

Stage	Schedule Time Frame (days)[1]		Time Taken in Practice (days)	
	Without Objection	With Objection	Without Objection	With Objection
1. Meeting, Scrutiny and Approval by District Land Acquisition Committee	30	30	60	60
2. Service of Notice under Clause 3 and Settlement of objection and submission to Land Ministry	15	30	30	60
3. Return to Deputy Commissioner after Approval by Land Ministry	30	90	90	120
4. Service of Notice by Deputy Commissioner Under Clause 6	15	30	30	60
5. Preparation of Estimate by Deputy Commissioner and forwarded to BWDB	7	7	30	60
6. Approval by BWDB Superintending Engineer and Placement of Fund under Clause 7(3)	60	60	60	60
7. Settlement of Land Compensation by Deputy Commissioner under Clause 10(2)	60	60	60	90
8. Transfer of Possession	30	30	45	45
TOTAL TIME	**247**	**337**	**405**	**555**

Note: 1. As per 1994 Land Acquisition Law
Source: Executive Engineer, BWDB Netrokona

5.6 Summary of Key Problems and Issues

The most important river management problems and issues that beset the project area are as follows:

- a substantial portion of the project area is subject to overbank spills, breaching and channel shifting, bank erosion and sediment deposition due to recurrent instability on the Kalni-Kushiyara River. The main cause of this instability can be traced to the Suriya avulsion which has caused aggradation in the reach between Ajmiriganj and Madna;

- the increasing frequency of pre-monsoon floods are the major cause of damage to the *boro* rice crop in the project area;

- flooding and erosion damage and subsequent diminished rice production cause significant economic loss for all sectors of rural communities. An enhanced process of pauperization has led to increasing landlessness and impoverishment;

- erosion damage to villages and infrastructure is caused by both bank erosion and wave attack. A portion of village people do not always have the resources to protect their villages against severe erosion. Also some villages are more exposed than others;

- sedimentation below Ajmiriganj adversely affects navigation in the dry season, and restricts water transport in the reach between Ajmiriganj and Madna;

- sedimentation and channel aggradation also adversely impact fisheries production through habitat alteration;

- so far, efforts to carry out effective channel maintenance and remedial works on the main channel have been minimal or counter-productive, and

- government and non-government institutions dealing with private land acquisition, *khas* land distribution, O&M, community-based platform management and socioeconomic development for landless households and poor women are either non-existent or not effective.

5.7 Project Photographs

The following pages present a set of photographs comparing the project conditions during the dry and monsoon seasons.

PHOTO 1 : **Confluence of Manu River and Kushiyara River in September 1991.**
Note : embankment breach near the bottom of the photo.

PHOTO 2 : **Deeply flooded area south-east of Ajmiriganj in September 1991.**

PHOTO 3 : **Kushiyara River near Markuli in September 1991.**
Note : high land along natural levees and deep flooding in adjacent basins.

PHOTO 4 : **Kushiyara River near Markuli in April 1994.**

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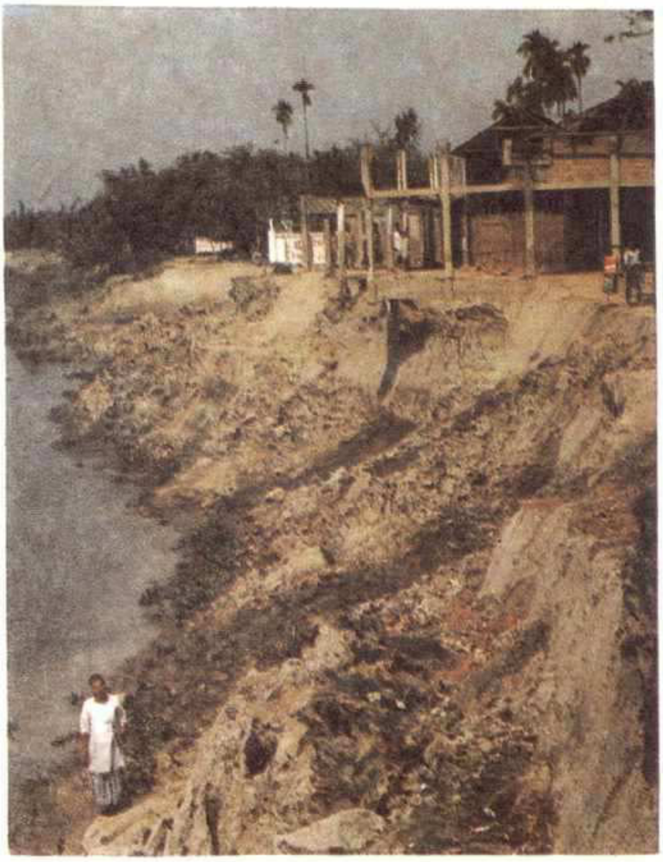

PHOTO 5 : **Bank erosion on right bank of Kushiyara River downstream of Sherpur.**

PHOTO 6 : **Slump failures in left bank near Markuli.**

PHOTO 7 : **Breach at the outside of a meander bend has formed a Dhala, allowing pre-monsoon floods to spill into cropped land.**

PHOTO 8 : **Cargo vessel trapped below Katkhal in June 1994 due to channel shifting and sedimentation.**

6. FUTURE WITHOUT PROJECT

6.1 Introduction

The purpose of this chapter is to characterize the future conditions in the project area, assuming no new interventions are carried out. This characterization is termed the "future without project" scenario, or FWO. The time frame considered in this analysis extends over a 30 year planning period to the year 2026.

6.1.1 Assumptions

In order to perform the analysis, certain assumptions were made regarding activities in and around the project area. It was assumed that present water management practices would continue in the project area, with the main focus on the maintenance of the existing submersible embankment projects. Other major initiatives in the project area were not considered. It was also assumed that the hydrological and sediment transport characteristics at the upstream boundary of the project area would remain approximately similar to the conditions that have existed over the last decade.

6.1.2 Tipaimukh Dam Project

The Project
A major water resources project has been proposed at Tipaimukh on the Barak River at its confluence with the Tuvai River, some 200 km upstream of the border between Bangladesh and India. The project is located at the tri-junction of the States of Manipur, Assam and Mizoram.

Tipaimukh is a multi-purpose project with a proposed hydropower plant of 1,500 MW capacity, to be realised in stages, together with an irrigation potential of 100,000 ha.

Security Status
Little information is available on Tipaimukh as both project report and data are "classified", ie. not available to the general public. To-date, information provided through the Joint River Commission on the proposed operating characteristics of Tipaimukh dam has been very limited.

Current Project Status
The following information is based on investigation results from a private sector firm in India. Studies were initially undertaken by the Central Water Commission (CWC) in the mid 1980s. These have been upgraded recently by the Brahmaputra Board. While the final report has been approved by CWC, clearances from the Ministry of Power and the Ministry of Environment and Forests in India are yet to be obtained. An Environmental Impact Assessment of the project is in progress, for which a provision of Rs. 5 million (Tk 5.5 million) was made during the year 1994-95.

The project also requires that no objections are raised from the States of Manipur and Mizoram, as areas of submergence are mostly in Manipur and partly in Mizoram. Although the project apparently has been recently supported by the Manipur government, the local population may still object to it.

The execution of the project is likely to require 10-12 years for the completion of the first phase of implementation.

Project Costs and Status of Financing
The initial project cost, at the end of the preliminary survey, was estimated at Rs 80 billion (Tk 88 billion). The estimated cost, in the final report, is of the order of Rs 150 billion (Tk 165 billion).

No funds have so far been committed to the project by the Government of India. Also, the project has not yet been proposed for bilateral or multilateral financing.

Project's Future
The future of the project is uncertain because:

- The government does not, at present, have access to financing for starting the project. Meanwhile, costs will increase further;
- There will likely be strong resistance to the project from the people of Manipur and Mizoram, who are not the major beneficiaries, but who will be the most affected as their land will be submerged;
- In view of possible major environmental impacts, clearance from the Ministry of Environment and Forests will be required prior to implementation, and
- There is currently a prevailing adverse public opinion against large dams.

Impact of Tipaimukh on KKRMP
A very preliminary assessment of the potential impact of Tipaimukh dam was previously provided by NERP (NERP, 1993a). The assessment showed that the dam could significantly alter the hydrologic regime of the Kalni-Kushiyara River, and could potentially produce both positive (reduced monsoon floods and reduced sediment inflows) and negative impacts (high post-monsoon flows). Considering all information available, it is assumed that the Tipaimukh dam will not be operational within the economic life of the project considered in this feasibility study. Moreover, there is a large drainage area between Tipaimukh and Amalshid, which receives one of the world's largest rainfall. There is a strong probability that the pre-monsoon flood affecting the project area are generated within this catchment. However, it would be necessary to obtain the daily flows at Tipaimukh in order to prove or disprove this hypothesis.

6.2 Socioeconomic Trends

6.2.1 Population

Population estimates for the future have been made on the basis of the projections used in World Bank literature. It has been assumed that the country will attain a Natural Rate of Reproduction (NRR) = 1 (no net increase in the number of women in reproductive age) by 2010. According to projections, the country will have an annual growth rate of 1.06% in 2025. Based on this assumption, the population adjusted for the project region will be 2.88 million in the year 2025 (Graph 6.1 and Table 6.1).

6.2.2 Urbanization

The urban population increased at an annual rate of over 5% during the inter-census period 1981-1991. An important feature of the 1980's was a heavy exodus of population from villages to *thana* headquarters largely due to the introduction of the *upazila* system. It is expected that this phenomenon will soon stabilize. The rate of urbanization in the project area will fall in a linear fashion, and will be 2% in the year 2025. However by 2025, the urban population will increase from the current (1995) figure of 0.19 million to 0.53 million. This means that the urban population will increase at an average annual rate of 3.6%, and the rural population at 1.1%, during the period up to 2025. In 2025, the urban population will be 18.4% of the total project population, compared to 8.9% in 1991 (Graph 6.1 and Table 6.1).

Graph 6.1: Population Growth of the Project Region

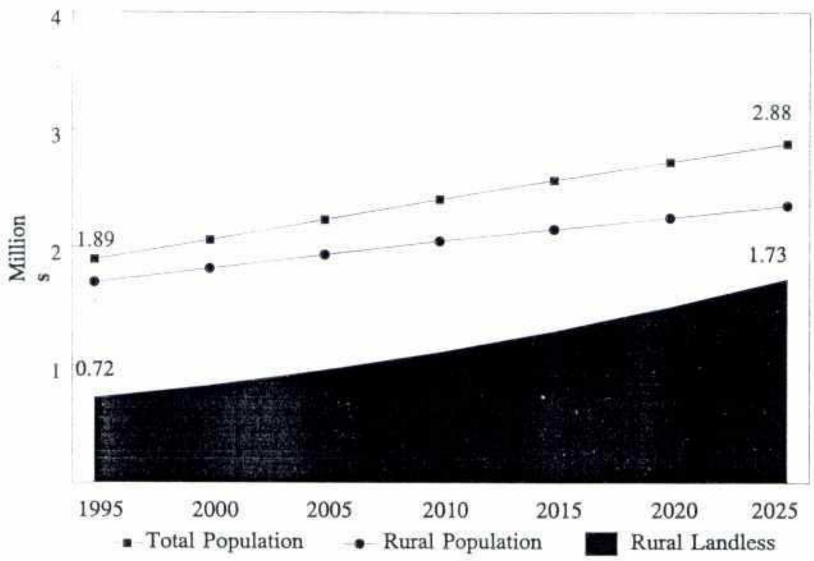

Table 6.1: Future Population

Year	Population ('000)				
	Total	Urban	Rural		
			Total	Landless	Farm
1995	1,894	193	1,701	725	976
2000	2,060	242	1,818	827	991
2005	2,234	297	1,937	958	978
2010	2,406	356	2,050	1,111	939
2015	2,568	416	2,151	1,288	863
2020	2,726	475	2,250	1,493	757
2025	2,882	530	2,352	1,731	621

6.2.3 Landlessness

According to the 1996 NERP household survey, the extent of rural landlessness is 43% in the project area. The landless population in Bangladesh increased annually at a rate of 1.5% during the period 1977-1991. Assuming that a similar rate of increase would be applicable to the region, the landless population will be 1.73 million in 2025. This will be 74% of the total rural population. On the other hand, the rural population will decline as a result of increasing urbanization.

6.2.4 The Demand for Jobs

Considering "working age" to be 15-64 years, the working population in the project area will increase by 0.54 million by 2025. To maintain the current level of employment, an additional 18,000 jobs every year will be required. Two-thirds of this labor force will be absorbed in the rural sector. This implies an average annual increase of job-seekers at a rate of 1.41%.

6.3 Future Evolution of the River

Given the history of channel instability over the last 30 years, it is difficult to accurately predict the future morphologic characteristics of the Kalni-Kushiyara River system. Avulsions and channel shifts are highly complex processes that may be triggered by chance events and are not entirely determined. Therefore, any forecast into the future will be somewhat speculative. Nevertheless, it was felt that a realistic scenario could be developed on the basis of the river's recent geomorphic evolution. The following comments summarize the main features of this assessment. Additional details of the analysis are contained in Annex A.

Figure 6.1 shows the general scenario that is expected to develop. Spills, river bank breaching and bank erosion will continue to occur between Sherpur and Ajmiriganj. However, the rate of bank erosion in this reach is expected to decline in comparison to the last 30 years. This is because most of the recent channel instability in this reach was related to channel adjustments following the Suriya avulsion and Markuli closure. It is expected the channel has reached its equilibrium width so that further channel widening will be minor. However, the meander pattern is still adjusting by eliminating short radius bends through natural loop cuts. This will cause some short-term bank erosion problems between Sherpur and Markuli which are described in Table 2.10 but should eventually lead to a more stable pattern.

Since 1993, the main instability on the river has occurred downstream of Ajmiriganj and it is expected that this situation will continue in the future. Cherapur Khal is enlarging rapidly and appears to be diverting a substantial amount of flow into the Baulai River system. A complete avulsion would result in the abandonment of the lower Kalni-Dhaleswari River and major erosion and sedimentation problems along the lower Baulai River. The magnitude of these impacts would be at least as large as the impacts resulting from the earlier Suriya avulsion. Based on a comparison of slopes along Cherapur Khal and the lower Kalni River, there is a significant risk of Cherapur Khal continuing to enlarge until it forms a major distributary channel. Empirical Regime equations suggests the top width of Cherapur Khal could reach up to 200 m (similar to the branch of the Kalni River that developed opposite Katkhal village in the early 1990's). Simulations with the MIKE-11 hydrodynamic model show the channel could eventually carry more than half of the incoming flows on the Kalni River during the dry season and pre-monsoon season. This development will produce significant channel adjustments on both the lower Baulai River and lower Kalni River systems.

Increased flows through Cherapur Khal will induce bank erosion and increase channel shifting along the 13.5 km length of the *khal*. Channel widening alone should produce bank erosion of approximately 280 ha and will add an additional sediment load of approximately 15 million tonnes to the Baulai River. Downstream of the diversion, Kalni River flows will be decreased substantially, particularly in the dry season and the pre-monsoon season (effectively the channel-forming flows on this river). The reduced discharges will result in partial infilling of the channel and a reduction of the channel cross section. Empirical Regime equations can be used as a guide for estimating the change in the channel geometry that will occur. However, more direct guidance can be provided from the observed channel changes that presently occur on the Kalni River immediately downstream of the Baida River bifurcation. At this point about 60% of the flow is carried by the Baida channel and about 40% continues down the Kalni branch. Surveys along this reach show the cross sectional area at bankfull stage decreases by around 450 m^2 (about 50%) below the bifurcation. On this basis it was estimated that the cross section of the Kalni River will be reduced by 400 m^2, downstream of Cherapur Khal. This corresponds to an increase in the average bed level of between 1.0-1.5 m. This would effectively cause the Dhaleswari branch between Issapur and Kalma to be abandoned in the dry season.

6.4 Hydrological Characteristics

The hydrological impacts of the morphologic changes were simulated using the MIKE-11 hydrodynamic model. This involved modifying the model's channel geometry to represent the estimated future conditions, then simulating annual hydrographs and comparing the predicted water levels and discharges with values that were computed for the present-day channel geometry. Results of the simulations showed the flow split into the Baulai River through Cherapur Khal will increase from around 20-30% at present to between 45-65% in the future during the dry season and pre-monsoon season. Table 6.2 shows the predicted water level changes for pre-monsoon floods along the Kalni-Kushiyara and Baulai Rivers.

Table 6.2: Increase in Pre-monsoon Water Levels

Station	1:2 year			1:5 year		
	Present (m PWD)	FWO (m PWD)	Diff. (m PWD)	Present (m PWD)	FWO (m PWD)	Diff. (m PWD)
Cherapur Khal	4.33	4.47	0.14	4.83	5.11	0.28
Madna	3.45	3.69	0.24	4.04	4.4	0.36
Baida Channel	3.73	3.89	0.16	4.31	4.66	0.35
Itna	3.70	3.91	0.21	4.63	4.82	0.19

Peak pre-monsoon water levels were estimated to increase by between 0.2-0.35 m in the lower Kalni River. Table 6.3 summarizes depth of gross inundation areas for various pre-monsoon flood conditions. The extent of pre-monsoon flooding is shown in Figures 6.2 to 6.4. It was found that about 99,734 ha (30% of the total project area) will be inundated by the 1:2 year flood during the pre-monsoon season. The gross inundated area will increase substantially for higher return periods, ranging from 239,385 ha (71%) for the 1:5 year flood, to about 294,714 ha (88%) for the 1:10 year flood. The increase in pre-monsoon gross inundated area under FWO scenario compared to the present conditions are 9% for the 1:2 year flood, 6% for the 1:5 year flood and 2% for the 1:10 year flood (Tables 2.12 and 6.3).

Table 6.4 summarizes the extent of inundation during the post-monsoon season (November-January) in the project area. For December, the analysis shows the gross inundated area will be increased by about 10,432 ha (44%) from its present level. Over 2,000 ha will remain under water after the date of last plantation (15 January). Late plantation makes the crop more vulnerable to accumulated rainfall inundation and subject to pre-monsoon floods.

Table 6.3: Pre-monsoon Gross Inundated Area Under FWO Conditions

Flood Return Period (year)	Non-Flooded (ha)	Gross Inundated Area (ha)					
	<0.3 m	0.3 to 0.9 m	0.9 to 1.8 m	>1.8 m	Total	% Total Area	Increase between Present and FWO (%)
1:2	235,867	53,352	37,251	9,130	99,733	30	9
1:5	96,215	69,793	113,863	55,729	239,385	71	6
1:10	40,886	44,430	121,482	128,802	294,714	88	2

Table 6.4: Comparison of Post-monsoon Gross Inundated Area

Month	Present (ha)	FWO (ha)	Additional Inundated Area (ha)	% Increase
November	81,974	102,863	20,889	25
December	23,847	34,279	10,432	44
January	8,621	11,070	2,449	2

Note: Month represents the last day of each month.

6.5 Water Resources Infrastructure

In the project area, there are six submersible embankment projects on the right side of the Kushiyara River providing pre-monsoon flood protection to a gross area of about 37,000 ha (Figure 2.1). In order to protect *boro* crops under the FWO scenario, it is anticipated that the embankments will have to be raised by approximately one metre. Based on 1995 prices, the total earthwork cost for raising the embankments is Tk 148 million. Moreover, this work will require the acquisition of an additional 150 ha land for the embankments, which would cost an additional Tk 27 million (assuming land costs of Tk 180,000/ha). The additional land will mostly be taken from existing cultivable areas.

The project area on the left side of the Kalni-Kushiyara River has a gross area of about 103,000 ha, of which only 13,563 ha is provided with pre-monsoon flood protection. Protection of *boro* crops in the remaining areas would require construction of submersible embankments in the central areas, and drainage cum regulating structures along the Kalni River downstream of Markuli. This would create a number of social problems, particularly for navigation and fish migration. These submersible embankments would also impede free flow during the pre-monsoon and post-monsoon seasons. The cost of constructing this additional flood protection has not been estimated at this time.

Pre-monsoon flood levels on the Baulai in the Itna-Sukdevpur reach were estimated to increase by approximately 20 cm as a result of the increased flow diversion through Cherapur Khal (Table 6.2). There are 17 submersible embankment projects on the right bank of Baulai River. At the very least, the embankments (totalling 650 km in length) would have to be raised to protect *boro* crop.

6.6 Agricultural Production in FWO Project

Cultivated Land

Present cultivated land will decrease by about 1% in the FWO scenario due to the development of infrastructure, expansion of homestead area and river bank erosion. The increase in volume of pre-monsoon floods would diminish the flood-free cultivated area and cause greater damage to winter crops in low-lying areas. Increased siltation in the Kalni-Kushiyara River, higher river levels and the closing of major channel outlets through sedimentation could further delay drainage of flood water, impede irrigation and increase loss of crop production.

Under the FWO scenario in the pre-monsoon season, the flood-free lands will be reduced by 13% for the 1:2 year flood, 27% for the 1:5 year flood, and 51% for the 1:10 year flood (Table 6.5). The increased inundation will mainly aggravate losses of *boro* crops and decrease rice production in the project area. The estimates presented in Table 6.5 are the result of the MIKE 11 hydrodynamic model.

Under the FWO scenario, an extra 10% of the Net Cultivated Area (NCA) will be inundated during the pre-monsoon season for the 1:2 year flood, 8% for the 1:5 year flood and 3% for the 1:10 year flood (Table 6.5).

Table 6.5: Inundated Cultivated Land Area (Present & FWO) During the Pre-Monsoon Season

Depth of Inundation (cm)	1:2 year		1:5 year		1:10 year	
	Present (ha)	FW0 (ha)	Present (ha)	FW0 (ha)	Present (ha)	FW0 (ha)
Flood-free	233,277	200,987	84,648	61,336	12,704	6,007
30-90	22,625	39,808	54,344	56,249	35,093	30,886
90-180	17,728	28,140	95,004	104,751	122,944	112,370
>180	6,220	8,010	45,854	54,609	109,109	127,682
TOTAL	**279,850**	**276,945**	**279,850**	**276,945**	**279,850**	**276,945**
Reduction in Flood-free Land (%)		13		27		51
Inundated area (%)	17	27	70	78	95	98

Crop Pattern and Area

The crops will continue to be grown mainly in the winter season. In the FWO scenario, the winter crops area will decrease from a present 86.3% to 85.6% of the NCA. The surface water irrigated area is expected to decrease due to siltation of permanent water bodies and river channels. About 97.7% of the winter crops will be irrigated compared to 98.1% at present.

There will be no significant changes in crop patterns in the FWO scenario. HYV *boro* rice area will continue to replace local *boro* in the future. However, the rate of replacement will be low compared to that in 1980s. The area irrigated by lifting water through traditional methods will decrease, and dependence on irrigation water from the perennial rivers will increase. The cropping intensity will increase slightly due to the cultivation of HYV *boro* after broadcast *aman* on lands raised by sediment deposition. The area of rainfed b.*aus* and t.*aman* will decrease due to the deposition of sediments, inadequate soil moisture and the increase in the extent of flooding.

There will be no significant changes in the area presently under non-rice crop. The area under wheat and pulse may increase due to unavailability of adequate irrigation water for potato cultivation. Similarly, vegetables and spices may replace HYV *boro* on lands where irrigation supply will not be adequate for *boro* production. Irregular deposition of sandy sediment will change the landscape, degrade the soil and diminish productivity in large areas. Non-rice crops will replace rice in these areas as sandy sediments will make the land unsuitable for rice cultivation.

Changes in Annual Food Production

Under the FWO scenario rice production will decrease as a result of the increase in inundated crop land and in crop losses during the pre-monsoon season (Table 6.6).

Table 6.6: Annual Crop Production, Present and FWO

Crop	1:2 year		1:5 year		1:10 year	
	Present ('000 tonnes)	FWO ('000 tonnes)	Present ('000 tonnes)	FWO ('000 tonnes)	Present ('000 tonnes)	FWO ('000 tonnes)
Rice Crop	1,052	995	823	782	713	697
Non-rice Crop	30	36	28	34	28	33
TOTAL CROPS	**1,082**	**1,031**	**951**	**816**	**741**	**730**

6.7 Navigation

In the FWO scenario, the Kalni-Kushiyara River system will experience two major hydromorphological changes (Sections 6.3 and 6.4). Firstly, the average bed level of the Kalni-Kushiyara River below Cherapur Khal (Dhakey-Kanchanpur Route) will increase by about 1-1.5 m. This would effectively cause the Dhaleswari River between Issapur to Kalma to be abandoned in the dry season. Secondly, Cherapur Khal will experience bank erosion and increased channel shifting along its 13.5 km length. This process will erode approximately 15 million tonnes of sediment and deposit it in the lower reaches of the Baulai River.

Because of these hydromorphological changes, water transportation will face setbacks during the post-monsoon season for a longer period, may be starting from November. The length of the critical dry period for navigation, which is currently February to March, may also increase to January to April.

Currently, the least available draught (LAD) is about 0.25 m at Issapur and falls below 0.75 m at many places (Khajirkhola, Adampur, Madna, Shambazar, Manumukh) during the dry period. Further deterioration indicates BIWTA services (launch) between Ajmiriganj and Bhairab Bazar which are still operational at present will be totally disrupted during the dry season. Moreover, medium and small size engine boats and non-mechanized country boats, may also disappear from the Kalni-Kushiyara River for a longer period (January-April) particularly from downstream of Cherapur Khal.

The cost of cargo and passenger transportation will increase considerably due to the need for frequent stoppage and transhipment due to inadequate draught. Moreover, in many places essential cargo items will have to take costlier, under-graded seasonal roads.

River communities between Cherapur Khal and Abdullahpur which presently represent about 295,000 passengers will be seriously affected based on NERP 1995 navigation survey (Table 6.7 the sum of Abdullahpur and Kadamchal). The cost of Petroleum, oil and lubricant (POL), fertilizer and seeds will also increase which in turn may have an adverse impact on *boro* production.

Table 6.7: Present Dry Season Traffic-Lower Reach

Station	Total Traffic	
	Cargo ('000 tonnes)	Passenger ('000)
Madna	0.8	70
Kadamchal	0.7	75
Adampur	7.3	326
Abdullahpur	5.2	220
Katkhal	2.4	268
Kakailseo	57.2	157
Ajmiriganj	39.9	1,655
Total	**113.5**	**2,771**

Source: NERP, 1995 Navigation Survey

Cherapur Khal (Dhakey-Kanchanpur route-Figure 3.3) will be perennial due to an increase in depth during the dry season. But the navigation distances will be increased by 12 km to Bhairab Bazar for the residents living upstream of Cherapur Khal. Based on NERP 1995 Navigation Survey, this will adversely impact over 2.08 million passengers in the river reach between Katkhal and Ajmiriganj (Table 6.7).

The bed level of the Baulai will be increased due to the deposition of 15 million tonnes of eroded materials. This might disrupt the Baulai navigation system during the dry season. As well, feeder rivers will also suffer loss of navigability as siltation will be enhanced at their confluences with the main river.

Forecasts on Freight Traffic
Table 6.8 shows that freight traffic in the project area will double in 2026 from its present level during the dry season (Annex G).

Table 6.8: Projected Dry Season Freight Traffic

Item	Present 1995 ('000 tonnes)	FWO 2026 ('000 tonnes)
Fertilizer Demand	22	48
Fertilizer Rehandled	2	5
Fertilizer Transit	28	28
Rice	30	46
Building Materials	73	208
POL-Urban	3	7
POL-Rural	7	17
Other Food Items	20	30
Consumer Goods	31	47
Internal Rehandled	13	26
Total	**227**	**462**

Source: NERP, 1995 Navigation Survey

Freight traffic has been analyzed based on the following assumptions:

- The total demand for building materials will continue to increase. It is assumed to increase by 3% over Years 2-10 and 4% over years 11-30;

- The demand for petroleum, oil and lubricant (POL) will increase 3% over Years 2-10 and 2% over Years 11-30 both for urban and rural populations, and

- The growth rate of consumer goods will be 2% during Years 1-10, 1.5% during years 11-20 and 1% during Years 21-30.

From the navigation FWO scenario, it can be inferred that the cost of living will increase significantly and the movement of people and freight will slow down to a minimum: a situation that is neither desirable nor acceptable. Moreover, people of the project area are already confined within their homesteads for three to five months a year during the monsoon season. Disruption of navigation will also confine them during the dry season.

6.8 Fisheries

6.8.1 Open Water Fisheries

Without project interventions, the structural quality of fish producing habitats, especially critical *beel* and *duar* habitats, is likely to continue declining (Table 6.9).

Table 6.9: Area and Fish Production by Habitat Type - FWO

Habitat Group	Habitat Type	Present Production (tonnes)	FWO Production (tonnes)	Reduction in Production (tonnes)
Riverine	Kalni-Kushiyara River (without *Duars*)	480	404	76
	Kalni-Kushiyara River (*Duars* only)	318	303	15
	Sub-total	798	707	91
	Other flowing rivers	848	848	0
	Closed and dead river	453	439	14
	Distributaries	152	147	5
	Sub-total Riverine	**2,251**	**2,141**	**110**
Floodplain	Floodplain	41,554	40,723	831
	Beels	6,711	5,684	1,027
	Ponds	4,036	3,834	202
	Sub-total Floodplain	**52,301**	**50,241**	**2,060**
	Total	**54,552**	**52,382**	**2,170**

Sedimentation of the Kalni-Kushiyara River channel will continue. This will result in decreasing channel depth, loss of *duars*, greater channel instability, more frequent avulsion events and disruption of migration routes (Sections 6.3 and 6.4). Distributaries are also likely to aggrade. This will decrease catches of riverine species. Shallow habitats during the dry season will accelerate fishing out of broodstock. The magnitudes of these impacts were analyzed on the basis of NERP fisheries studies and they are described below.

Kalni River Channel
Due to the ongoing process of siltation, the water surface area will be reduced by about 375 ha during the dry season. This will decrease fish production by about 76 tonnes from its present level based on current standing crop index. There are 6 *duars* in the Katkhal area (between Shantipur and Kadamchal, Annex H). Siltation of these *duars* will reduce fish production by about 15 tonnes on an area basis from its present level. The overall expected decrease is 91 tonnes.

Other Rivers
Observation of past fish production and field investigation suggest an annual decline of about 3% due to channel bed siltation. This corresponds to a reduction of about 19 tonnes from the present production level.

Floodplain
Floodplain inundation will increase during the pre-monsoon season due to frequent overbank spill and breaches in the river banks. It will increase fish catch in the floodplain during the pre-monsoon season. This is likely to be accompanied by a shift to more sedentary floodplain species. *Ilish*, *pangash* and some major carp species will possibly become extinct in the region (a trend that is already underway). However, the overall fish production in the floodplain will decrease by about 2% due to the decrease in overwintering ground (mainstream channel and *beel*) and broodstock. This corresponds to a reduction of 831 tonnes from the present level.

Beels and Haors
The rate of *beel* siltation will be increased due to frequent high velocity overbank spills and breaches. Estimated *beel* area loss over the next 30 years is approximately 1,095 ha (21.2%). This is equivalent to 642 tonnes of fish production on an area basis, and 1,027 tonnes if adjusted for the likely loss in maximum *beel* depth.

6.8.2 Closed Water Fisheries (Ponds)

The production rate from cultured ponds in the project area is low, about 1,635 kg/ha year. For culturable ponds in the area, the production rate is even lower. Lack of knowledge of culture techniques and unavailability of fry and fingerlings is reported to be the main reason for poor adoption of fish culture in the area. Under FWO scenario, the future evolution of the River (spills and breaches) will result in siltation of cultured ponds. The overall expected decrease in fish production from this siltation of ponds is 202 tonnes.

In summary, fish production will be reduced by 2,170 tonnes under the FWO scenario.

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7. PROJECT ALTERNATIVES

7.1 Project Formulation

7.1.1 Project Scope

The Kalni-Kushiyara River has experienced ongoing instability and sedimentation problems over the last 30 years which have led to increased pre-monsoon flood damage to *boro* rice cultivation, deteriorating river navigation and loss of productive agricultural land and human settlements. The process has intensified during this period while the population has doubled. The expected Future Without scenario (FWO) indicates the situation will continue to worsen over the next 30 years, particularly in the reach downstream of Ajmiriganj. Given the nature of the problems facing the region, the project has been formulated to meet multiple objectives, including:

- improving the river's stability and providing a more stable environment for development;
- reducing damage to agriculture by reducing pre-monsoon flood damage and improving post-monsoon drainage;
- improving living conditions along the river by reducing erosion damage to villages, and by creating new flood-free village platform, and
- improving navigation along the river during the dry season.

7.1.2 River Management Strategy

In order to meet all of the project's objectives, a coordinated river management strategy was developed. In this approach, river stabilization measures required for improving agricultural production, are also used to benefit navigation, fisheries and human settlements. The Pilot Dredging Project demonstrated that waste spoil from channel excavation work can be used as a valuable resource for constructing new flood-protected village platforms. At the same time, using the spoil to build new platforms provides an effective means of solving a difficult waste material disposal problem that is commonly associated with channel excavation work. However, the quantity of material produced by channel excavation must be carefully matched with the availability of suitable sites for constructing new platforms. Furthermore, the distance the spoil can be transported sets a major limitation on planning and design of new settlements. Therefore, careful coordination is needed between the designers of the channel improvements and the social development planners. This was accomplished through the use of a multi-disciplinary team, with the Community Organizers ensuring the concerns and opinions of the local communities were properly integrated into the planning process.

Because of stability and ecological problems that have arisen in many past flood control projects, any attempt to modify a natural channel to provide increased flood capacity needs careful assessment. The main aim in this project is to restore the present channel to a more stable configuration, rather than impose a new regime on a stable channel system. Therefore, guidance on the type of stable channel configuration that is required was provided from conditions that existed in the past prior to de-stabilization.

It was realized that problems arising from sedimentation and channel instability can seldom be permanently solved by a single capital works project alone. Although these initial measures may be required, it is vitally important to provide systematic monitoring and routine channel maintenance. This adaptive channel management approach provides an opportunity to monitor the river's response to past works, diagnose potential problems before major instability occurs and then carry out remedial works and maintenance in a manner that is compatible with the river's overall regime. In order to help implement this approach, the project has been sub-divided into two principal parts - an initial work programme that is designed to stabilize the channel and produce the key benefits from flood control and navigation and a long-term programme of river maintenance that is designed to ensure that the benefits can be sustained.

Experience from other major rivers has provided a number of important lessons on river management (Bayley, 1991). Some of the most relevant that have been applied to this project are highlighted below:

- *Basic Data* - is crucial to the ongoing design and operation of maintenance works as well as for assessing the human, economic and environmental costs of floods and the measures to manage them;

- *Comprehensive Planning* - avoids the inefficiencies of piecemeal approaches;

- *Pilot Projects* - allow the planners to test concepts and system components;

- *Flexibility* - planners and designers need to be willing to adapt rapidly to changing hydrologic, geomorphic, economic and social conditions;

- *Consensus* - must be obtained regarding the plan's approach and methods, and

- *Cooperation* - requires putting in place strong national and local institutions to develop, operate and maintain the system.

7.1.3 Methodology

The initial priority was to develop a workable plan to improve the river's overall stability, since the other project objectives can not be met without achieving a more stable channel configuration. Once a tentative set of works was developed, the additional requirements needed for flood control and navigation were defined. Finally, plans for providing new village platforms and for enhancing village development were developed.

Using industry standard mathematical hydraulic models, an iterative series of hydraulic design calculations were carried out to assess the effectiveness of the proposed engineering works. Preliminary calculations were made using the standard step backwater program "HEC-2" developed by the US Army Corps of Engineers. The main advantage of using this program is that it has features for representing channel improvements such as dredging, levees and flood control embankments. This allows many different in-channel concepts and alternatives to be quickly screened and evaluated. Following this initial analysis, the designs were represented in the MIKE-11 hydrodynamic model of the Northeast Region.

This model can simulate the complex interaction between the main Kalni-Kushiyara River and the surrounding network of channels and floodplain areas. As a result, the impacts of the project alternatives on the surrounding water levels can be assessed. Therefore, the hydrodynamic model was a key tool for evaluating the project's physical impacts and benefits.

7.2 Design Criteria

The following criteria were used for planning and design of the proposed interventions:

- Flood protection to agricultural crops: 1:5 year pre-monsoon flood;
- Flood protection to human settlements: 1:20 year monsoon flood;
- Design of protection against wave erosion: 1:20 year storm;
- Design of bank protection works: 1:20 year flood;
- Navigation channel improvements: BIWTA Class II (2.4 m minimum depth).

7.3 Engineering Components

General methods of channel modification that have been considered for stabilizing the channel and providing flood control benefits include embankments, channel re-alignment, channel enlargement and bank protection.

7.3.1 Embankments

So far, past flood control initiatives have focused on constructing submersible embankments around individual *haors*. The Systems Rehabilitation Project (SRP) prepared feasibility studies for upgrading these *haor* development schemes (SRP, 1992-94). The proposed programme involved raising the existing embankment heights by more than 1 m over a total embankment length of 160 km. Pre-feasibility level investigations were also carried out for two major new submersible embankment schemes in the region - the Surma-Baulai-Kushiyara Basin Project and the Kushiyara-Bijna Inter-Basin Project (NERP, 1993b). These projects were planned under the assumption that the main river system could be maintained in a relatively stable alignment and that the pre-monsoon flood levels do not continue to increase over time. It was also recognized that an increase in embankment heights of 1 m or more will result in embankment crest levels at or above the mean annual flood that occurs in the monsoon season. The result will be increasing confinement of both pre-monsoon and monsoon flood flows which could lead to higher flood levels along both the Kushiyara River and Surma River. Furthermore, increased flow confinement will also induce additional sedimentation problems downstream of the embankments, and could adversely affect post-monsoon drainage and induce other adverse environmental impacts, particularly to the fisheries. For these reasons, SRP recommended that rehabilitation and raising of the existing projects be deferred at this time.

A case can be made for constructing embankments in conjunction with other measures that increase the channel's flood capacity. For example, other measures may reduce flood levels but may still allow flooding along reaches where the bank levels are unusually low compared to adjacent ground. In these reaches low levees may be able to maintain a uniform bankfull flow condition along the river without seriously affecting the river's stability. This approach was adopted for the reach upstream of Ajmiriganj.

7.3.2 Bank Protection

Bank protection is used to protect channel banks and embankments against velocities and shear stresses that are too high for natural bank materials to withstand, or to arrest scour that may cause progressive bank failure due to geotechnical factors such as slumping and excess pore pressure. Bank protection is commonly used as a means for controlling meandering and preventing bank breaching. Methods of bank protection may be divided into continuous types such as revetments or intermittent types such as spurs. Revetments are usually constructed from stone or concrete blocks. Spurs may be constructed from loose materials such as stone, concrete blocks or gabions, or from piles using steel pipe, concrete or bamboo.

Short lengths of bank revetment at points of active river attack are not usually effective in the long-term since the attack usually shifts to other points and outflanks the protection. Consequently, in meandering streams, bank protection usually has to extend along the entire outer bank of the meander bend. Due to the high cost of stone for revetment construction, it was realized that providing bank protection to all sites that are threatened by river erosion could not be justified. As a result, bank protection was considered only for sites where erosion was contributing to widespread flood damages through breaching and spills.

7.3.3 Channel Re-alignment

Re-alignment of meandering streams has been widely used in the past to increase hydraulic capacity and to reduce loss of land from bank erosion. This re-alignment usually involves eliminating selected meander bends by excavating loop cuts. The increased capacity results from increased slope, bed lowering due to degradation and from reduced eddy losses (US Army Corps of Engineers, 1994). In environments with relatively stable meanders, flat gradients, and erosion-resistant banks, channels may be re-aligned without serious consequences. In environments where the banks are predominately sand, slopes are steep and sediment loads are high, straightening meandering streams has led to serious problems of channel degradation and bank erosion. Based on morphologic studies and observation of past channel changes, the Kalni River has a sufficiently flat gradient and relatively erosion resistant bank material so that individual loop cuts can be constructed without seriously de-stabilizing the channel.

Three loop cuts were constructed on the river upstream of Ajmiriganj in 1978. Observations of the channel's response showed the new channels developed slowly and did not produce serious instability problems along the river. This experience provides a good indication that constructing additional loop cuts downstream of Ajmiriganj will not produce major undesirable or unforseen impacts. In fact, the main lesson from this earlier work is that the river adjusts very slowly to the newly constructed channel. The earlier cuts were made by excavating a small pilot channel, then closing the old channel and diverting the flow into the new one. The pilot channel enlarged over a period of 10 to 15 years before it reached its full section. This caused a local flow constriction as well as local erosion problems upstream and downstream of the cut. Therefore, at the loop cuts proposed in this project, it is planned to excavate the new channels to their full "regime" cross section in order to eliminate the formation of a temporary constriction.

The bottom graph of Figure 7.1 illustrates the idealized channel adjustments that occur after a loop cut on the Kalni River downstream of Ajmiriganj. This simulation was produced using a one-dimensional morphologic model (HEC-6) and is intended to provide a generalized indication of the channel changes that can be anticipated. The simulated bed levels shows a transient wave of degradation heads upstream from the cut and temporary aggradation occurs downstream of it. Over a period of a few years, the downstream bed levels return to their pre-project condition, while the upstream bed levels are permanently reduced by an amount equal to $(L_0 - L_f)*S_f$, where L_0 and L_f are the initial and final channel lengths and S_f is the uniform slope that develops after the channel adjusts to the loop cut. Given the flat slopes that exist on the river, the risk of experiencing excessive degradation is very small unless the channel is shortened tremendously by complete re-alignment of the channel pattern. For example, the steepest slopes in the reach between Madna and Ajmiriganj typically average around 0.00006 or only 6 cm/km. Shortening the river by 10 km will produce a long-term profile adjustment of around 0.6 m upstream of the cut. Therefore, water level lowering due to degradation from loop cuts on the Kalni River is expected to be relatively small.

7.3.4 Channel Enlargement

Channel enlargement or excavation has often been advocated in Bangladesh as a means of increasing the hydraulic capacity of various small streams, canals and *khals*. However, to our knowledge, it has never been attempted on a major waterway. Channel enlargement can be achieved by deepening the channel's bottom, increasing the bottom width, flattening the side slopes, side berm excavation or a combination of these methods. The two main potential problems with channel excavation are related to sediment deposition and bank instability. If the channel carries substantial sediment loads and if the cross section provided to meet flood control requirements is much greater than its natural "regime" dimensions, then the section may infill with sediment deposits in a relatively short time period. Consequently, the flood capacity may not be achieved without ongoing maintenance excavation. The top graph of Figure 7.1 illustrates the idealized pattern of infilling in an excavated trench on the river. It can be seen that the trench behaves like a sediment trap, with deposition occurring at the head of the excavation and temporary degradation occurring downstream of it. Therefore, it is important to ensure that the modified channel is capable of properly conveying the post-project sediment loads that will be imposed on the river. A secondary problem is that if depths are increased appreciably, then adjacent river banks may experience erosion due to undercutting.

Figure 2.21 shows the river bed profile that existed along the Kalni River in the early 1960's. Figure 2.18 shows the present-day bed profile. The past aggradation has occurred in the form of a 50 km long sediment wedge, reaching up to 5 m near Ajmiriganj and decreasing with distance downstream to virtually zero near the junction of the Baida-Dhaleswari Rivers. Upstream of Ajmiriganj, the bed levels drop appreciably, with depths in the dry season typically reaching 8 m or more. Therefore, the main scope for channel excavation lies in the 30 km reach downstream of Ajmiriganj. Based on the bed profile shown on Figure 2.18, potential locations for channel excavation are the reaches between Kakailseo - Rahala, between Kadamchal and Abdullahpur and in the Dhaleswari channel below Madna. Excavation would be carried out by suction cutter dredgers, with the spoil pumped into permanent disposal chambers on the floodplain.

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Significantly increasing the channel's discharge capacity by excavation alone would require major excavation work and is deemed too costly. For example, at present, the cross sectional area at bankfull stage typically ranges between 1,000 m^2 to 1,500 m^2 near Ajmiriganj and the bankfull discharge capacity is around 1,600 m^3/s. Excavating a 100 m wide portion of the channel to a depth of 3 m below the existing grade would increase the cross sectional area by 25% to 33% (1,300 m^2 to 1,800 m^2), with the bankfull capacity possibly increasing to around 2,000 m^3/s. This would require an excavation volume of 300,000 m^3/km of channel or roughly Tk 25 million/km of channel (assuming dredging costs of Tk 82/m^3).

7.4 Development Alternatives

The 1993 pre-feasibility study proposed a combination of loop cuts (near Issapur and Katkhal), bank protection and channel excavation to develop a more stable channel configuration and to achieve the required flood control benefits. This basic approach was adopted for the feasibility investigation. However, as more field information was gathered about river processes, flooding mechanisms and navigation problems, a number of modifications were made to the original concept. In particular, a combination of bank protection works at major spills and low levees were proposed for reducing the pre-monsoon flooding and erosion problems upstream of Ajmiriganj. Also, the additional channel excavation requirements to improve navigation were defined.

The pre-feasibility study included a new loop cut near Issapur to shorten the river by about 16.5 km (Figure 7.3). The main purpose of this new channel was (1) to reduce upstream water levels, (2) to promote a more self-scouring channel upstream of the cut and (3) to reduce sediment deposition in the lower Dhaleswari branch, particularly around the junction of the Ratna and Khowai River. During the early stages of the feasibility study, concerns were raised that the loop cut could adversely impact local communities whose cultivable land lay along the route of the new channel. As a result, an assessment was made to determine whether the Issapur loop cut could be eliminated and the same benefits could be achieved by additional channel excavation along the Dhaleswari River channel. Consequently, two alternatives were considered:

Alternative 1: construct loop cuts at Katkhal and Issapur, along with other necessary channel excavation and bank stabilization works upstream of Kalma;

Alternative 2: construct only the Katkhal loop cut, along with other channel excavation and bank stabilization works in order to provide equivalent flood control benefits as Alternative 1.

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7.5 Alternative 1

7.5.1 River Stabilization and Flood Control Works

Figures 7.2, 7.4 and 7.9 show the location and extent of the river stabilization and flood control works that are proposed. The main works include (1) excavating portions of the channel between Ajmiriganj and Madna, (2) providing bank protection works at localized areas upstream of Ajmiriganj to reduce damaging spills, (3) constructing low levees on the floodplain at local low banks to help contain pre-monsoon spills, (4) constructing loop cuts near Katkhal and Issapur to provide a more stable alignment, increase the river's self-scouring capacity and to help reduce water levels. Table 7.1 summarizes the primary river stabilization and flood control works proposed in Alternative 1. The following comments briefly describe the main works, proceeding in an upstream direction along the river. Additional detailed description of the civil works are provided in Annex C - Engineering.

Issapur Loop Cut

This re-alignment involves making a 2.75 km long excavation from Kalma in Dhaleswari River to Issapur in the Kalni River, which will reduce the river's length by 16.5 km. After the new channel is opened, a closure will be constructed across the old channel entrance near Issapur. This closure will effectively block sediment laden water from the Kalni River from depositing material in the branch of the Dhaleswari channel between Madna and Kalma. The lower end of the Dhaleswari channel (from Madna to Kalma) will be excavated to ensure drainage from the Ratna/Khowai River system is improved. Design parameters of the new channel are summarized in Table 7.2.

The channel will be provided with embankments set-back a minimum distance of 100 m from the new channel's banks. The crest elevation of the embankments was determined by the 1:20 year monsoon flood level, with an allowance of 0.90 m for freeboard. The purpose of these embankments is to guide flood flows along the desired alignment in order to reduce the chance of future channel migration. The embankments will not be "tied-in" to high ground, so that during the monsoon season, flows will continue to be carried on the floodplain on both sides of the structures. Therefore, they will not confine monsoon season flood flows and should not raise water levels. The embankments will be protected with concrete blocks to protect against wave erosion and scour in the monsoon season. A typical cross-section of Issapur Loopcut is shown in Figure 7.5.

The loop cut will require 4.12 million m^3 of excavation, of which about 3.1 million m^3 is to be made using hydraulic dredges. Suction cutter dredgers will be used for the excavation, with spoil pumped into permanent disposal chambers on the floodplain (Figure 7.7). About 1 million m^3 of material will be excavated manually and will be used for the construction of the embankments cum confinement dykes and the closure dam. The embankments have a total length of about 5 km and require about 0.67 million m^3 of material. An additional 30,000 m^3 will be used for constructing the closure dam. The remaining volume will be used for infilling the two confinement chambers (for later use as village platforms) along the river side (Figure 7.6).

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Table 7.1: Primary Flood Control and Channel Stabilization Works - Alternative 1

Kilometre	Name	Proposed Works	Purpose	Other Beneficiaries
53-72.5	Issapur loop cut	• Shorten river by 16.5 km by excavating a new channel from Kalma to Issapur • Close entrance to old Kalni channel • Excavate Dhaleswari channel from Madna to Kalma	• Reduce sediment deposition in Dhaleswari channel • Improve drainage in lower Ratna/Khowai system • Reduce pre-monsoon flood damage by lowering water levels and making the channel more self-scouring	• Navigation • Community development
72.5-83.0	Issapur-Kadamchal excavation	• Dredge Kalni River channel	• Restore channel capacity to reduce pre-monsoon flood damage • Reduce risk of avulsion at Cherapur Khal	• Navigation • Community development • Fisheries
83.5-85.5	Kadamchal re-alignment	• Excavate accretion on right floodplain	• Re-align bend to reduce bank erosion near Kadamchal • Remove local constriction caused by floodplain accretion	• Community development • Fisheries
86.5-96.5	Katkhal loop cut	• Shorten river by 5.5 km by excavating a new channel from Bishorikona to Shantipur	• Stabilize the river and prevent avulsion through Cherapur Khal • Lower pre-monsoon flood damage by lowering upstream water levels and making the channel more self-scouring	• Navigation • Community development
96.5-107.0	Ajmiriganj excavation	• Dredge Kalni River	• Restore channel capacity to reduce pre-monsoon flood damage	• Navigation • Community development • Fisheries
114.0-114.5	Pituakandi revetment	• Construct bank protection	• Prevent bank breaching and pre-monsoon flood spills • Stabilize meander bend	• Fisheries • Existing project
114.5-115.5	Koyer Dhala revetment	• Construct bank protection and regulator	• Prevent bank breaching and pre-monsoon flood spills • Stabilize meander bend • Restore irrigation water supply and boat access	• Fisheries • Settlement
125.0-142.0	Intermittent levees	• Construct low levees along low sections of banks	• Prevent pre-monsoon flood spills	• Fisheries • Settlement
138.5-139.5	Akkilshah revetment	• Construct bank protection	• Prevent bank breaching and pre-monsoon flood spills • Stabilize meander bend, reduce erosion damage	• Fisheries • Settlement • Existing projects

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Table 7.2: Channel Properties at Loop Cuts - Alternative 1

Loop Cut	Base Width (m)	Bottom Elevation (m PWD)	Side Slope	Ground Elevation (m PWD)
Issapur	230	-3	1V:3H	2.5-4.5
Katkhal	230	-2.5	1V:3H	3.0-3.5

The Issapur loop cut will require acquiring 216 ha of land for constructing the new channel and disposal of the spoil at new village platforms. Field surveys by Community Organizers verified that no villages lie in the path of the proposed excavation. However, the new channel would cause a loss of cultivable land to some land-owners and would divide some existing land-holdings. Subsequently, detailed field studies were carried out by the Community Organizers and Social Development Team to define the compensation programme that would have to be provided to the people impacted by the proposed works. A description of this compensation package is contained in Chapter 9.

The Dhaleswari channel will be excavated from the mouth of the Ratna/Khowai Rivers (Km 64) down to Shibpur (Km 56) near the junction with the new loop cut channel to improve drainage at the outlet of the Khowai/Ratna River systems. This will also provide a minimum Class II (2.4 m deep) navigation channel, which will allow water transport up to Adampur in the dry season. The excavation will be carried out by dredging a 50 m wide channel to El. -1.5 m PWD. Approximately 740,000 m^3 of material will be excavated and the spoil will be used to infill a low-lying floodplain area opposite Madna and to construct two village platforms at Shibpur (Sites 3-5; Figure 7.6).

Initially, there was concern that serious deposition problems could develop over time near the junction of the Ratna/Khowai Rivers just upstream of Madna. Subsequent geomorphic studies show the Khowai River deposits most of its sediment load on the broad, low-lying floodplain just below Habiganj (25 km upstream of the Kalni junction) when it spills overbank. Therefore, very little additional sedimentation is expected at the mouth of these tributaries. However, an allowance has been made for periodic maintenance dredging in the Dhaleswari channel. The two most likely reaches requiring maintenance dredging are (1) downstream of the Ratna/Khowai junction and (2) near Kalma where the new channel joins with the Dhaleswari River.

Channel Excavation-Issapur to Kadamchal

Design parameters for the main channel excavation work are as follows:

- bottom width varies from 75-100 m, and
- design grade varies, from El. -3 m near Issapur to El. -2.5 near Kadamchal.

The volume of excavation, excluding any work associated with the construction of loop cuts is summarized in Table 7.3. The total volume of material that needs to be removed from the channel from Kadamchal to Issapur amounts to 4.2 million m^3. However, it is expected that degradation will occur once the loop cuts are opened up; this could reduce the need for excavation by around 1.4 million m^3 (Table 7.3, marked phase 2). Therefore, it is proposed to excavate 2.8 million m^3 of material during the initial project construction phase, and then monitor the response of the bed to the loop cuts and other works. Depending on the channel's response, additional excavation would be carried out to achieve the final design grade.

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In order to provide a conservative estimate of project costs, it has been assumed that all of the bed lowering will have to be accomplished by dredging and that any contribution from degradation will be negligible.

Suction cutter dredgers will be used for the excavation, with the spoil pumped into permanent disposal chambers on the floodplain (Figure 7.7). The size of the chambers has been designed so they will retain at least 95% of the pumped sediment. This method of handling dredge spoil disposal is very protective of the environment. After dredging is completed, most of the disposal chambers will be converted into new village platforms to benefit the local communities.

Table 7.3: Summary of Channel Excavation and Associated Village Platforms - Alternative 1

Location	Reach (km)	Phase	Grade Level (m PWD)	Excavated Volume ('000 m^3)	Village Platform Statistics		
					Total Platforms	Disp. Sites	Area (ha)
Issapur	72.7-76.5	2	-3.0	1,370	8	6-13	28.0
	76.6-79.0	1	-3.0	710	4	14-17	16.0
Abdullahpur	79.0-81.0	1	-3.0	951	4	18-21	24.8
Kalimpur	81.0-83.0	1	-3.0	764	2	22-23	18.1
Kadamchal	84.5-86.5	1	-2.5	426	1	26	9.5
Rahala	97.5-98.8	2	-2	670	2	38-39	18.6
Kakailseo	98.8-102.3	1	-2.0	543	2	40-41	6.4
Shahanagar	102.3-104.5	1	-2.0	572	3	42-44	13.0
Ajmiriganj	104.5-107.0	1	-2.0	448	3	45-47	9.8
Total				**6,454**	**29**		**144.2**

Kadamchal Re-alignment

A channel constriction has developed in the large meander bend downstream of Katkhal (Km 84) as a result of land accretion along the right bank in the point bar opposite Kadamchal (Figures 7.8 and 7.14). This accretion has reduced the width of the river from typically 250 m to only about 100 m which causes higher upstream water levels. This accretion has also deflected the river towards the left bank, causing bank erosion between Anwarpur (Km 82) and Kadamchal (Km 85). The proposed work involves removing part of the accreted land along the right bank to eliminate the constriction. In the long-term, it would be useful to construct two or three spurs on the left bank near Anwarpur to deflect the flow towards the right side of the channel. These structures would permanently alter the river's alignment and would reduce the requirements for ongoing maintenance excavation along the right bank. Pilot studies on the Brahmaputra River using permeable structures such as concrete or steel piles have shown considerable promise, but involve very high costs. Since the re-alignment is only a short distance downstream of the Katkhal loop cut, it is anticipated that some channel shifting will occur in this reach during the first years after the new channel is opened. Therefore, it was decided that installation of these structures should be deferred to a later date when the upstream adjustments from the loop cut have slowed. At this point only requirements for channel excavation have been included. This work would involve manual excavation of 140,000 m^3 in the dry and dredging approximately 300,000 m^3. The material will be used to raise the existing ground on the right bank and for constructing platforms (Sites 24 and 25; Figure 7.14).

Katkhal Loop Cut
Figures 7.4, 7.15 and 7.16 show the layout of Katkhal loop cut. The loop cut is intended to stabilize the channel near Shantipur and will prevent a major flow avulsion into the Baulai River through Cherapur Khal. The loop cut will also shorten the channel length by around 5.5 km through the reach, which will reduce water levels in the pre-monsoon, post-monsoon and dry season.

Temporary emergency works will be constructed in the first year of the project to slow down further channel widening at the entrance to the *khal*. This will involve constructing a series of bamboo structures ("retards" or "porcupines") on both sides of the *khal* to induce slower velocities along the base of the bank and to promote deposition in the *khal*.

The loop cut channel has 3 main components. Proceeding from upstream to downstream, these include:

- Shantipur-Katkhal Section: A gently curved 1,465 m long new channel, having a radius of curvature of 2,943 m and an average top width (W) of around 280 m;

- Kaisar Section: A 1,420 m long channel that transitions from the bend into a straight alignment. This part of the loop cut follows an existing channel, and

- Shahebnagar Section: A 1,200 m long new channel that follows a straight alignment until meeting the present channel near Bishorikona.

Table 7.2 summarizes the design parameters for the new channel. Bank protection (stone revetment with launching apron) will be constructed along 1,050 m of the right bank of the new channel to prevent future channel shifting.

A closure will be constructed across the present channel that leads directly from Katkhal towards Cherapur Khal. This will effectively shift the entrance to the *khal* approximately 4 km downstream from its present location (Figure 7.15) near the village of Bishorikona. The *khal* will remain open through the channel leading to Nayakurar Kandi village, so it will still be accessible to navigation and will provide some post-monsoon drainage relief. Permanent bank protection will be constructed at the new entrance to ensure the inlet remains stable.

The channel will be provided with guide bunds set-back at least 100 m from the new channel bank to prevent spills from causing bank erosion which could eventually cause the new channel to be out flanked. However, since the structures are not tied-in to high ground, they will not confine the flood flows and should not raise water levels in the monsoon season. The embankments will be protected with concrete blocks to protect against wave erosion in the monsoon season.

Constructing the new channel will require excavating approximately 4.4 million m^3 of material, of which about 3.22 million m^3 will be made by hydraulic dredges. About 1.25 million m^3 of earth will be excavated manually and the spoil will be used for the construction of guide embankments, two closure dams and one village platform. The total length of guide embankments is about 8.1 km and requires about 1.13 million m^3 of earth work including 0.28 million m^3 for the two closure dams. Approximately 195 ha of land will be required for constructing the Katkhal loop cut and its ancillary works. Eleven village platforms (Sites 27 to 37) will be developed from the dredged spoil (Figures 7.4, 7.15 and 7.16).

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Channel Excavation - Rahala to Ajmiriganj

Table 7.3 summarizes the channel excavation volumes and grade levels in this reach upstream of the Katkhal loop cut. The total volume amounts to 2.23 million m^3 from which 10 disposal sites will be developed (Sites 38 to 47) sites as shown on Figures 7.17 and 7.18. It is expected that some channel degradation will occur upstream of the loop cut after the new channel is opened, which could reduce the amount of dredging that is required. Therefore, it has been planned to dredge only about half of this volume in the first phase, and then monitor the channel's response for a period to assess whether the additional excavation is required.

Bank Protection at Spill Channels

Figure 7.9 shows the location of bank protection works. It is proposed to construct bank protection works at three major bank breaches (*dhalas*) to arrest further bank erosion and to control future pre-monsoon spills:

- Koyer Dhala (Km 114.5-115.5) (Figure 7.10);
- Pituakandi revetment (Km 114.0-114.5) (Figure 7.10), and
- Akkilshah revetment (Km 138.5-138.9) (Figure 7.11).

Provision has been made for a regulator/fishpass at Koyer Dhala so that the protection will not obstruct irrigation water supplies, navigation or fisheries. Given the deep scour that occurs at these sites and high costs of piles for permeable groins, it was decided to use conventional rip rap revetments for the bank protection works. Since these sites are not deeply flooded, they will not be subject to severe wave erosion. The height of the protection will extend only up to the average top of bank level, so that it will be submerged throughout most of the monsoon season. Therefore, monsoon flood levels should not be impacted from the work.

Requirements for bank stabilization against river attack include (1) providing adequate stone size in the revetment to resist the shear stresses from the river currents during extreme floods, (2) providing sufficient stone volume in the revetment toe to provide a suitable launching apron that will prevent undermining of the slope by scour and (3) providing adequate slope preparation and grading to ensure the revetment will not be subject to geotechnical failures from sloughing or rotational slumping.

Prior to carrying out the bank protection design a review was made on the performance of existing bank protection along the Kushiyara River, from Amalshid to Sherpur. This involved undertaking field inspections (accompanied by BWDB engineers) and monitoring scour and erosion processes by carrying out repeat cross section surveys before and after floods. This monitoring included surveys of recently constructed protection at Amalshid and Zakiganj during and after the major flood of 1993. Methods for estimating the stone size and scour depth were tested against actual field measurements. Results of these studies are included in Annex C-Engineering. On the basis of these observations, it was concluded that the design chart developed by C. R. Neill (1973) and the methods for constructing bank protection outlined in BWDB (1993) could be used for the proposed works.

A single size gradation and specification was adopted for the river bank protection:

- Gradation:
  254-305 mm 60% by weight
  153-254 mm 40% by weight
- Nominal thickness: 600 mm
- Side slope: 1V:2H

This specification is similar to the bank protection constructed near Zakiganj. Estimates of scour depths were based on direct field surveys of deep scour in bends (Annex M - Project Maps and Engineering Drawings), scour calculations using Blench's method and results of studies of bend scour by Thorne et al (1986). The volume of stone in the apron was estimated so that sufficient material was available to launch down to the anticipated scour level. This estimated volume was then increased by 50% to account for potential losses and re-distribution during launching.

Levees
Figure 7.9 shows the extent of levees along the main channel. Low levees will be required in localized reaches between Raniganj Bazar and Ajmiriganj to ensure the pre-monsoon flood flows can be confined with an adequate degree of security. In this reach, flood flows spill over local low portions of the banks even though the channel's average bankfull capacity has not been exceeded. It will be more practical and less expensive to construct levees to provide a uniform bankfull level along the reach, rather than lowering the flood level by further channel excavation.

The levees can be less than one metre in height and will be able to confine a 1:5 year pre-monsoon flood with 0.3 m of freeboard. The levees will be set-back from the main channel by at least 100 m.

Regulators and Fishpass
Figures 7.9 and 7.16 show the location of the two regulating structures that will be constructed. A drainage cum flushing pipe sluice will be installed at Barabaria Khal to drain accumulated water from local depressions blocked by the Katkhal embankments. The structure will also facilitate irrigation water supplies to this area during the dry season.

A multi-purpose regulator will be installed at Koyer Dhala in order to divert some Kalni River flow to the left bank for most of the year. The structure includes three main components:

- flushing cum drainage;
- fishpass, and
- navigation pass.

The structure will facilitate irrigation water supplies to the existing projects and post-monsoon drainage from the adjacent floodplain, fish migration to Kodalia fisheries and floodplain and will reopen traditional navigation route from Kalni to Habiganj. Design details are presented in Annex C - Engineering.

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7.5.2 Navigation Channel Improvements

The channel stabilization and flood control works also effectively improve the navigation channel to at least a Class II standard up to Ajmiriganj. However, the main water transportation routes on the Kalni-Kushiyara system extend up to Fenchuganj, 60 km upstream of Ajmiriganj. Therefore, in order to significantly improve navigation, additional dredging will be required upstream of Ajmiriganj. Based on the present channel topography, navigation dredging will be required at five locations between Ajmiriganj and Fenchuganj in order to achieve a Class II channel (Figure 7.9). These sites are located at local shoals that develop in straight reaches between major bends, primarily between Manumukh (near the mouth of the Manu River) and Fenchuganj. Although the total excavation required is relatively small (164,000 m^3), it is anticipated that the shoals will re-form after each monsoon, so that dredging will be required annually.

Five disposal sites (Sites 49 to 52) have been identified for the navigation dredging. Land at four sites has already been acquired by BIWTA, so that only land at the Galimpur site (Site 50) needs to be acquired by the project. A provision for acquisition of 3 ha land for navigation dredging has been made in the capital cost.

Table 7.4: Summary of Navigation Dredging and Disposal Sites - Alternative 1

Location	Reach (km)	Excavated Volume ('000 m^3)	Disposal Site Statistics	
			Number	Area (ha)
Nawanagar	107.5 - 110.8	31	48	3.6
Manumukh	182	19	49	8.6
Galimpur	188	9	50	3.0
Omarpur	202	59	51	3.0
Fenchuganj	215-216	46	52	4.0

7.5.3 Village Platforms

Spoil from the proposed channel excavation work can be used as a beneficial resource for constructing new village platforms or raising existing flood-prone ground. Figures 7.7 and 7.12 illustrate the general concept involved in constructing a new platform. Based on initial planning and analysis, up to 52 platforms can be constructed during the implementation period of the Kalni-Kushiyara River Management Project (Tables 7.4 and 7.5). Thirteen platforms will be developed from the construction of the two loop cuts and 39 platforms will be constructed from excavation of the Kalni and Dhaleswari Rivers. Figures 7.6 and 7.13 to 7.18 show the tentative location of these platforms. All of the sites are located within 1.5 km of proposed channel excavation work, in order to avoid the higher cost of using booster pumps with the dredgers. Out of 52 disposal sites, 44 sites will be used for constructing homestead platforms. The Issapur platforms (Sites 1 and 2) have been identified for multi-purpose use, while the Site 5 near Madna will be used for raising flood-prone land in order to grow non-cereal crops. The 5 navigation dredging disposal chamber, (Sites 48-52) will be used for annual disposal operations until they are eventually filled, at which point they could be used for other purposes.

The homestead platforms generally range between 2 to 7 ha in size and have a total area of about 247 ha (165 ha from channel excavation and 82 ha from constructing loop cuts). In most situations, the land for the platforms will be dedicated by the villagers and returned to them after the construction is completed. Therefore, land acquisition will not be required in these circumstances. At Sites 6 to 17 and Site 39, the land ownership is believed to be mostly *khas* land and is not yet inhabited. However, a provision was made in the cost estimate to acquire this land and use it for settling landless families. About 1,250 households could be settled on these sites.

Table 7.5: Summary of Kalma-Ajmiriganj Disposal Sites - Alternative 1

Physical Components	Total Platforms	Disposal Site Ref. Number	Platform Use
Issapur Loopcut	2	1-2	multi-purpose
Dhaleswari Channel Excavation	3	3-4	extension of existing village platforms
		5	non-cereal crops
Channel Excavation Issapur-Ajmiriganj	29	6-17	new homestead platforms
		18-23, 26, 38 & 40-47	extension of existing village platforms
		39	new homestead platforms
Kadamchal Channel Re-alignment	2	24-25	extension of existing village platforms
Katkhal Loopcut	11	27-37	extension of existing village platforms
Total	**47**	• **new homestead platforms = 13** • **extension of existing village platforms = 31** • **various use = 3**	

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Table 7.6 summarizes the main civil works that are required at each village platform. A detailed description of each component is provided in Annex C - Engineering. The following comments highlight the most critical issues that affect the design of the works.

Table 7.6: Civil Works Associated With Village Platform Construction

Number	Component	Function	Comments
1	Confinement Dyke	• Provides settling basin for pumped dredged spoil	• Will be re-graded following the monsoon season to provide permanent platform slope
2	Effluent Outlet Structure	• Maintains adequate ponding level in settling basin during pumping • Prevents erosion by return effluent	• Only required during platform filling
3	Effluent Outlet Channel	• Prevents dredge effluent return flows damaging adjacent crops and land	• Will be filled-in after platform filling is completed
4	Platform Top Grading	• Final levelling and grading of platform after filling completed	• Will be done in association with post-monsoon repairs of confinement dykes
5	Platform Drainage	• Safe disposal of rain and prevention of slope erosion	• Temporary drainage provision will be made in the first year. Permanent structure will be installed in Year 2.
6	Platform Protection	• Prevents platform erosion from waves and river erosion	• Combination of "hard" and "soft" protection has been proposed, depending on exposure
7	Platform Access	• Prevents slope damage from people and livestock	• Permanent access facilities will be installed in Year 2.
8	Green Manuring	• Improves structure and productivity of dredge spoil to enhance cultivation on the platforms	• Combination of short and long-term programs has been proposed. This includes top-soil, plantation of quick growing plants and research.

Confinement Dykes

Confinement dykes are earthen embankments enclosing the disposal chamber area. They must be designed to withstand the combined soil and water pressure from the dredged fill during the dry season and to remain stable during the monsoon season when the exterior slope is saturated.

The height of the confinement dykes may vary from 4.0 m to 7.0 m. Based on experience with the pilot project and additional slope stability analysis, 2 design cross sections were adopted for the platforms (Table 7.7).

Table 7.7: Adopted Dyke Cross Section

Dyke Height (m)	Crest Width (m)	Exterior Slope	Interior Slope
Less than 5.0 m	3.00	1V:2.5H	1V:1.5H
Greater than 5.0 m	4.27	1V:3H	1V:2H

Platform Construction Level

The village platforms were designed on the basis of providing protection up to a 1:20 year annual flood, with a freeboard allowance for wave runup and an additional allowance for settlement. In the absence of specific design criteria for homestead platforms, a freeboard allowance of 0.90 m has been adopted. The long-term settlement was estimated to be 5% of the depth of the fill material. An example of the required platform elevation is presented below:

- flood elevation: 7.77 m PWD (1:20 year annual maximum flood);
- freeboard: 0.90 m;
- flood construction level: 7.77+0.90 = 8.67 m PWD;
- average ground elevation: 3.00 m PWD;
- depth of fill: 8.67-3.00 = 5.67 m;
- allowance for settlement: 0.28 m;
- required platform top elevation= 8.67 + 0.28 = 8.95 m PWD.

It is proposed that a 0.15 to 0.40 m thick layer of topsoil be placed over the dredged fill to complete the platform for habitation. Therefore, in this case, the top elevation of the dredged fill could be set at El. 8.80 to 8.55 m.

Wave Protection Requirements

During the initial planning studies, an effort was made to locate the new platforms in areas that were at low risk from severe wave action or overbank flood spills. However, given the limited distance that the dredged can be pumped, the range for site selection is relatively restricted. Experience from the pilot project and other field studies clearly demonstrated that platforms must be adequately protected against wave erosion and river currents or they will suffer ongoing erosion damage. The greatest risk of erosion damage occurs at sites directly adjacent to the deeply flooded *haors*. In these areas, the wave height will be governed mainly by the size of the *haor* (which determines the fetch), the water level at the time of the storm and the wind speed and direction. Table 7.8 summarizes the estimated stable block size needed to resist wave erosion during a 1:20 year storm event. These calculations show that the size of slope protection increases very rapidly once the fetch exceeds about 2 km. Consequently, slope protection requirements were divided into 2 categories: "soft protection" at sites exposed to low erosion hazard (typically sites on relatively high ground, at areas sheltered by other highlands or areas with limited fetches) and "hard protection" at sites exposed to higher wave conditions.

Table 7.8: Wave Protection Requirements - 1:20 Year Storm

Fetch Length (km)	Stable Block Size (kg)		
	Depth = 2 m	Depth = 3 m	Depth = 4 m
2	5	9	9
5	15	24	24
10	19	36	52
20	24	52	71

"Soft" protection will utilize traditional methods of homestead protection in the *haor* areas and involves the use of a bamboo frame (locally called *aar bandh)* with *chailla* (*Hemarthria protensa*) grass and *tarja* applied to the outside slope of the dyke. The bamboo frame and *chailla* grass must be replaced each year. Trees, shrubs and grasses, planted near the toe of the dyke serve as long-term protection to reduce the effect of wave erosion.

"Hard" protection will consist of concrete blocks (nominal weight 150 kg) placed on the dyke slope over a filter layer. A brick cutoff wall will be constructed to provide toe protection against scour. A typical design of the platform slope protection is shown in Figure 7.19. The block protection will be constructed in the second dry season, after the dyke fill material has attained sufficient degree of settlement. Temporary "soft" protection will be installed in the first year.

Platform Preparation Prior to Habitation

Once the disposal chambers are filled, a number of additional works are required before the structures can be used as village platforms. These components include top grading of the dredge fill, provision of permanent drainage structures and platform access facilities, and improvement of the spoil's soil structure. The permanent drains will be installed at the time of constructing the concrete block slope protection by constructing 0.3 m x 0.3 m gutters with sealed joints. Permanent steps or ramps will be provided to reduce damage from pedestrians and livestock climbing the earthen slopes and to provide landing/*ghats* for boats during the monsoon. "Green manuring" involves improving the soil structure and productivity of the dredge spoil by the production of biomass on the platform by quick growing plants (African *dhaincha*, or possibly straw and water hyacinth).

7.6 Alternative 2

River Stabilization and Flood Control Works

Figure 7.20 shows the general arrangement of works in Alternative 2. With this alternative, the Issapur loop cut is eliminated and in its place, additional channel excavation would be carried out along the Kalni River and Dhaleswari River. All other elements of Alternative 2 are similar to Alternative 1. Based on a review of the hydrographic survey data, additional channel excavation will be required on three main reaches:

- Km 55-59 on Dhaleswari River near Shibpur;
- Km 61-65 on Dhaleswari River near Madna, and
- Km 67-71 on Kalni River near Islampur.

In Alternative 1, it was proposed to defer channel excavation upstream of Issapur between Km 72.5 to Km 77. This was done to allow upstream degradation from the Issapur loop cut to partially lower the bed levels and reduce the excavation volumes that are required to achieve the design grade. In Alternative 2, the reach between Km 72.5 to 77 will have to be dredged in order to achieve the required design grade.

Hydraulic analysis demonstrated that it would not be practical to achieve the same degree of channel improvements as Alternative 1 with Alternative 2. Additional dredging downstream of the Baida-Kalni bifurcation simply caused more flow to be diverted from the Baida channel back into the Kalni-Dhaleswari channel, which maintained the high water levels near Madna. In order to achieve approximately similar water levels at Issapur during a 1:2 year pre-monsoon flood, at least 9 million m^3 of material would have to be removed from the Dhaleswari channel, which would lower the bed levels by around 5 m. It was judged this magnitude of over-dredging would require excessive maintenance dredging in order to sustain the increased conveyance. Therefore, it was decided to excavate the channel only to the typical bed level that existed in this reach during the 1960's prior to sediment infilling. This also ensured that a Class II navigation channel would be maintained in this reach during the dry season.

Table 7.9 summarizes the main components of Alternative 2. All improvements upstream of Issapur are identical to Alternative 1. Therefore, this section highlights the main differences between the two alternatives downstream of Issapur. Figure 7.20 and Table 7.10 summarize the location and extent of the channel excavation work and the disposal sites. Alternative 2 will require an additional 1.0 million m^3 of channel excavation along the lower Kalni-Dhaleswari River between Kalma and Issapur.

Figures 7.20 and 7.21 show tentative locations for new village platforms associated with excavating the reach between Kalma and Islampur. With this alternative, six additional platforms will be constructed. Of these, one platform will be constructed near Shibpur (Site 3), and remaining five platforms will be constructed between Madna and Islampur (Sites 5 to 9; Figure 7.21). These new village platforms will cover an additional area of about 19.0 ha.

7.7 Schedule

7.7.1 Alternative 1

An itemized implementation schedule is shown in Figure 7.22. A minimum of 7 years are required for the pre-construction and construction of the main physical works. In the project area, the construction season coincides with the dry season, which begins in November-December. Hence, it is proposed to start the construction time from October, not the calendar year.

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Table 7.9: Primary Flood Control and Channel Stabilization Works - Alternative 2

Kilometre	Name	Proposed Works	Purpose	Other Beneficiaries
55.0-72.0	Dhaleswari-Kalni excavation	Dredge channel	• Improve drainage in lower Ratna/Khowai system • Reduce pre-monsoon flood damage	• Navigation • Community development
72.5-83.0	Issapur-Kadamchal excavation	Dredge Kalni River channel	• Restore channel capacity to reduce pre-monsoon flood damage • Lower risk of avulsion at Cherapur Khal	• Navigation • Community development • Fisheries
83.5-85.5	Kadamchal re-alignment	Excavate accretion on right floodplain	• Re-align bend to reduce bank erosion near Kadamchal • Remove local constriction caused by floodplain accretion	• Community development • Fisheries
86.5-96.5	Katkhal loop cut	Excavate a new channel from Bishorikona to Shantipur	• Stabilize river and prevent avulsion through Cherapur Khal • Lower pre-monsoon flood levels at Ajmiriganj by shortening river's length 5.5 km to increase the slope and make the channel more self-scouring	• Navigation • Community development
96.5-107.0	Ajmiriganj excavation	Dredge Kalni River	• Restore channel capacity to reduce pre-monsoon flood damage	• Navigation • Community development • Fisheries
114.0-114.5	Pituakandi revetment	Construct bank protection	• Prevent bank breaching and pre-monsoon flood spills • Stabilize meander bend	• Fisheries • Existing projects • Settlement
114.5-115.5	Koyer Dhala revetment	Construct bank protection and regulator	• Prevent bank breaching and pre-monsoon flood spills • Stabilize meander bend • Restore irrigation water supply and boat access	• Fisheries
125.0-142.0	Intermittent levees	Construct low levees along low sections of banks	• Prevent pre-monsoon flood spills	• Fisheries • Settlement
138.5-139.5	Akkilshah revetment	Construct bank protection	• Prevent bank breaching and pre-monsoon flood spills • Stabilize meander bend	• Fisheries • Settlement • Existing projects

Table 7.10: Summary of Channel Excavation and Village Platforms - Alternative 2

Location	Reach (km)	Grade Level (m PWD)	Excavated Volume ('000 m^3)	Village Platform Statistics		
				Total Platforms	Disposal Sites	Area (ha)
Shibpur	55-59	-3.0	650	3	1-3	15.2
Madna	61-65	-3.0	700	3	4-7	8.3
Islampur	67-71	-3.0	300	2	8-9	7.1
Issapur	72.7-76.5	-3.0	1,370	8	6-13*	28.0
	76.6-79.0	-3.0	710	4	14-17	16.0
Abdullahpur	79.0-81.0	-3.0	951	4	18-21	24.8
Kalimpur	81.0-83.0	-3.0	764	2	22-23	18.1
Kadamchal	84.5-86.5	-2.5	426	1	26	9.5
Rahala	97.5-98.8	-2.0	670	2	38-39	18.6
Kakailseo	98.8-102.3	-2.0	543	2	40-41	6.4
Shahanagar	102.3-104.5	-2.0	572	3	42-44	13.0
Ajmiriganj	104.5-107.0	-2.0	448	3	45-47	9.3
Total			**8,104**	**34**		**174.3**

Note: * indicates the nos. from Alternative 1.

Pre-Construction

Two years have been assigned for completing the main pre-construction activities, which include:

- institutional development (which will continue throughout the project implementation period);
- survey and investigation;
- detailed design;
- preparation of tender documents;
- preparation of implementation plan;
- invitation and award of tender;
- land acquisition, and
- mobilization.

Cadastral surveys for land acquisition and topographic surveys for planning, design and quantity estimates should be completed in the first dry season of Year 1. Efforts should be made to complete the hydrographic survey of at least the river reach from Markuli to Astagram during the first post-monsoon season, Year 1. Identification, selection, and finalization of disposal sites should be completed in the working season (October to May) of Year 1.

Detailed engineering design, preparation of tender documents and implementation plan will be completed in Year 1. Approval of the implementation plan and tender documents should be made at the beginning of Year 2. Invitation of tenders and award of contract must be related with the timing constraints for mobilization. In particular, dredges cannot be mobilized at the work sites after November 15 due to inadequate water depths.

Mobilization of manpower should be completed by the end of November so that earthwork could be started by the first week of December, Year 2.

Land acquisition should be started in Year 1 and should be completed in Year 2, prior to start of construction.

Construction
The project's implementation needs to be sequenced carefully to avoid adverse impacts and to minimize channel maintenance costs. A tentative recommended sequence is as follows:

- construct emergency remedial works at Shantipur and Cherapur Khal;
- construct Issapur loop cut, Kadamchal Re-alignment, Katkhal loop cut;
- complete Phase 1 channel excavation prior to opening of the loop cuts;
- construct bank protection, spill closures and levees upstream of Ajmiriganj, and
- commence navigation dredging.

The spill closures and levees, which are mainly located in the upstream reach, have been delayed until after the works in the downstream reach are completed. This is necessary since the upstream works will increase the magnitude of pre-monsoon flood flows further downstream. If the closures were constructed first, then flood damages could be increased in the lower reach during the period when the loop cuts are being constructed. The navigation dredging upstream of Ajmiriganj can also be delayed until after the loop cuts and downstream channel excavation work is completed. This is because these downstream channel improvements must be completed in order to provide any benefit to navigation.

All of the following river works include village platform construction components.

Issapur Loop Cut
Surface excavation and construction of confinement dykes will commence from Year 3 and will be completed during the same dry season (April-May). Dredging will start in April-May, Year 3 and will be completed by December of Year 4. The opening of the offtake is targeted for the month of January, Year 4. Construction of the closure dam will commence from January, Year 4 and will be completed before the onset of pre-monsoon floods.

Dhaleswari Channel Dredging
Dhaleswari channel dredging will start in January, Year 4 and will be completed by the same dry season (April-May). Construction of confinement dykes will start in December-January, Year 4 and will be completed in the same year.

Katkhal Loop Cut
Surface excavation and construction of guide embankments will commence from December-January, Year 3 and will be completed in Year 5 (January). Dredging is expected to start from February in Year 3 and will be completed including opening of the offtake in Year 5 (January).

Kadamchal Dredging and Channel Realignment
Kadamchal channel dredging, channel re-alignment and construction of village platforms will start in Year 5 and will be completed in the same year.

Issapur-Ajmiriganj Channel Dredging
Construction of confinement chambers and dredging will start in Year 5 and will be completed in Year 6. Rahala-Ajmiriganj channel and navigation dredging will start in Year 6 and will be completed in the same year. Construction of structures will start in Year 5 and will be completed in Year 6.

7.7.2 Alternative 2

With Alternative 2, the projects' overall duration and main-sequence of work will be similar to Alternative 1. Therefore, eliminating the Issapur loop cut will not shorten the construction period of the project.

7.8 Operation and Maintenance

Solutions to problems associated with channel instability and sedimentation generally require a long-term management approach. ***A crucial aspect of river management involves carrying out ongoing channel maintenance.*** In this context, "maintenance" involves more than routine repair of existing structures. In the KKRMP, the scope of the maintenance operations will extend along the entire length of the river. Systematic data collection and field observations will provide the direction and guidance for the maintenance work. An important requirement for this type of adaptive river management approach is the need for institutions with the capacity and the resources to carry out the monitoring and channel maintenance work. Institutional arrangements for both implementation and management are discussed in Chapter 10.

7.8.1 Channel Stabilization and Flood Control Works

The main types of channel maintenance that are described in this chapter include channel excavation, and work associated with bank protection, levees, embankments and village platforms.

Bank Protection
There will be a need for ongoing monitoring of channel shifting and bank erosion, and construction of bank protection works at strategic locations, particularly during the first five years after the main capital works have been constructed. Table 7.11 provides a preliminary list of sites where the threat of future bank erosion is high. Consequently, bank protection may be required in the future at these locations. Other sites may be identified later on, after the project is constructed.

Table 7.11: Tentative Locations For Future Bank Protection

River Kilometre	Name	Bank	Comment
52.0-53.0	Kalma	LB	Bank will start eroding after loop cut is opened up. Monitor bank retreat and decide on final preferred bank alignment. Stabilize bank if necessary. (ALTERNATIVE 1 only)
83.5-85.0	Anwarpur	LB	Monitor ongoing retreat. If erosion rate accelerates after Katkhal loop cut then add additional bank protection
86.0-86.5	Bishorikona	LB-RB	Bank will start eroding after loop cut is opened up. Monitor bank retreat and decide on final preferred bank alignment. Stabilize bank if necessary
114.0-115.0	Koyer Dhala	LB-RB	Monitor performance of closures at Pituakandi and Koyer Dhala, extend/repair if necessary
119.0	Tangua Dhala	RB	Monitor/upgrade existing protection
129.5	Fayjullapur	RB	Monitor/upgrade existing protection
139.0	Akkilshah Bazar	LB	Monitor performance of new closure, extend, upgrade if necessary
144.0		RB	Monitor/upgrade existing protection
149.5	Balisri	LB	Upgrade spill closure
153	Raniganj	RB	Monitor/repair/extend existing protection
156-161		LB	Monitor future cutoff development, construct new bank protection if required

Channel Maintenance Dredging

Requirements for channel maintenance dredging were based on experience from the pilot project, results of long-term channel monitoring studies, and sediment transport modelling and analysis. The incoming coarse silt and sand load on the river presently amounts to around 3.5 million m^3/year (at Sherpur and Markuli). It is this bed material load that will create the primary need for ongoing maintenance dredging downstream of Ajmiriganj. At present, the reach below Katkhal can not transport all of the incoming sediment load. For example, morphologic studies showed approximately 1.2 million m^3 of material was deposited between Kadamchal and Issapur during 1995. In order to achieve a long-term equilibrium in this reach, the channel would have to transport all of this silt and sand load into the Meghna River.

Results of the pilot project monitoring near Gazaria and Kakailseo villages showed that deep, local excavations in the river bed filled-in within a matter of weeks. Overall, with a total excavation of approximately 450,000 m^3, the average bed level in the dredged reaches filled in by about 50% by the end of the monsoon season. However, the extent of the pilot dredging was very limited (about 1 km at each location) and did not involve other measures to improve the self-scouring capacity of the river. The project's proposed channel improvements should reduce the need for future dredging along the river. For example, the loop cuts will shorten the river's length, which will initially steepen the river's gradient and increase the channel's transport capacity. Also, the closures and levees upstream of Ajmiriganj will increase the pre-monsoon velocities in the lower reach, since spills and losses into the floodplain will be reduced. This will increase the lower reach's capacity to transport sediment which will promote channel scouring before the monsoon season. Furthermore, assuming a major new avulsion can be prevented, the river should begin to establish a more stable configuration than it has in the last 30 years, which will reduce sediment production from bank erosion. A series of morphologic modelling simulations and sediment transport calculations were made to provide preliminary estimates of the future channel maintenance requirements along the river (Annex A). On the basis of this analysis it was concluded that annual channel maintenance dredging will have to be carried out on the river to preserve the improved channel conveyance. Given the inherent uncertainties with sediment transport predictions, these computations can provide indicative results only. It was decided to use the results of the predictions as baseline estimates, then carry out a sensitivity analysis during the project's economic evaluation to assess the impact of variations in maintenance dredging on the overall project economics.

Table 7.12 summarizes the estimated maintenance dredging volumes by reach after project completion. With Alternative 1, the greatest need for maintenance dredging will be in the 7 km reach downstream of the Issapur loop cut on the Dhaleswari River (Km 49 to 42), downstream of Katkhal loop cut between Bishorikona and Kadamchal (Km 87-85) and below Kalimpur (Km 82 to 79) on the lower Kalni River. No major re-excavation is expected immediately upstream of the loop cuts, since these reaches will degrade after the new channels are opened. With Alternative 2, continuous maintenance dredging will be required along the Dhaleswari River between Kalma and Issapur (Km 52 to 72) on the Dhaleswari River, from downstream of Abdullahpur to Kalimpur on the lower Kalni River (Km 76 to 82) and downstream of Katkhal loop cut from Bishorikona to Kadamchal (Km 87 to 85).

Table 7.12: Maintenance Dredging After Project Completion

Location	Reach (km)	Maintenance Dredging ('000 m^3/year)	
		Alternative 1	Alternative 2
Kalma	47-52	200	
Shibpur	54-58	100	200
Adampur	63-66	100	300
Islampur	68-71		200
Issapur	70-72.5		300
Abdullahpur		400	600
Navigation Dredging		125	125
Total		**1,000**	**1,800**

Maintenance requirements will decrease over time with Alternative 1 as the channel adjusts to the two loop cuts. Therefore, after Year 14 the volumes will be reduced by 20%. Over a 30 year planning period, the total maintenance dredging quantities amounts to 19.3 million m^3 with Alternative 1 and 34.8 million m^3 with Alternative 2. This work will create an ongoing need to find disposal sites along the river as well as an opportunity to continue developing new village platforms.

7.8.2 Navigation Channel Maintenance

The additional dredging carried out for navigation improvement is all situated upstream from the influence of any proposed river training or channel improvement works. The shoals in this upper reach (Manumukh, Omarpur and Fenchuganj) are all located at "cross-overs" or "riffles" between bends. These shoals will re-form each year after excavation, so that it can be assumed the maintenance dredging volumes will be similar to the initial excavation amounts. Therefore, the initial navigation dredging of 125,000 m^3 upstream of Sherpur will require a total maintenance dredging effort of 3.7 million m^3 over the 30 year planning period.

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7.8.3 Village Platform Maintenance

One of the main requirements for village platform maintenance involves sustaining the platforms' slope protection. While "hard" protection should not require substantial repair except possibly after major floods, "soft" protection requires annual replacement and repair. Provision for "soft" protection has been included in the cost estimate, assuming annual replacement for four years following construction. In the last three years, the platform beneficiaries will be expected to contribute to the costs of platform protection through the contributions of material and labor. Community motivation practices will be carried out in platform communities. The enhanced production of *chailla* grass for use in traditional platform protection will be encouraged. Village-based nurseries will be established for the production and sale of adult-sized *koroch* saplings. Full protection and maintenance costs will be assumed by platform landowners after the 3 year program.

7.9 Costs

7.9.1 Capital Costs

Total project capital cost is estimated to be Tk 2,788 million for Alternative 1, and Tk 2,366 million for Alternative 2, including cost of mitigative measures, compensation plan and enhancement program. A breakdown of the costs by component is shown in Table 7.13. These costs were estimated on the basis of *FPCO Guidelines*. Detailed quantity and cost estimates have been provided in Annex C - Engineering and Annex I - Environmental Impact Assessment.

Unit rates for earthwork, structures and other associated items have been taken from BWDB's 1995 Schedule of Rates for Moulvibazar O&M Circle. Future dredging costs have been taken as US\$ 2/m^3 (equivalent to Tk 82/m^3), the international rate for 1995. By comparison, the dredging rate for the Jamuna Bridge in May 1995 was Tk 94/m^3, equivalent to US\$ 2.09 at an exchange rate of Tk 45/US\$. Cost of mitigative measures, compensation and enhancement program has been estimated on the basis of pilot project experiences.

Land costs reflect the current prices obtained from field interviews. High agricultural land *(boro)* in Issapur area was assumed to be priced at Tk 180,000/ha, high agricultural land *boro* in Katkhal and upstream reaches was priced at Tk 125,000/ha and lowland on the downstream of Abdullahpur was priced at Tk 80,000/ha.

Physical contingencies equal to 15% of base construction costs as per *FPCO Guidelines* were used to cover unforeseen costs. Engineering costs (survey, design, preparation of implementation plan and tender documents, supervision of construction and administration) were estimated to be Tk 291.8 million, which is about 12% of base construction costs plus physical contingencies.

Table 7.13: Capital Cost Summary

Item	Alternative 1		Alternative 2	
	Cost (million Tk)	Cost (million US$)	Cost (million Tk)	Cost (million US$)
Channel Dredging	603.36	14.72	677.98	16.54
Issapur Loop Cut	455.32	11.11	n/a	-
Katkhal Loop Cut	513.40	12.52	513.39	12.52
Channel Realignment	35.38	0.86	35.38	0.86
Homestead Platforms	298.45	7.28	351.66	8.58
River Training Works	110.67	2.70	110.67	2.70
Levees	10.86	0.26	10.86	0.26
Regulators	23.17	0.57	23.17	0.57
Madna Closures	1.45	0.04	1.45	0.04
EMP	57.60	1.40	49.60	1.21
BASE COST	**2,109.66**	**51.46**	**1,774.16**	**43.28**
Physical Contingency	316.45	7.72	266.12	6.49
SUB-TOTAL	**2,426.11**	**59.18**	**2,040.28**	**49.77**
Study Cost	291.80	7.12	291.80	7.12
Land Acquisition	70.02	1.71	34.38	0.84
TOTAL	**2,787.93**	**68.01**	**2,366.46**	**57.73**

Note: Conversion Factor Tk 41/US$.

7.9.2 Operation and Maintenance Costs

The O&M cost estimates are divided into 3 categories:

- annual maintenance dredging;
- physical components, and
- village platforms.

The O&M cost was estimated on the basis of *FPCO Guidelines* and pilot project experience. These costs will cover technical staff, departmental overheads, maintenance of physical components and replacement of items subject to normal wear and tear. Physical contingencies equal to 15% of base costs (Table 7.14) as per FPCO *Guidelines* were used in the economic evaluation to cover unforeseen costs.

Annual Maintenance Dredging

Cost of annual maintenance dredging associated with construction of disposal chambers and other related components including the EMP has been estimated based on the adopted estimating procedure of capital costs. Estimated annual maintenance dredging and other associated costs are given in Table 7.14.

Physical Components
Physical components mainly include: embankments, levees, closures structures, river bank protection and embankment slope protection (permanent) at Issapur and Katkhal. The O&M cost of these physical components has been calculated as a percentage of capital costs on the basis of FPCO *Guidelines*. The breakdown of these costs is given below:

- embankments, levees & closures: 6%;
- structures: 3%;
- river bank protection: 10%, and
- slope protection: 3%.

Village Platforms
Platform maintenance mainly includes post-monsoon platform dyke repairs and protection against wave erosion through traditional methods (soft protection). Maintenance of village platforms has been sub-divided into the following two categories:

- first year program; and
- three year program.

This approach was developed on the basis of experience from the pilot project. The first year maintenance program will be carried out by the contractor who constructed the confinement dykes. In the three year program, the village platforms will be maintained jointly by the project authority and the beneficiary households. Beneficiary households will assure their contribution of labor and materials for soft protection. They will only facilitate the works for hard protection by providing space for casting blocks and storage facilities. After the 3 year program, the platforms will be maintained by the beneficiaries themselves (Annex D - Social).

The cost of the 3 year platform maintenance program during construction of the initial capital works has been included in the capital cost (Chapter 11). Additional village platforms will be constructed during the ongoing channel maintenance dredging operations after the project is constructed. These costs have been included in Table 7.14.

Table 7.14: Annual O&M Base Costs

Alternative	Year	Annual Dredging (million Tk)	Physical Components (million Tk)	Village Platform (million Tk)	Annual O&M Base Costs (million Tk)
Alternative 1	8-10	93.61	22.76	0.58	116.95
	11-13	84.25	22.76	0.52	107.53
	14-17	74.89	22.76	0.46	98.11
	18-30	67.77	22.76	0.01	90.54
Alternative 2	8	169.18	20.25	1.27	190.71
	9-17	140.98	20.25	1.06	162.29
	18-30	126.96	20.25	0.07	147.28

8. IMPACT OF PROPOSED DEVELOPMENT

8.1 Introduction

This chapter describes the "future with project" (FW) scenario and, by comparison to the "future without" (FWO) scenario (Chapter 6), provides a summary of the anticipated project impacts. The magnitude of the impacts are governed by both the effects of the proposed interventions as well as anticipated changes that have been predicted for the "FWO" scenario.

Sections 8.2 to 8.9 address Alternative 1 only, and discuss physical impacts (changes to the channel hydraulics, river morphology and hydrological characteristics in the project area), impacts to agriculture, human settlements, navigation, habitat and fisheries. Section 8.10 then describes the significant differences in impacts between Alternative 2 and Alternative 1, since many of the impacts are the same for both alternatives. Finally, Section 8.11 compares the 2 alternatives.

In all cases, impacts discussed in this chapter refer to either the medium or long-term - i.e. post-project intervention. Short-term impacts related to project implementation are discussed in the Environmental Management Plan, Chapter 9.

8.2 River Morphology and Sedimentation

It has been predicted (Chapter 6) that substantial morphological changes will take place in the FWO scenario. In order to assist in interpreting results, this section not only compares the FW and FWO scenarios, but also the FW and FWO to the Present conditions.

The physical response of the channel to the project's interventions will be driven primarily by changes to the pattern of discharge and sediment transport along the channel. Therefore, this section begins by discussing the expected changes to the discharge on the river, and then follows with a description of the expected morphologic impacts. Unless otherwise noted, Figure 7.2 should be referred to in the remainder of this section.

8.2.1 River Discharges

The impacts to the discharge regime were estimated from the MIKE-11 hydrodynamic model. The project is not expected to significantly alter the discharges upstream of Sherpur (Km 177) or downstream of the Baulai-Dhaleswari River junction (Km 20) at any time of the year. Therefore, the main reach where discharges will be modified extends over the 157 kilometres between Sherpur and the Dhaleswari-Baulai River junction. The project is not expected to significantly alter the main channel discharges during the monsoon season since none of the proposed works will confine or affect the monsoon flood flows. The impacts will be largely restricted to changes in the pre-monsoon and dry season discharges.

The project interventions will modify the magnitude and frequency of discharges in the pre-monsoon season, particularly in the reach downstream of Markuli. This is because the major pre-monsoon spill channels will be closed, which will reduce flows into the floodplain and cause the main channel to carry more of the river's total discharge.

Table 8.1 summarizes the estimated pre-monsoon flood discharges at various points along the river under the FW scenario, FWO scenario and Present conditions. Due to the confinement of the flow, the peak discharge at Ajmiriganj is expected to increase above present conditions by 16.7% at the 1:2 year pre-monsoon flood and by 26.8% at the 1:5 year pre-monsoon flood. Downstream of Cherapur Khal, the flows will be approximately the same as at present. These flows are substantially higher than the predicted FWO scenario which forecasts a substantial diversion of flow into the Baulai River system. Therefore, the project prevents Cherapur Khal from capturing the flow of the Kalni River and becoming the dominant channel.

Flows in the Baida River channel below Issapur will be reduced substantially from the Present conditions, since most discharge will be carried by the newly constructed channel. However, the FW and FWO flows in the Baida channel are approximately the same (Table 8.1). Downstream of the Baida/Dhaleswari River junction the discharges will be the same as the Present conditions.

Table 8.1: Discharges along Kalni-Kushiyara River

Location	1:2 year Pre-monsoon Flood Discharge (m^3/s)			1:5 year Pre-monsoon Flood Discharge (m^3/s)		
	Present Conditions	FWO	FW	Present Conditions	FWO	FW
Sherpur	1,704	1,700	1,700	2,410	2,401	2,400
Markuli	1,556	1,287	1,661	1,929	1,559	2,310
Below Koyer Dhala	1,417	1,153	1,625	1,798	1,433	2,283
Ajmiriganj	1,378	1,143	1,609	1,798	1,430	2,270
Below Cherapur Khal	976	330	1,311	1,429	521	1,998
Baida River channel	565	323	300	966	517	685

8.2.2 Future Evolution of the River

The following comments summarize the expected impacts of the proposed project on the channel morphology. For this discussion, the river has been sub-divided into four reaches and the impacts are summarized by reach.

Upper Kushiyara - Fenchuganj to Sherpur
Only minor navigation dredging will be carried out in this reach. However, water levels in the dry season will be lowered by as much as 1.0 m at Fenchuganj. This will return the water levels to comparable conditions that were experienced in the 1960's -70's. It is expected that the low flow channel will cut down through local shoals in some areas, particularly at the mid-channel "crossings" that occur in straight reaches between meander bends. Some downcutting (drop in bed and water levels) may also occur in the lower reaches of tributaries such as Juri River and Manu River. This may cause adjacent sloughs to dry out.

Kushiyara River - Sherpur to Markuli
Levees and local bank protection work will be constructed along portions of this reach. Downstream improvements will lower pre-monsoon flood levels at Markuli by about 0.4 m. Water levels in the dry season will be lowered by up to 1.5 m (Figure 8.1).

The proposed flood control works will reduce the frequency and magnitude of pre-monsoon spills and breaches downstream of Raniganj (Km 152). This will reduce the deposition of sediment "splays" into the adjacent flood basins and distributary channels in this reach. Minor adjustments may occur in the meander pattern in response to the installation of bank protection. However, these changes will be very small in comparison to the natural pattern of channel shifting. The channel is already very deep in this reach. Therefore, no major impacts are expected as a result of lower water levels in the dry season.

Kalni River - Markuli to Ajmiriganj

Local bank protection and navigation dredging will be carried out in this reach. Downstream improvements will lower pre-monsoon flood levels by about 0.5 m. Under the present condition and the assumed "future without" scenarios, spills in the pre-monsoon season cause the discharges in the main channel to decrease in the downstream direction between Markuli and Ajmiriganj. When the project is completed, these pre-monsoon spills will be virtually eliminated in most years. Consequently, the magnitude of pre-monsoon flood discharge on the Kalni River will increase somewhat downstream of Markuli. It is estimated that the dominant or channel-forming discharge will be increased from about 1,650 m^3/s to around 1,900 m^3/s. During the first decade of operations, the channel may tend to widen slightly. Simple Lacey "Regime Theory" equations indicate the increase in width could reach up to 15 m. Meander migration and bank erosion may also be accelerated temporarily. However, once the river adjusts to the higher flows a new equilibrium will be established.

Kalni River - Ajmiriganj to Upper Meghna River Confluence

This reach will be affected by the loop cuts and channel re-excavation and the modified pre-monsoon discharge regime. The project is designed to prevent the river from developing a new avulsion into the Baulai River through Cherapur Khal. Consequently, the drainage system in the lower Baulai/Ghorautra River system will not experience a major episode of channel instability, bank erosion and sedimentation. Furthermore, the lower Kalni River below Cherapur Khal will continue to carry most of the river's flow.

Due to the low gradients along the river and the manner in which the loop cuts will be constructed (excavated full section rather than construction of a pilot channel) it is anticipated that adverse impacts will be relatively minor. For example, some localized bank erosion is expected downstream of Katkhal loop cut between Bishorikona and Kadamchal. The cutoff portions of the river will be turned into ox-bow lakes but will still remain connected to the main channel at their downstream ends. The depths in these ox-bows will gradually be reduced over a period of 30 years due to sedimentation in the monsoon season.

Figure 8.2 shows the predicted bed profile changes along the Kalni River after loop cutting. The predictions were made with a one-dimensional morphologic model. Shortening the channel will induce degradation upstream of the cuts (about 0.7 m at Issapur and 0.5 m at Katkhal) which will slowly progress upstream of Ajmiriganj in approximately 5 to 10 years.

The loop cuts will cause temporary aggradation in the first years of operation immediately downstream of the new channels. However, this will be transient and the bed will eventually return to the initial condition before the loop cut was opened. The potential aggradation downstream of Katkhal will be mitigated by over-dredging between Kadamchal and Kalimpur, so any potential deposition will not raise the bed above its pre-project level. The sedimentation studies indicate that ongoing maintenance dredging will be required in the reach downstream of

Kadamchal to sustain the increased channel conveyance. Sedimentation rates in the branch of the lower Kalni-Dhaleswari River below Issapur should be reduced in comparison to the present and "future without project" scenario. This is because the closure below Issapur will prevent sediment laden water from depositing material in the reach. The 12 km long Dhaleswari channel between Madna and Kalma will gradually narrow over time in response to the lower discharge regime and the land filling along the right bank near Adampur (Figure 7.6). The channel bottom will remain at around El. -1.5 m PWD as a result of maintenance dredging operations. Major deposition in this reach is not expected from the Khowai/Ratna River inflows since most of the sediment from those rivers is deposited far upstream on the floodplain near Habiganj (Figure 2.1).

Historically, the Baida channel has been enlarging in response to the deposition in the Dhaleswari channel. In both FW and FWO project scenarios, the Baida channel is expected to respond to the lower flows (Table 8.1) by gradually developing a smaller cross sectional area - i.e. the active channel will shrink over time. In other words, relative to the FWO scenario, the project will have no overall impact on the morphology of the Baida channel.

Sedimentation rates will increase downstream of the Issapur loop cut, particularly in the 8 km long reach immediately downstream of Kalma. However, maintenance dredging is planned for this reach, so the bed is not expected to aggrade significantly. Furthermore, this maintenance dredging will prevent the downstream progression of the sediment accumulation. Therefore, a scenario with no maintenance dredging was also examined. It shows that if no maintenance was carried out in this reach, the sediment would eventually progress further downstream into the lower Dhaleswari River near Astagram (Figure 8.2). As shown in Figures 8.1 and 8.2, the river deepens by up to 10 m further downstream as it joins the Upper Meghna River system. Furthermore, the discharge increases by a factor of five when the river meets the Upper Meghna River system. Therefore, this lower reach can easily accommodate temporarily increased sediment inflows without significantly reducing the channel's conveyance. Results of the morphologic model simulations showed that impacts of the loop cuts on bed levels in the Upper Meghna River will be undetectable.

8.3 Hydrological Characteristics

8.3.1 Water Levels

The project's impacts will be greatest during the dry season and pre-monsoon season, when the river slopes are steepest; and close to negligible during the monsoon season when the gradients are controlled by the downstream level of the Meghna River. Figure 8.1 shows a longitudinal profile of the 1:5 year pre-monsoon flood levels and the bank levels. This profile shows the project will be able to maintain the water levels below the top of the bank except in localized areas just upstream of Katkhal and near Kadamchal. Consequently, all major upstream spills will be eliminated due to the development of the project. The project will lower 1:5 year pre-monsoon flood levels by 0.35 to 0.45 m between Madna and Ajmiriganj in spite of the increased discharge carried by the main channel (Figures 8.3 to 8.5). Upstream of Markuli the lowering will be negligible during peak pre-monsoon flood conditions. Peak pre-monsoon flood levels will be lowered on the floodplain by around 0.4 to 0.6 m northeast of Madna and by 0.3 to 0.4 m northwest of Ajmiriganj on the right bank of Kalni-Kushiyara River, and near Cherapur Khal (Figure 8.6).

Figure 8.7 shows project impacts on water levels over the entire year. As expected, monsoon flood levels are only slightly lowered by the channel improvements. The project has a major impact on post-monsoon and dry-season water levels on the Kalni - Kushiyara River, with levels lowering by up to 1.5 m between Ajmiriganj and Markuli. Dry season water levels at Fenchuganj will be lowered by between 0.7 to 1.0 m. Impacts to post-monsoon levels on the Ratna floodplain were estimated to be around 0.5 m in mid-December while on the Chamti-Darain floodplain will be around 0.4 m.

8.3.2 Flooding Extent

The FPCO definition of "flood free" land has been adopted in this study. This definition considers all land inundated by less than 0.3 m to be classed as "flood free". Comparison of FWO and FW scenarios (Table 8.2) shows that the project will increase the flood-free land by 64,100 ha during a 1:2 year pre-monsoon flood, 55,200 ha during a 1:5 year flood and by 44,450 ha during a 1:10 year flood. These differences represent the gross areas inundated in the project area. The extent of flooding was determined by means of the MIKE 11 hydrodynamic model and the digitized floodplain map. The extent of pre-monsoon flooding for floods with varying return periods is presented in Figures 8.8 to 8.10.

Table 8.2: Impacts of Pre-Monsoon Flooding - Alternative 1

Depth of Flooding	1:2 year Pre-monsoon Flood		1:5 year Pre-monsoon Flood		1:10 year Pre-monsoon Flood	
	FWO (ha)	FW (ha)	FWO (ha)	FW (ha)	FWO (ha)	FW (ha)
"Flood-free" (<0.3 m)	235,867	299,971	96,215	151,428	40,886	85,333
0.3-0.9 m	53,351	13,981	69,793	62,594	44,430	32,743
0.9-1.8 m	37,252	16,062	113,863	80,132	121,482	120,527
>1.8 m	9,130	5,586	55,729	41,446	128,802	96,997
Total Flooded Area	**99,735**	**35,629**	**239,385**	**184,172**	**294,714**	**250,267**
% Inundation	**30**	**11**	**71**	**55**	**88**	**75**
Total Project Area	**335,600**	**335,600**	**335,600**	**335,600**	**335,600**	**335,600**

8.3.3 Drainage

Table 8.3 summarizes the extent of impacts on the post-monsoon drainage in the project area. These results were estimated using the MIKE-11 hydrodynamic model and represent the total gross land areas. Analysis shows that the project will facilitate early plantation for an area of about 14,000 ha, particularly in the lower elevations of the project area. Early plantation will make the crop less vulnerable to pre-monsoon floods and accumulated rainfall inundation.

Table 8.3: Impact of Post-Monsoon Drainage: Inundated Area - Alternative 1 (1:2 Year)

Month	FWO ('000 ha)	FW ('000 ha)	Improved Area ('000 ha)
November	103	69	34
December	34	20	14
January	11	8	3
February	8	7	1

8.3.4 Impacts on Other Rivers

Tables 8.4 and 8.5 summarize the predicted water levels on adjacent rivers during the pre-monsoon and post-monsoon seasons under FWO and FW project scenarios.

Table 8.4 shows that the Issapur loop cut could lower the pre-monsoon water level at Habiganj by as much as 0.84 m (1:2 year flood). There is no change predicted for the 1:5 year flood. However, the Madna channel water level will be lowered by 0.4 m in the 1:5 year flood during the pre-monsoon season due to the loop cut (Section 8.2). This suggests that in the lower reaches of Khowai River the hydraulic slope will be steeper. As a result, proposed and planned submersible embankments on the Khowai River below Habiganj might receive substantial benefit from the KKRMP. However, this benefit was not quantified or used in the economic analysis in this study because of uncertainties in the implementation of these submersible embankments.

Table 8.4: Pre-Monsoon Water Levels - Alternative 1

River	Location	1:2 Year		1:5 Year	
		FWO (m PWD)	FW (m PWD)	FWO (m PWD)	FW (m PWD)
Khowai	Habiganj	9.63	8.79	10.63	10.63
Baulai	Sukdevpur	5.13	5.09	5.91	5.84
	Khaliajuri	4.13	3.96	4.94	4.75
	Itna	3.91	3.60	4.82	4.59

Table 8.5 shows that the Baulai water level will be lowered during the pre-monsoon and post-monsoon seasons under FW project scenario. There are 17 submersible embankment projects on the right bank of Baulai River. Currently, these projects are subjected to increasing pre-monsoon flood levels and delayed post-monsoon drainage due to high water levels in the Baulai River. The project will have some positive impacts on these submersible embankments due to a predicted decrease in Baulai water levels during the pre- and post-monsoon seasons. However, this benefit was not quantified nor included in the economic analysis.

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Table 8.5: Post-Monsoon Water Levels - Alternative 1

River	Location	December		January		February	
		FWO (m PWD)	FW (m PWD)	FWO (m PWD)	FW (m PWD)	FWO (m PWD)	FW (m PWD)
Baulai	Sukdevpur	3.9	3.62	3.07	2.76	2.05	1.83
	Khaliajuri	3.47	3.05	2.69	2.26	1.88	1.62
	Itna	3.3	2.8	2.55	2.07	1.82	1.56

8.4 Water Resources Infrastructure

8.4.1 Existing Projects

There are 6 major submersible embankment projects around Markuli on the right bank of the Kushiyara River, providing pre-monsoon flood protection to a gross area of about 37,000 ha (Figure 2.1). Through reduced pre-and post-monsoon flood levels, the KKRMP will provide the opportunity for improved operations and reduced maintenance requirements for these projects. Furthermore, it is anticipated that these embankments will not have to be raised and upgraded in order to provide pre-monsoon flood protection. This avoids the need to acquire an additional 150 ha of land, which would be required if the embankments were raised.

In 1988, BWDB completed the Bashira River Project (Figure 2.1). That project involved construction of two regulators on tributaries of the Bashira River, which at that time was an offtake of the Kalni River immediately upstream of the proposed Katkhal loop cut. The Bashira project was designed to provide irrigation supply for nearby *beels*. However, as a result of downstream channel changes on the Kalni River, pre-monsoon floods began to spill into the Bashira River. As a result, local people closed the Bashira offtake, thereby adversely impacting *boro* cultivation in an area of about 1,900 ha. With reduced pre-monsoon flood levels on the Kalni River, the project could potentially be revitalized by permitting re-opening of the offtake.

8.4.2 Irrigation

The KKRMP will improve irrigation water supplies by providing flushing regulators at two locations, by improving access to water supplies, by increasing the channel depth in the dry season, and by reducing damage and siltation along distributary channels. Although lower dry season water levels will lead to higher pumping heads upstream of Ajmiriganj, the increased head is within the operating range of the existing LLPs. The additional operating costs associated with the increase in head is not expected to be significant.

Koyer Dhala Multi-Purpose Regulator

The Koyer Dhala regulator will provide flushing for irrigation during the dry season to the Old Kushiyara Irrigation Scheme, Jhingari Nadi Irrigation Scheme and fallow lands along the Baniachang-Ajmiriganj Road (Figure 8.11). NERP case studies in 1996 show that the Old Kushiyara Irrigation Scheme, with a command area of about 2,500 ha, is almost ineffective due to offtake siltation of the Old Kushiyara River. The Jhingari Nadi Irrigation Scheme has a net area of about 3,600 ha and the Old Kushiyara River is this scheme's the main source of irrigation water supplies. This scheme has also become ineffective. The irrigation water provided by the Koyer Dhala regulator will restore the effectiveness of both of these projects.

The regulator will also provide irrigation water to an area of 1,200 ha, located along the southern side of Baniachang-Ajmiriganj road (Figure 8.11). The area, which is currently fallow, remains flood-free even with 1:5 year pre-monsoon flood (Figure 8.9), and local people report that the land is suitable only for *boro* crop.

Access to Water Supplies

The Issapur loop cut will reduce the cost of local irrigation water supplies. Currently, the cultivable area between the Dhaleswari and Baida channels is irrigated from these two sources. The new cutoff channel will create an additional source that reduces the length of the irrigation canals and consequently the costs.

The Katkhal loop cut will have a similar impact on irrigation in the area of the cutoff. In addition, the installation of a drainage and flushing regulator is planned at the offtake of Barabaria Khal (Figure 7.16). This regulator will facilitate drainage from and irrigation water supply to the Barabaria area. Currently, this area suffers from inadequate dry season irrigation water supply, which can be easily met from the Kalni River.

8.5 Agriculture

In the FW project, crop damage due to over bank spills, inundation and breaches in the river banks during the pre-monsoon season will be reduced, and the area of flood-free land will be increased. The existing flood control infrastructure will be more effective and production will be increased towards its optimal level under damage-free conditions. Reduced spills in the pre-monsoon season will enable farmers to harvest more local and high yielding varieties of *boro* rice. As a result, production is expected to increase at least to the level other farmers are obtaining under damage-free conditions. This may induce the farmers to replace some of the local *boro* with HYV *boro*. However, pre-monsoon flooding will not be eliminated from the project area and it has been assumed that damage to local and high yielding varieties of *boro* rice will continue but at a reduced scale. Reduction in the depth of flooding during the pre-monsoon season will to some extent also reduce damage to local varieties of broadcast *aman* at the early growth stage, and this will contribute to the establishment of this crop.

There will be no change in monsoon flooding conditions after implementation of the project. Therefore, cropping patterns will remain similar to those under the FWO scenario.

Drainage improvements in the post-monsoon season will increase the land available for timely plantation of *rabi* crops. Farmers are expected to utilize residual soil moisture for *rabi* crop cultivation. This would include fodder crops to meet the requirement of cattle feed.

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8.5.1 Land Use

About 938 ha of land (about 0.30% of the project gross area) will be required for disposing of dredged material and for the construction of loop cuts and levees (Table 8.6). Of this, 806 ha will be taken from cultivable areas. The impact of this land use change has been taken into consideration during calculation of the Net Cultivable Area (NCA) under the FW scenario. Out of 938 ha, about 335 ha will be used as homestead platform and 330 ha will be used for homestead garden and non-cereal crops (Section 8.9).

However, loss of agricultural land will negatively impact farmers where land must by acquired. This will particularly be the case for the Issapur loop cut.

Table 8.6: Changes in Land Use-Alternative 1

Land Use	Change in area (ha)
Cultivated	-806
Village Platform	+335
Village Garden	+330
Rivers	-
Channels	-
Fallow	-132
Net Change	-273

8.5.2 Cultivated Land

Table 8.7 summarizes the extent and depth of inundation of the cultivated land in the project area under FWO and FW scenarios for 3 different pre-monsoon floods (1:2 year, 1:5 year and 1:10 year).

Table 8.7: Pre-monsoon Flood Extent on Cultivated Land - Alternative 1

Flood Depth Range	Net Cultivated Area					
	1:2 year Flood		1:5 year Flood		1:10 year Flood	
	FWO (ha)	FW (ha)	FWO (ha)	FW (ha)	FWO (ha)	FW (ha)
"Flood Free" (< 0.3 m)	200,987	265,405	61,336	116,862	6,007	50,767
0.3-0.9 m	39,808	485	56,249	49,098	30,886	19,247
0.9-1.8 m	28,140	7,000	104,751	71,070	112,370	111,465
>1.80 m	8,010	4,534	54,609	40,394	127,682	95,945
Total Flooded Area	**75,958**	**12,019**	**215,609**	**160,562**	**270,938**	**226,657**
% Inundated Area	**27**	**4**	**78**	**58**	**98**	**82**
Total Cultivable Area	**276,945**	**277,424**	**276,945**	**277,424**	**276,945**	**277,424**

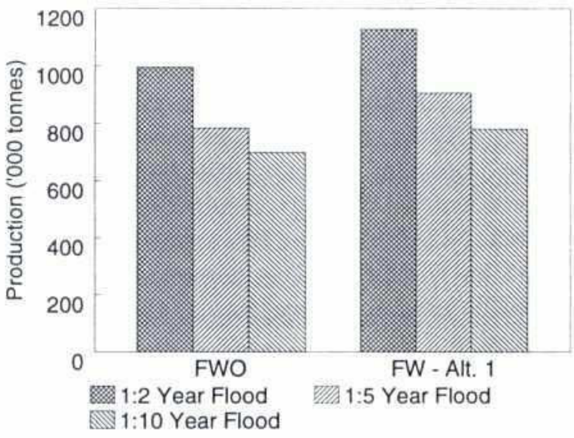
8.5.3 Crop Pattern and Area

The project will increase HYV *boro* rice area in pre-monsoon flood free land. The increase in HYV rice will result from the replacement of low-yielding local boro rice varieties due to reduction in pre-monsoon flood, improvement in post-monsoon drainage and greater availability of surface water from permanent water bodies. The regulator at Koyer Dhala will increase surface water availability during the dry season and will bring some fallow land under HYV boro cultivation.

8.5.4 Crop Production

The project is expected to increase average annual rice production by reducing crop losses. The comparison of rice production under the FWO scenario and under Alternative 1 is presented in Graph 8.1 and Table 8.8.

Graph 8.1: Changes in Paddy Production



The non-rice crop production will decrease in the FW scenario, due to the increased cultivation of rice in response to improved drainage. However, protection of crop from flood damage for consecutive years and higher *boro* output may relieve the pressure for growing rice and lead the farmers to produce other crops in some areas.

Table 8.8: Annual Crop Production, FWO and FW - Alternative 1

Crop	1:2 year		1:5 year		1:10 year	
	FWO ('000 tonnes)	FW ('000 tonnes)	FWO ('000 tonnes)	FW ('000 tonnes)	FWO ('000 tonnes)	FW ('000 tonnes)
Rice Crop	995	1,127	782	893	697	789
Non-rice Crop	36	30	34	28	33	28
TOTAL CROPS	**1,031**	**1,157**	**816**	**921**	**730**	**817**

8.5.5 Crop Losses

Crop losses to flooding will decrease significantly compared to that of the FWO scenario. The loss of rice production will decrease by 75%, 16% and 14% respectively for the 1:2, 1:5 and 1:10 year flood in Alternative 1. Timely harvest of *boro* rice crops in a larger flood free area will be the main factor for this gain. The comparison of crop losses under the FWO scenario and under Alternative 1 is presented in Graph 8.2 and Table 8.9.

Graph 8.2: Project Impact on Paddy Losses

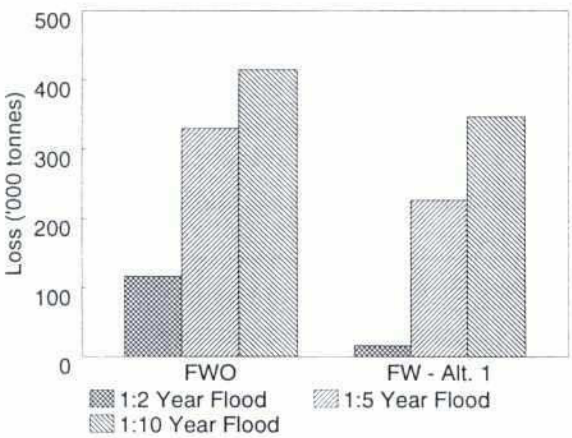


Table 8.9: Annual Crop Production Losses, FWO and FW - Alternative 1

Crop	1:2 year		1:5 year		1:10 year	
	FWO ('000 tonnes)	FW ('000 tonnes)	FWO ('000 tonnes)	FW ('000 tonnes)	FWO ('000 tonnes)	FW ('000 tonnes)
Rice Crop	116.5	17.7	329.8	251.7	414.5	355.2
Non-rice Crop	0.6	0.0	2.5	1.6	3.3	2.3
TOTAL CROPS	**117.1**	**17.7**	**332.3**	**253.3**	**417.8**	**357.5**

8.6 Navigation

Navigation along the Kalni-Kushiyara River will be significantly improved. The channel improvements between Madna and Ajmiriganj, including the removal of shoals at 5 locations upstream of Ajmiriganj, will facilitate year-round navigation for large mechanized vessels (BIWTA Class II). Given adequate navigational draught during the dry season, cargo movement between Bangladesh and India has the potential to improve. Inflow and outflow of major commodities will be increased substantially and it is expected that the Ajmiriganj port will regain its former importance. Movement of passenger traffic will also be increased because of the direct navigable water link with Dhaka and a shortened distance of about 22 km. The navigation impacts are summarized in the following sections.

8.6.1 Freight Traffic Benefits

The potential navigation benefits for cargo movements were estimated based on seasonal cost savings and projected cargo volumes.

Table 8.10: Freight Rate Savings

Fertilizer:	(Tk/tonne)
Project area use	67.5
Rehandled traffic	12.5
Trans-shipment	122.5
Through traffic	36.0
All other commodities	64.5

The expected cost savings are based on the difference in freight rates between wet and dry seasons (Table 8.10). In the dry season, FWO project rates are higher because goods need to be transferred to more expensive land transport in order to bypass unnavigable waters. The FW project would remove this cost differential. The difference is calculated as the differences between BIWTA type craft rates operating at 2.4 m LAD (Class II) versus dry season rates for country boats.

Cargo Profiles and Forecasts
Table 8.11 groups cargo traffic movement into several sub-categories and shows that freight traffic will be increased by about 200,000 tonnes.

Fertilizer is the main industrial traffic on the river. It consists of the following components: internal demand, internal re-handling, trans-shipments and through-shipments.

Internal demand for fertilizer is mainly determined by paddy fertilizer requirements. This has been estimated based on the FW cropping pattern and fertilizer application rates along the 10 km band centred on the Kalni-Kushiyara River channel (Annex G).

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Since commodity movements tend to be from the wholesale market to the local market and then to the village, there is also an *internal rehandling* component. The NSA traffic survey (Annex G) shows rehandle as about 7.5% of net inbound cargo during the dry season and over 20% in the monsoon season. A 10% rehandling factor has been assumed for the analysis.

Because of the presence of major fertilizer wholesalers at Kakailseo and Ajmiriganj, there are also fertilizer *trans-shipments*. These wholesalers buy large quantities of urea from the Fenchuganj plant and then retail it to farmers in the project area. At present the merchants in Kakailseo and Ajmiriganj ship some 28,000 tonnes in excess of local needs and they have indicated that with a more effective dry season navigation channel they could increase their business about 30%. Based on this, it is estimated that FW fertilizer trans-shipments during the dry season should amount to about 36,000 tonnes.

Table 8.11: Projected Dry Season Freight Traffic - Alternative 1

Item	FWO (2026) (tonnes)	FW (2026) (tonnes)
Fertilizer Demand	47,490	51,270
Fertilizer Rehandling	4,750	5,130
Fertilizer Trans-ship	28,000	36,000
Fertilizer Through - S.		160,000
Rice	46,040	46,040
Building Materials	207,830	228,700
POL-Urban	7,360	9,820
POL-Rural	17,170	18,920
Other Food Items	30,070	30,070
Consumer Goods	47,200	47,300
Internal Rehandle	25,510	38,090
Total	**461,420**	**671,340**

Fertilizer is also transported through the project area. For FW, *through-shipments* are expected to include 10,000 tonnes from the existing fertilizer plant at Fenchuganj and 150,000 tonnes from the Shah Jalal plant. The production capacity of Shah Jalal plant is 310,000 tonnes and is expected to start operation in Year 2000.

Details of cargo profiles and forecasts are presented in Annex G.

8.6.2 Passenger Benefits

Although passengers should realize some savings, most of these are likely to be time-related rather than actual reduced travel costs. For example, a passenger might reduce his travel time from 5 hours to 4 hours and this time-saving could have an opportunity cost (or implied benefit) similar to his/her hourly wage rate. Additionally, improved access to more remote areas during the *rabi* season will inevitably generate additional commercial activity which would then translate into more direct and indirect (i.e. spin-off) employment opportunities. This includes additional employment for boat crews.

For example, if dry season passenger traffic was equal to even 75% of monsoon season passenger traffic, this would suggest that passenger traffic could climb by 800,000 people. Thus, even if each passenger saved or generated just 20 additional *taka* from this economic activity (which is about half a farm laborers daily wage), it could amount to some Tk 16 million/year. However, this benefit is not included in the economic assessment, because the available data do not distinguish between launch passengers on purely local routes and those on longer runs where savings may be achievable.

8.6.3 International Traffic Benefits

The proposed project would also make it physically possible to accommodate additional international transit traffic through the Kalni-Kushiyara River reach. Recent traffic volume is about 24,000 tonnes/year but, based on historical data, traffic could increase to over 250,000 tonnes/year as the population in the Northeast Hill States of India has doubled since 1961-62 when the transit traffic was 113,000 tonnes (Table 3.14). This may enhance regional annual economic benefits by between Tk 2.4 million to Tk 25 million, assuming a GOB levee of Tk 100/tonne, a reasonable assumption. However, this benefit is also not included in the economic assessment because changes in future freight traffic through the Kalni-Kushiyara system will depend on international agreements, rather than on projections.

8.7 Fisheries

8.7.1 Open Water Fisheries

The inter-relation of various fish habitat types in the project area make it difficult to predict fisheries impacts with a high degree of certainty. Loss of a particular habitat results in direct losses of production from that habitat, as well as indirect or second order losses from other habitat types. The methods for estimating these second order impacts are not precise enough to allow for reliable evaluation in an economic analysis. As a general guideline, however, it may infer that loss of *duar* or *beel* habitat will have a relatively large second order loss effect, while loss of river or floodplain habitat will have a smaller second order effect. When *duars* are lost, indirect loss of fish production from the neighbouring floodplain and riverine habitats occurs, because these habitats are dependent on *duars* for restocking.

The project is expected to have the following positive impacts on fisheries:

- The increased channel depth from dredging, and alleviation of channel siltation, will increase fish production in the river channel. The impact of increased depth and wetted surface area will be especially favourable during the dry season. A new *duar* will be created by construction of the Katkhal loop cut at Kaisar, and

- The proposed installation of a fishpass at Koyer Dhala will allow fish to cross the existing *khal* closure. The impact will be greatest during the pre-monsoon flood period, when both adult broodstock searching for spawning grounds, and hatchlings and fingerlings requiring nursery grounds, will be able to access the Kodalia fishery grounds (Figure 8.11).

The expected negative impacts of the project are as follows:

- The two proposed loop cuts will remove existing *duars*, thus resulting in direct and indirect losses of fish production (Figure 8.12), and

- The inundated area of the floodplain will remain constant during the main monsoon flood period, but the duration and depth of flooding will be reduced due to flood protection during the pre-monsoon flood period and improved drainage during the post-monsoon period. This will result in reduced pre-monsoon access to the floodplain and more crowding of fish and reduced growth during the late monsoon, both of which will lower fish production.

As noted above, quantification of impacts is difficult. The breakdown presented below should be considered indicative.

Kalni River Channel
In general, increased water surface area results in increased fish production; however, increased water depth supports higher fish biodiversity and relatively higher production (measurable either as biomass per unit water surface area or unit water volume). Dredging will marginally widen (increasing surface area) and noticeably deepen the channel. Widening is expected to result in a nominal increase in fish production of about 131 tonnes; deepening is expected to increase fish yields by 200-300 tonnes.

Near Katkhal loop cut, the depths in 6 existing *duars* will decrease compared to the present situation. The reduction in depth is estimated to average 27% in the dry season. Three *duars* (Mathabpur, Cherapur, Kanchanpur) will become detached from the mainstream channel and semi-isolated in the loops. At Kaisar, the new loop-cut channel alignment will create a new *duar*, which is expected to dampen the loss in direct production from lost *duars* to about 10% (3 tonnes). The impact of *duar* modification is expected to result in an indirect loss to approximately 1,300 ha of floodplain, which converts to a loss of about 24 tonnes of fish production.

Impacts on fish production at the Issapur loop cut will be minimal. The *duar* at Issapur is likely to remain stable (or possibly scour deeper), while the small shallow *duar* at Bangalpara (a recent unstable formation) will become detached from the mainstream channel and likely fill in again. No net change in fish production is expected.

The increase in fish production due to channel deepening will exceed the decrease due to *duar* modification and loss, resulting in a net gain in fish production from the mainstream river channel. Also, the increased pre-monsoon flows and greater self-scouring capacity of the channel will lead to further deepening of the other mainstream *duars*, thus increasing their capacity to harbour broodstock during the dry season and further enhance production.

Other Rivers
As there is considerable fish traffic between the Kalni mainstream channel and smaller tributary rivers, any increase in Kalni River fish stocks should also result in an increase of fish stocks in other rivers.

Floodplain
The flooded area during the pre-monsoon will be reduced, and this will negatively impact fish production. The loss is dependent on the magnitude of the flood. As can be inferred from Table 8.2, the loss decreases with increasing flood magnitude.

Studies have shown that pre-monsoon flooding is extremely important for breeding migrations and annual restocking of floodplain nursery and grazing habitats. Interference with pre-monsoon flooding can therefore have a major impact on the subsequent monsoon flood grow-out period, even if monsoon flood intensity is adequate.

The proposed fishpass at Koyer Dhala would act to mitigate the negative effect of pre-monsoon flood constriction on fish production on the left bank floodplain around Ajmiriganj by allowing *boal*, *kalibaush*, *gonia* and other important migratory species to enter the tributary system to spawn on the floodplain in greater numbers during the pre-monsoon. Passive drift of hatchlings and fingerlings through the fishpass from upstream areas would further enhance floodplain fish production. The degree to which this will compensate for the loss in pre-monsoon flooding during the average flood return period on both river bank floodplains is, however, unclear. Conservatively, the net benefit recovered might be in the order of 10% to 20%.

More rapid drainage during the post-monsoon will reduce the duration of inundation and the depth. The result will reduce fish production due to a marginally shorter growing period and possibly more crowding. Because the open floodplain is the most productive environment for fisheries, even small reductions in fish growth increments (e.g. 1% or 2%) can lower overall fish production significantly. The proposed project intervention will reduce flooded area progressively from November (highest reduction) through February (lowest reduction) by a total of about 51,500 ha-months as shown in Table 8.3. Monsoon flooding from June to October covers some 260,200 ha of floodplain, and represents 1,301,000 ha-months of flood intensity. The overall loss due to accelerated late monsoon drainage is thus about 4%. Faster drainage would also force a marginal fraction of fish off the floodplain and into overwintering refuge habitats where their growth rate is expected to decrease, resulting in some loss of fish production.

The net impact of the project on floodplain fish production is expected to be an approximate loss of 5%, or 2,078 tonnes.

Beels/Haors

Bank spills and breaches of the river banks during the pre-monsoon season will be reduced and consequently *beel/haor* siltation will also be reduced. *Beel* fish production will accordingly stop being negatively impacted by siltation, and should stabilize at present levels. Stabilization of *beel* habitats will have a positive benefit for floodplain production as overwintering *beel* fish stocks also provide 'seed' for annual restocking of the floodplain environment during the monsoon flood period (in a manner similar to river *duars*). On the negative side, prevention of spills reduces subsequent *beel* production, but this is a much smaller impact than the benefit of reduced *beel* siltation. It is expected that *beel* production will increase by 5.0%, or 1,363 tonnes.

Total impacts on open water fisheries production were analyzed on the basis of catch assessment survey, fisheries effort survey and market survey (Annex H). The magnitude of the expected impacts is summarized in Table 8.12.

8.7.2 Closed Water Fisheries

The project is expected to have a small positive impact on pond fisheries in so far as the flood duration is expected to decrease, thus resulting in a longer growing period for pond fish and reduced risk of pond flooding.

The two proposed loop cuts will create two isolated river loops or ox-bow lakes. These loops will retain hydraulic links to the Kalni River mainstream channel and will thus continue to be fish producing habitats, albeit greatly modified from their original qualities.

Table 8.12: Areas and Fish Production by Habitat Type - Alternative 1

Habitat group	Habitat Type	FWO	FW	
		Production (tonnes)	Production (tonnes)	Impact vs FWO (tonnes)
Riverine	Kalni-Kush. River (without *Duars*)	404	780	376
	Kalni-Kush. (*Duars* only)	303	315	12
	Sub-total	707	1,095	388
	Other flowing rivers	848	1,018	170
	Closed and dead riv.	439	453	14
	Distributaries	147	182	35
	Sub-total Riverine	**2,141**	**2,748**	**607**
Floodplain	Floodplain	40,723	39,476	(1,247)
	Beels	5,684	7,047	1,363
	Ponds	3,834	4,440	606
	Sub-total Floodplain	**50,241**	**50,963**	**722**
	TOTAL	**52,382**	**53,711**	**1,329**

Note: 1. Figures in parenthesis show the reduction in fish production.

8.8 Habitat

8.8.1 Aquatic Habitat

Aquatic Flora
Since the project does not affect the monsoon season water level, there will be no impact on aquatic flora. However, channelization of the pre-monsoon flow and early post-monsoon drainage might have some negative impact on wetland flora due to a reduction in potential life span. These impacts are difficult to quantify.

Aquatic Fauna
The impact on aquatic fauna will be insignificant.

8.8.2 Terrestrial Habitat

Terrestrial flora
The project is expected to impact on the production of vegetables and fruit-bearing trees on village platforms and on the production of high value, non-cereal crops on the dykes and set-back areas of the loop cuts and the Dhaleswari channel fill.

Homestead vegetation
The project will have substantial positive impacts on homestead vegetation by offering increased security against flooding and an increase in available vegetation area due to the newly built homestead platforms. About 90% of the homestead trees are vulnerable to flood damage. As a result, local people are reluctant to plant saplings in their homestead platforms. Increased flood protection and homestead areas will lead to increased tree plantation.

Based on Pilot Project experience, homestead vegetable gardening will expand rapidly on the newly developed platforms and will occupy about 25% of the new area. Hence about 173 ha (112 ha from homesteads and 61 ha for two multi-purpose platforms constructed from the Issapur loop cut) will be available for vegetable gardening and non-cereal crops in the FW project. In addition, it is planned to reuse the dyke set-back areas of the loop cuts for non-cereal crops. The set-back distance is 100 m between the bank of the new channel and the dyke. Between the two loop cuts, about 99 ha will be available for non-cereal crops, keeping 10 m free space along the channel bank and toe of the dyke. Also, the Madna channel filling will provide an additional 58 ha of land to non-cereal crops. Thus there will be a total of about 330 ha available for reuse.

The flood-free homestead platforms will also facilitate plantation of about 120,000 water resistant saplings along the confinement dykes. In addition to providing protection against wave erosion, it is expected that these trees will be partially harvested for wood.

Orchard, Grassland, Roadside Vegetation, Winter Grazing Areas
Impacts on all these types of vegetation will be negligible.

Terrestrial fauna
The project will not have any long-term negative impact on terrestrial fauna.

8.9 Settlements

8.9.1 Village Platform Development

The project will provide substantial positive impacts by developing homestead platforms during the implementation and annual maintenance stages. An area of about 447 ha will be raised as homestead platforms over the 30-year economic life of the project; of this, 335 ha (75%) will be used for rural household development and the remaining 112 ha (25%) is expected to be used for developing homestead vegetation.

About 44 homestead platforms will be developed within a span of five years during the implementation stage. Thirty one (31) platforms will be built on dedicated, privately-owned land, as extensions to existing village platforms. Thirteen (13) platforms will be newly constructed on *khas* land provided by GOB for the settlement of destitute and landless families. The 44 homestead platforms will provide 247 ha of new land for about 6,250 households.

During the operation and maintenance of the project, the equivalent of about 428 ha of land will be required by the Year 2026. Of this, at the expected development rate of 4 platforms per year, about 200 ha of platforms will be developed from project Years 8 to 17. The remaining land will be developed for agricultural use through the green-manuring program (Chapter 9). Based on this assumption, an area of 150 ha (75% of 200, assuming 25% for vegetable cultivation) will be available for homestead development which will facilitate households for 5,000 families.

Experience from the Pilot Project indicates that, although the socioeconomic and organizational characteristics of privately-owned homestead platforms will vary, general patterns can be predicted. For the 31 homestead platforms to be constructed as extensions to existing villages, no land needs to be acquired.

PRA studies indicate that all landowners are eager to dedicate their privately-owned land for use as a disposal site, on the expectation that the land will be returned to them as a developed homestead platform. An owner's land will gain ten times in value when it becomes flood-protected, homestead land. Landowners will use their raised and expanded platform space for improved post-harvest rice processing, vegetable production, cattle rearing, sanitation and water facilities.

However, not all households in the village will benefit equally from platform development. Within the village, the percentage of households directly benefiting from new platform land will vary, according to the configuration of homesteads. The village configuration is in turn, a product of historical patterns of settlement, land exchanges and platform erosion. Even though not everyone in the village will benefit directly from platform ownership, most people will receive indirect benefits from the construction of a flood-protected platform in their village. Community uses of a developed platform include improved school playgrounds as recreational facilities, flood-protected passage during the monsoon, and on some platforms, greater employment opportunities in an expanded market.

8.9.2 Homestead Displacement

Twenty households in Nayapara of Shahebnagar village will be displaced due to construction of the Katkhal loop cut. Nayapara is located about 100 m west of Shahebnagar school, on the left bank of the Kalni River. As compensation and mitigation, the residents of Nayapara will be re-located to a new platform to be constructed on the northeast corner of Shahebnagar village. A plan for their compensation and mitigation has been prepared (Chapter 9).

8.9.3 Impacts due to Land Acquisition

A total of 491 ha of land will be acquired for the implementation of the project. Of this, 216 ha is required for the Issapur loop cut, 195 ha for the Katkhal loop cut, 44 ha for the disposal sites located downstream of Abdullahpur village, 13 ha for the Anandapur disposal site, 20 ha for the construction of levees, and the remaining 3 ha for navigation disposal sites. Field information indicates that the land related to the loop cuts is private and the remaining is mostly *khas* land.

Of the 216 ha of land to be acquired for the Issapur loop cut, 106 ha will be re-used for non-cereal crops by the affected landowners. The remaining land will be required for the new Issapur channel and the embankments. Similarly at Katkhal, of the 195 ha to be acquired for the loop cut, 54 ha will be re-used by the affected landowners. A proportionate re-use of land has been incorporated into the compensation and mitigation plan for private landowners (Chapter 9).

8.9.4 Water, Sanitation and Health

Based on Pilot Project experience, it is anticipated that with expanded space, households will be willing to improve their sanitation and water facilities. On a cost-sharing basis, the project will assist 6,250 households on 44 homestead platforms to construct water seal latrines. Access to tubewell water will be provided for 1,250 poor households who will be settled on the 13 new (*khas* land) platforms. For 5,000 households on 31 existing homestead platforms, tubewells will be provided to supplement the domestic water sources lost as a result of platform extension.

The installation of tubewells and sanitary latrines on homestead platforms will contribute to the GOB's goal of universal coverage. Access to clean water for both drinking and domestic purpose and the proper disposal of human waste will reduce the incidence of water-borne diseases. In addition, proximity to tubewell water represents a time saving for women of the household. During the monsoon season, women, children and the elderly will be particularly convenienced by access to a sanitary latrine on raised compound land.

8.9.5 Status of Women

On the newly created land of expanded homestead platforms, women will play an enhanced role in production through rice processing, homestead gardens and livestock and poultry rearing. However, women will need the economic resources and the organizational capacity to contribute to protection and maintenance of the new platforms. In the remote project area, women have not been exposed to any of the development programs, widely found in other rural areas of Bangladesh. They have no form of gender-specific groups or organizations, and no access to education, technical knowledge or credit. Women have had no effective role on the platform committees in the Pilot Project communities. This issue will be addressed in part through a women-oriented program included in an extension of the Pilot Project (1997-98). Furthermore, following construction, a community development component will be provided in platform villages for a three year period. During that time, the community will be strengthened to assume platform maintenance responsibilities and expand homestead production.

Gender-specific initiatives are included in both the Environmental Management Plan and in proposed Capacity Development initiatives (Chapters 9 and 10).

8.9.6 Quality of Life

In the FW project, quality of life will be enhanced through people's improved material standards in homestead security, income, nutrition, sanitation, health and education.

Human Security
Human security, as defined in the UNDP's Human Development Report (UNDP, 1996), represents safety from such chronic threats as hunger, disease and repression, as well as protection from sudden and hurtful disruptions in the patterns of daily life. On raised homestead platforms, an estimated 11,250 households will gain increased flood-security during the implementation and O&M stages. Households will spend less on homestead shifting and land-raising when they have a more flood-secure platform. Improved water and sanitation facilities for these households will be reflected in their improved health.

In the project area as a whole, small and medium farmers will benefit from improved agricultural production. The process of pauperization may be slowed when farmers with improved harvests and flood-protected homesteads are less likely to lose their land through indebtedness.

Some percentage increase in household income is anticipated, and this generates indirect benefits. For example, if a 10% increase in income is assumed for all households, the proportion of the population below the poverty line (both absolute and hard-core) will be reduced by about 5%. An increased household income will allow a greater expenditure on nutritious food and health care and provide an opportunity for poorer families to send their children to school. In villages where raised platforms provide passage during the monsoon, children will have year-round access to schools. An assessment of this benefit - which is lumped into a number of quality-of-life factors - is included in the economic analysis.

Socioeconomic Equity
It is suggested that a public investment project of this nature will largely enhance privately owned resources and distribute benefits in favour of the wealthier land owners. In the highly stratified society of the rural project area (Chapter 3), the only way to assure that benefits reach women and men from destitute households will be to specifically target these groups in a structured development program. Such an approach is termed "targeted poverty alleviation", to differentiate from the overall poverty alleviation which will accrue to the whole project area, as a result of improved agriculture. Therefore a "Landless Settlement Program" which is targeted at the landless, is included in the project (Section 9.4.5).

8.9.7 Poverty Alleviation

Project-specific *a priori* measures which indicate the extent to which the relatively poor will directly benefit from the Project are the following: a) food availability; b) agricultural employment; c) non-agricultural employment; d) land tenure; e) transportation infrastructure ; f) community infrastructure, and g) overall impact. Each of these anticipated impacts is briefly summarized as follows:

Food Availability
There are at least four elements to this; crops, fisheries, garden and fruit trees, and livestock. The expected change in crop food availability per person with and without the project has been calculated and is presented in Table 8.13.

Table 8.13: Per Capita Crop Food Availability

Crop type	Per Capita Crop Food Availability (kg/day)			
	Present	FWO Year 15	FW Year 15	Change (%)
Rice/Cereal	0.94	0.66	0.75	+13.5
Non-Cereal	0.04	0.04	0.03	-16.9

With respect to fisheries, the FWO projection suggests a gradual decline of about 12%. Most of this loss would be prevented in the FW situation. This is very significant in that an estimated 60% of all households in the Kalni-Kushiyara River region (and these are often relatively poor households) are fish-dependent. For 28% of all households, fish is their primary source of income.

Up to 90% of homestead trees and gardens are also presently vulnerable to flood damage. Proposed platform development will enhance these production opportunities for an estimated 6,250 families in the first 10 years of Project development; 11,250 families by Year 20. Kitchen gardens and fruits increase both nutritional standards and flood security. They typically contribute about 7% to total farm family income (Hossain, 1994).

Finally, additional flood protection will also provide additional security and encourage additional growth of the livestock sector. Assuming this was proportional to projected crop production changes, the net value of this incremental production could increase by about 10%. Livestock production already accounts for about 11% of farm household income (Hossain, 1994).

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Agricultural Employment Opportunities
Largely due to crop production increases, labor requirements will climb by approximately 10% for harvest and post-harvest activities (including drying). This translates into a 2.4% overall increase in agricultural employment. This is particularly important in three respects; 1) underutilization of labor during the *boro* (winter) season is reduced; 2) it would affect women disproportionately more because they conduct most post-harvest activities at the homestead, and 3) it would be particularly beneficial to the landless and the relatively poor (often one and the same).

According to NERP Household Survey, the poor mainly depend on wage labor for their survival. Nearly one-half of all farm households secure at least some income from farm labor.

Non-Agricultural Employment Opportunities:
This includes employment in the fisheries and water transportation sectors, as well as additional activities at the village level. Assuming the 1995 population of 1.89 million increases by 1.77%/year, the general magnitude of this expansion is expected to be as Table 8.14.

Table 8.14: Non-Agricultural Employment Opportunities

Sector	Existing (person year)	Expansion (person year)	Change (%)
Fishing	100,000	2,400	2.4
Water Transportation	20,000	1,000-2,000	5 to 10

Land Tenure
This has two elements which are relatively beneficial to the poor; a) FW scenario will reduce the rate of land concentration and increasing landlessness, and b) some landless will be specifically targeted for homestead land access.

Bandak is the traditional and widespread credit and mortgage system. Under this system, the lender (usually larger farmers and traders) holds the right to cultivate the mortgaged land and get all the benefits from it until the loan is repaid. If one is not able to repay the loan within a stipulated period, the land is forfeited to the lender. Improved flood management will reduce the loss of land due to the forfeiting of mortgaged collateral.

Approximately 1,250 destitute and landless households will also be specifically targeted for resettlement on the new platforms proposed for Abdullahpur Dokkhin Char (12) and Anandapur (1). It is expected that activities related to children's schooling, women's vocational training, micro-credit and intensive horticulture programs will be developed for these landless households to supplement the income they earn as agricultural laborers.

Transportation Infrastructure
Aside from additional direct employment in navigation, there are 3 additional impacts which could provide a very substantial impetus to growth and sustainable development in the region: a) enhanced marketing and commercial activities during the *boro* season; b) potential passenger benefits, and c) potential international traffic benefits. During the *boro* season, a Class II waterway will allow for the improved movement of both inputs (e.g. fertilizer) and outputs (e.g. rice and fish). Consistent with the international literature on feeder roads, this could alone increase production and long-term income opportunities in the hinterland (defined as a 10 km river band) by about 10%.

Community Infrastructure
Numerous enhancement measures are proposed in conjunction with the village platform development, tree plantations, straw soil enhancement, *Dhaincha* soil enhancement, a plantation of water-tolerant shrubs and grasses, *Chailla* grass production, potable water tubewells (1/10 HH), and latrines. These are progressive measures which will further help empower the relatively powerless, particularly women and the relatively poor.

Overall Poverty Alleviation Impact
The proposed KKRMP would reduce risk and uncertainty; thus gradually changing attitudes and giving more hope and opportunity to the region (particularly the less-empowered). The immediate result will be additional private capital investment and growth. The attitudinal change itself, however, is the most important single ingredient in the gradual development of a more sustainable regional economy in a very fragile and unforgiving physical environment. This can become well-engrained during the very pro-active initial construction and employment period. It sends a message "Somebody cares; we can do it." And then they will.

8.10 Alternative 2

8.10.1 Background

For the most part, Alternative 2 is similar to Alternative 1. The only difference in physical interventions is that for Alternative 2, the Issapur Loop Cut is replaced by increased channel re-excavation and maintenance dredging along the nearby Dhaleswari channel. For the most part, impacts from Alternative 2 are also similar to Alternative 1, except for the local area around the Baida-Dhaleswari reach of the river between Issapur and Kalma (Figure 8.13).

These differences in physical interventions will result in some expected local differences the most significant of which is to agriculture on the Ratna floodplain north of Madna.

Table 8.15 summarizes the differences between Alternatives 1 and 2. There are 5 areas that will have a significant difference: river morphology, hydrology, water resources infrastructure, agriculture and settlements. These topics are discussed below.

Table 8.15: Difference between Alternative 1 and 2

Effect on:	Significant Difference	Insignificant or No Difference
River Morphology & Sedimentation	●	
Hydrology	●	
Water Resource Infrastructure	●	
Agriculture	●	
Settlements	●	
Water, Sanitation & Health		●
Status of Women		●
Quality of Life		●
Navigation		●
Fisheries		●
Aquatic Habitat		●
Terrestrial Habitat		●

8.10.2 Future Evolution of the River

Discharges
Under Alternative 2, the magnitude of the discharges and the flow split between the Baida and Dhaleswari River channels will remain approximately the same as at present. Under the FWO scenario, the Dhaleswari branch will become essentially abandoned (due to the diversion through the Cherapur Khal). Therefore, the discharge regime in the Dhaleswari branch should be preserved at its present condition provided the ongoing dredging operations are continued.

River Morphology and Sedimentation
Without the Issapur loop cut, it is expected that the historical pattern of deposition will continue to occur in the Kalni-Dhaleswari reach. Hence, in Alternative 2, additional capital and maintenance dredging will be carried out to preserve the conveyance of the channel in the lower part of this reach. It is estimated that an additional volume of 23 million m^3 over the 30 year project period will need to be dredged. With this dredging, the Alternative 2 will stabilize the current regime, which means there should not be any significant downstream changes from the present situation. The main impact differences from Alternative 1 are as follows:

- the Baida channel will remain the dominant channel and will not be diminished;
- erosion along the left bank of the Dhaleswari will likely increase, and
- temporary deposition downstream of the Issapur loop cut will not occur.

Hydrological Characteristics- Water Levels and Flooding Extent
Impacts on pre-monsoon water levels will be similar than for Alternative 1 except in the lower reach of the Kalni river between Madna and Kadamchal. In this reach, the pre-monsoon water levels will remain close to the present conditions, and will be up to 0.45 m higher than with Alternative 1.

Table 8.16 (compare to Table 8.2) summarizes the extent of inundation in the gross project area for Alternative 2. Compared to the FWO scenario, Alternative 2 will increase the flood-free land by about 47,000 ha during a 1:5 year pre-monsoon flood. This value is roughly 8,000 ha lower than for Alternative 1, and mainly reflects lower benefits along the Ratna floodplain area north of Madna.

Table 8.16: Impacts of Pre-Monsoon Flooding - Alternative 2

Depth of Flooding	1:2 year Pre-monsoon Flood		1:5 year Pre-monsoon Flood		1:10 year Pre-monsoon Flood	
	FWO (ha)	FW (ha)	FWO (ha)	FW (ha)	FWO (ha)	FW (ha)
"Flood-free" (< 0.3 m)	235,867	291,784	96,215	143,342	40,886	79,722
0.3-0.9 m	53,351	20,153	69,793	62,696	44,430	27,617
0.9-1.8 m	37,252	17,975	113,863	86,942	121,482	121,343
>1.8 m	9,130	5,688	55,729	42,620	128,802	106,918
Total Flooded Area	**99,733**	**43,816**	**239,385**	**192,258**	**294,714**	**255,878**
% Inundation	**30**	**13**	**71**	**57**	**88**	**76**
Total Project Area	**335,600**	**335,600**	**335,600**	**335,600**	**335,600**	**335,600**

8.10.3 Water Resources Infrastructure

Without the Issapur loop cut, pre-monsoon water levels in the Khowai and Baulai rivers would be reduced to a lesser extent than for Alternative 1. Similarly, pre-monsoon drainage would be facilitated to a lesser extent in these rivers. Alternative 2 would, therefore, reduce or perhaps nullify potential benefits in the Khowai River project, as well as in some or all of the 17 submersible embankment projects in the right-bank floodplain of the Baulai River.

8.10.4 Agriculture

Table 8.17 (compare to Table 8.7) summarizes the extent of inundation of net cultivable land in the project area for Alternative 2. Compared to FWO project scenario, Alternative 2 will increase the flood-free land by about 47,000 ha during a 1:5 year pre-monsoon flood. This value is about 8,000 ha lower than for Alternative 1. Accordingly, agricultural benefits are less. The expected increase in annual rice production between FWO and Alternative 1 is 82,800 tonnes (13.4%); and between FWO and Alternative 2 this drops to 74,000 tonnes (12%).

Table 8.17: Pre-monsoon Flood Extent on Cultivated Land - Alternative 2

Flood Depth Range	1:2 year Pre-monsoon Flood		1:5 year Pre-monsoon Flood		1:10 year Pre-monsoon Flood	
	FWO (ha)	FW (ha)	FWO (ha)	FW (ha)	FWO (ha)	FW (ha)
"Flood-free" (< 0.3 m)	200,987	257,218	61,336	108,776	6,007	45,156
0.3-0.9 m	39,808	20,153	56,249	49,200	30,886	14,121
0.9-1.8 m	28,140	17,975	104,751	77,880	112,370	112,281
>1.8 m	8,010	5,688	54,609	41,568	127,682	105,866
Total Flooded Area	**75,958**	**43,816**	**215,609**	**168,648**	**270,938**	**232,268**
% Inundation	**27**	**13**	**78**	**61**	**98**	**84**
Total Cultivated Area	**276,945**	**277,424**	**276,945**	**277,424**	**276,945**	**277,424**

8.10.5 Settlements

At present, 11 disposal sites have been identified in the area. The right river bank is already densely settled and has very little agriculture or *khas* land. The left bank is less populated with low, privately owned agricultural land but very little *khas* land. Stretches of the reach between Issapur and Laura have no villages along the right bank. Maintenance dredging in the Dhaleswari reach will require constructing 3 to 4 new platforms/year over the life of the project.

It could be problematic to dispose off the spoil in Alternative 2. The volume of dredging is higher than in Alternative 1 and there may not be sufficient nearby homestead sites to accommodate the spoil. This may require the acquisition of agricultural land for the disposal.

8.11 Comparison of Alternatives 1 and 2

Alternative 2 does not consider the Issapur loop cut and increases capital and maintenance dredging in the Dhaleswari River. Early on in the study, Alternative 2 was formulated to investigate an alternative to the Issapur loop cut and its adverse impact at Chowdanta and Bhatura (local communities located in the general vicinity of the proposed loop cut channel), while achieving the same upstream benefits as Alternative 1.

After the study team's investigation of the physical, social and economic impacts of Alternative 2, several conclusions became apparent:

1. Alternative 2 can not achieve the same benefits as Alternative 1. Alternative 2 results in higher upstream, pre-monsoon water levels and less flood-free land, primarily in the Ratna River floodplain area north of Madna. This results in a decrease in the net flood-free land, and hence a reduction in agricultural production which is the main economic benefit of this project.

2. Alternative 2 requires increased capital dredging, but more importantly, it requires a commitment to increased maintenance dredging over the life of the project and beyond. Further, project benefits will be lost quicker and perhaps permanently if maintenance dredging is not done properly. Given that maintenance is key to the sustainability of this project, this is believed to be a serious constraint.

3. As a result of the increased maintenance dredging, there will be a need for more disposal sites in a localized area between Issapur and Madna. Although at this time, 11 additional village platform sites have been identified; obtaining sufficient platform disposal sites could become problematic in the future.

4. Field investigations concluded that the negative impacts of Alternative 1 to Chowdanta and Bhatura villages can be satisfactorily compensated and mitigated in an environmental management program.

Considering the above, a decision was taken to conclude the study by focussing only on Alternative 1. Hence, the Environmental Management Plan and Capacity Development approach (Chapters 9 and 10) focus on only Alternative 1. However, economic analyses for both Alternatives are presented in Annex E - Economics.

9. ENVIRONMENTAL MANAGEMENT PLAN

9.1 Introduction

The purpose of this environmental management plan (EMP) is to provide specific environmentally-related action plans that will be carried out during the Implementation and Operation and Maintenance (O&M) phases of the project. This action plan will manage the negative post-implementation impacts discussed in Chapter 8, and the negative short-term (implementation) impacts discussed in the Environmental Impact Assessment (Annex I). Actions taken under this EMP will reduce the negative impacts to an acceptable level and make the project environmentally friendly. The plan also includes monitoring. This is necessary to ascertain whether the measures taken for reducing the impacts are adequate, and to verify whether any unanticipated impacts occur. In order to capitalize on the positive impacts resulting from the project interventions, an enhancement program has also been included in this plan. The EMP has 6 components:

- Compensation Plan;
- Environmental Protection Plan;
- Enhancement Plan;
- Contingency Plan;
- Monitoring Plan, and
- Training Plan.

As indicated in Chapter 8, this EMP applies only to Alternative 1.

In this Chapter, the costs labelled as "*budgeted in the EMP*" do not include contractor's nor consultant's (labor and expenses) costs. The contractor's costs are budgeted under the project Capital Infrastructure Costs and the consultant's costs are budgeted under the Project Study Costs.

Moreover, the long-term benefits monitoring program (Section 9.6.7) costs are also not budgeted in the EMP. Although, the monitoring programs costs (Sections 9.6.1 to 9.6.6), during the construction phase of the project, are budgeted in the EMP.

The budgeted EMP costs are summarized in Section 9.9.

9.2 Compensation Plan

9.2.1 Land Acquisition

Impact
About 411 ha of agricultural land will be acquired for the construction of the Issapur (216 ha) and Katkhal (195 ha) loop cuts.

Compensation
The BWDB, in its pre-construction phase cadastral survey, will determine the registered land ownership and the value of land to be expropriated for the loop cuts. Values will be based on agricultural capability, location, recent land transactions and other parameters normally used for calculating the land values. Land acquisition will be discussed with individuals affected and through participation, the most appropriate form of compensation for each affected landowner will be decided.

As a further compensation for the effects of land loss as a primary source of income and economic resource, a total of 160 ha of high land on both sides of each loop cut will be proportionately returned back to landowners in the loop cut areas for re-use in intensive agriculture. After completion of construction, it is anticipated that the set back areas will be ready for re-use within 2 to 3 years.

Based on the precedent set by the Jamuna Multipurpose Bridge in resettling project affected persons (PAPs), the following compensation package plan is proposed for the landowners:

- allocate 106 ha of reusable land to Issapur affected landowners in compensation for the acquired land;
- similarly, allocate 54 ha of land to Katkhal affected landowners;
- allocate 20% (appropriation value) cash grant to Issapur and Katkhal affected landowners to use in income generating activities;
- employ the affected poor in project's construction and O&M activities, and
- allocate nearby *khas* land to the affected landless persons.

Compensation should be carried out in a manner similar to that used for the Jamuna Multipurpose Bridge resettlement program. This approach ensures that each land owners will receive cash in hand that reflects the current market value of the land. One payment only should be made (not by instalments) immediately upon signing of the land title transfer.

An EMP cash grant for Issapur and Katkhal affected landowners has been budgeted based on current land prices obtained from field interviews.

Another 80 ha of land also needs to be acquired for disposal sites downstream of Abdullahpur and Anandapur, for navigation as well as for construction of levees and structures. These are *khas* lands and do not require to be budgeted in the EMP beyond the original cost of land acquisition (Section 8.9.3).

9.2.2 Crop Loss

Impact and Compensation

Crop will either be damaged or prevented from cultivation during the installation of shore pipelines, construction and filling of effluent outlet channels, and collecting earth for the maintenance of dykes. Crop compensation is budgeted for the platforms where agricultural land is privately owned. No compensation will be made for land acquired for the various project components.

Responsibility

BWDB will be responsible for crop compensation except when it relates to dyke construction and maintenance. The earthwork contractors will be responsible for crop compensation for any work related to dyke construction and maintenance. The consultant will select the pipeline route and effluent outlet route in association with the local people and will facilitate the compensation.

9.2.3 Homestead Loss

Impact and Compensation
Homestead loss includes loss of large fruit trees, latrines and ponds due to the extension of the existing homestead platforms. Costs for homestead loss are budgeted in the EMP.

Responsibility
BWDB will ensure compensation to the affected landowners. The consultant will facilitate the compensation process.

9.2.4 Fishers

Impact and Compensation
Fishers, particularly along the Issapur and Katkhal loop cuts may be partially impacted. They should be compensated. It is proposed to lease the new channel sections to these affected fishers.

Responsibility
BWDB and the consultant will be responsible for this activity.

9.3 Environmental Protection Plan

The Environmental Protection Plan (EPP) includes specifically a mitigation plan. The EPP is designed to protect the environment from deterioration due to project construction. Responsibilities have been assigned to implement this mitigation plan.

9.3.1 Local Employment

Impact and Mitigation
Landless households in the 2 loop cut areas may lose a portion of their annual income through the loss of agricultural labor opportunities. However, this will be mitigated by the provision of assured labor opportunities during the implementation and O&M phases. The pilot project experience indicates that labor contracting societies earn approximately 16% more than they can earn as sub-contracted labor. The following mitigation measures will be applied:

- the contractor shall, to the maximum possible extent, employ local labor for manual earth works. Local female labor must comprise at least 25% of the work force for earthwork, and

- during the O&M phase of the project, local labor should be provided with direct contracting opportunities through their own landless groups.

Responsibility
BWDB will be responsible for local employment: 1) through the contract documents during the implementation stage and 2) by providing contracts directly to the landless groups during the O&M stage. The consultant will maintain liaison between the project engineer and the contractor to obtain fair wage and working conditions.

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9.3.2 Labor Camp

Impact and Mitigation

Considering the amount of labor which will be required, it is anticipated that local labor (both female and male) will travel long distances to the work sites. The contractor must provide secure overnight camp facilities, including adequate water and sanitation, for the local laborers. BWDB standard rules relating to layout, water supply, canteen, sanitation and security both for the workers and the local population in labor camp must be strictly followed.

Responsibility

The contractor will be responsible for these facilities. BWDB field officials and the consultant will ensure that camp facilities will be as per BWDB standard rules.

9.3.3 Landing Facilities

Impact and Mitigation

The Issapur loop cut will disrupt the easy access of Bhatura villagers to a high school and administrative installations. To mitigate their loss of access, landing facilities *(ghats)*, will be provided on both banks of the river. These will be at Chowdanta village and at a place mid-way between Bhatura and Issapur villages. The cost for the construction of 4 *ghats* is budgeted in the EMP.

Responsibility

BWDB will be responsible to install these *ghats* through the contractors. The consultant will facilitate the selection of locations in association with the local community people.

9.3.4 Market Facilities

Impact and Compensation

To mitigate the Chowdanta villagers' loss of easy access to the market and to provide an opportunity for the development of trade and small business in the area, a market will be developed at Chowdanta. The market area will be provided with drainage, water and sanitation facilities. Shopkeepers will be expected to develop their own structures.

The cost for these market facilities are budgeted in the EMP.

Responsibility

BWDB will carry out this activity through the contractors. The market should be planned, designed and implemented with platform drainage and access facilities. The consultant will facilitate selecting the location and the number of shops in association with the Chowdanta people.

9.3.5 Relocation of Households (HHs)

Impact and Mitigation

About 20 HHs will be displaced due to construction of the Katkhal loop cut particularly at the Shahebnagar section. The Nayapara HHs to be displaced, are vulnerable to severe river erosion, particularly in the pre-monsoon period. Despite the fact that they will lose homestead land, the Nayapara HHs support construction of the loop cut. They will accept relocation to flood-secure land as a highly desirable alternative to erosion. Loss of their homestead land, houses and outbuildings represents both an economic and social loss. This should be compensated and mitigated.

The Nayapara HHs will be permanently relocated on homestead platform No. 31 (Figure 7.15). The platform will be constructed on the silted-up offtake of the Kalni River, located on the northeast corner of Shahebnagar village simultaneously with the guide embankment of the new channel. The platform is scheduled to be completed between Years 3 and 4. The proposed excavation plan and location of Nayapara HHs indicates that they can stay in places until the completion of homestead platform 31. Each HH will be provided with 20 decimals of land and a cash grant. This will cover land raising, house and outbuilding construction, and drinking water supply and sanitation facilities.

Costs for this relocation program are budget in the EMP.

Responsibility
BWDB will facilitate the relocation plan and give the cash grant. In association with the appropriate local committee, the consultant will execute the plan and will ensure land titles are secured for these relocated villagers.

9.3.6 Drainage from Adjacent Lands

Impact and Mitigation
Extension of an existing platform, when it is connected to more than one village *(para)*, may disrupt the existing surface drainage systems from the adjacent lands. For example, during the implementation of the pilot project, the Kakailseo platform disrupted the natural drainage system from the adjacent *paras*. It had to be re-established from the project budget. Costs to address this issue are budgeted in the EMP. However, special attention should be given to avoid this issue as much as possible during the planning and selection of disposal sites.

Responsibility
BWDB and the consultant will be responsible for this mitigation. The mitigation plan should be executed through the same contractor responsible for the construction of confinement dykes.

9.3.7 Irrigation Network Systems

Impact and Mitigation
The existing irrigation network systems (earthen canals) may be disrupted during the installation of shore pipelines and construction of effluent outlet channels. As a mitigative measure, the disrupted sections will be reinstalled by the project. In the pilot dredging project, the disrupted sections were temporarily rehabilitated by installing pipes across the effluent outlet.

Responsibility
The contractor will be responsible for the reinstallation of irrigation network systems. BWDB and the consultant will arrange land required for these activities.

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9.3.8 Road Shifting

Impact and Mitigation
In some village, communication systems will be disrupted. All riverine communities have earthen, raised roads leading from the *haor* and river to their existing platforms. These roads are critical in transporting the harvested grain. Some village roads may require rerouting for the installation of shore pipelines and construction of the effluent channel and the confinement dykes. Costs for road shifting are budgeted in the EMP.

Responsibility
The consultant will prepare and execute the mitigation plan in association with the local people. BWDB will facilitate the program. The mitigation plan should be executed through the same contractor responsible for the construction of confinement dykes.

9.3.9 House Shifting

Impact and Mitigation
To facilitate the construction of confinement dykes, particularly along the existing platforms, some houses may require shifting. Based on the pilot dredging project experience, costs for shifting 6 houses per platform are budgeted in the EMP.

Responsibility
The consultant will prepare and execute the house-shifting plan in association with the affected people. BWDB will facilitate the program.

9.3.10 Supplementary Tubewells

Impact and Mitigation
The extension of existing platforms will infill sources of domestic water supplies. These are generally ditches, located behind the houses. The disruption of domestic water supplies will be mitigated through the installation of supplementary tubewells.

Based on the pilot dredging project experience, costs assuming 1 tubewell per 50 HHs are budgeted in the EMP.

Responsibility
The consultant will prepare the plan and install the tubewells in association with the local people. BWDB will facilitate the tubewell installation plan.

9.3.11 Water Quality Protection Measures

Impact and Mitigation
Disposing of the dredged spoil in a properly designed containment chamber is the primary mitigation measure that will be used to control turbidity releases. In addition, *tarja* walling and silt curtains will be placed in the disposal chambers in such a way as to maximize the retention time of the turbid waters. If needed, some barriers could also be installed at the place where the effluent discharges into the river.

Based on the pilot dredging project experience, costs for the water quality protection measures are budgeted in the EMP.

Responsibility
The contractors will be responsible to control turbidity through the specified methods. The consultants will monitor turbidity at regular intervals. The consultant will identify required mitigative measures at specific sites and execute them through the contractors. BWDB will facilitate the program.

9.4 Enhancement Plan

9.4.1 Platform Protection

The objective of this enhancement plan is to achieve long-term sustainability and to reduce the O&M cost of the new platforms against wave erosion through non-structural measures. The non-structural measures mainly include:

- plantation of water-tolerant trees;
- development of nurseries;
- protection and care of trees, and
- *chailla* production.

Plantation of Water-tolerant Trees
The long-term sustainability of the new platform will be greatly dependant on the plantation of water-tolerant trees, shrubs and grasses along the toe of platform dykes. These non-structural measures dissipate wave energy. They have been proven by the *haor* society to be one of the best methods of protection against wave action.

The water-tolerant trees, *hizol* and *koroch* species, were identified as the most suitable for protection against wave erosion. However, preference should be given for plantation of more *koroch* saplings since its pattern of branching is more effective in dissipating wave energy. Moreover, *koroch* trees are less likely to be harvested for fuel than *hizol*, which have also a higher market value for use in constructing fish *kathas*.

Approximately 120,000 water-tolerant trees will be required for the project including the mortality rate based on pilot project experience. Most of the trees will be produced in the project nurseries, which may require about 4 to 5 years to produce initial supplies.

To meet the initial demand of trees at Katkhal, Kadamchal and Shibpur disposal sites in Years 3 and 4 (Figure 7.22), particularly for the soft protected length, about 20,000 man-height trees will be purchased directly from the suppliers. Costs for these 20,000 trees are budgeted in the EMP.

Nurseries
Two central and eight village nurseries will be developed to produce the remaining 100,000 water-tolerant trees. The central nurseries will have the capacity to produce 20,000 saplings per year.

The 8 village nurseries will be established throughout the project area. Poor women will be targeted to work in the village nurseries. Year-old *koroch* saplings will be provided from the central nursery to the village nurseries for their growth up to 3 years. The project will purchase man-height trees from these village nurseries at the rate of Tk 10/tree.

Costs for the plantation program are budgeted in the EMP. This includes development and management of 2 central and 8 village nurseries; initial purchase, management and maintenance of 100,000 saplings for the central nurseries as well as purchase of adult-size trees from the village nurseries.

Central and village nurseries should be established between Years 1 and 2 in order to meet the project requirements. However, one central nursery could be established on the relocated platform (Section 9.3.5) which can also be used during the O&M of the project.

New platform landowners will also be encouraged to plant shrubs and grasses at the toe and lower slopes on their own section of dyke to be protected. This includes mainly *ikor* (Sclerostachya fusca), *dhol kolmi*, *murta* (Clinogyne dichotoma), and *nol kagra*. These plants can be partially harvested while leaving the main stock intact. However, to ensure that shrub and grass coverage is provided for all platforms, an EMP budget item is identified for this activity.

In all cases, a 3 to 5 m strip for plantation is required at the toe of the platform. Those who dedicate land for the platform will also be obliged to dedicate space outside the platform for plantation.

Responsibility
BWDB will be responsible for the purchase of water-tolerant trees, establishment of nurseries and quantity control of the plantation program. The consultant will facilitate the purchase and establishment of the nurseries. They will also ensure training, management, the supply of trees and the execution of plantation program as per plan.

Protection and Care of Trees
The water-tolerant trees are subject to damage from animal grazing. These trees will be protected with bamboo baskets. Plantation must be done immediately after the post-monsoon drainage. To ensure their survival rate, these saplings will require watering for a period of about 4 months.

Costs for the protection and care of trees are budgeted in the EMP.

Responsibility
The protection and watering of trees along the embankments of Issapur and Katkhal loop cuts will be done by appointing women workers. The dedicated platform owners will be responsible for care of the trees along their own section. The consultant will be responsible for the execution of the program. BWDB will be responsible for payment and supervision.

Chailla Production
The vegetation preferred in traditional platform protection is *chailla* grass because of its capacity to withstand decay over a lengthy submersion period. NERP studies show that current *chailla* production is not sufficient to meet the project requirements.

Chailla production needs to be enhanced in order to fulfil the project demand. Farmers will be encouraged to grow more *chailla* through the provision of production grants.

EMP grants for *chailla* production are budgeted in the EMP.

Responsibility
The consultant will be responsible for the *chailla* production plan, the execution of program and the availability of *chailla*. BWDB will facilitate the program through payment and supervision.

9.4.2 Top Soil and Green Manuring

The objective of this enhancement measure is to improve the soil structure and productivity of the dredged spoil in order to protect the site from erosion, health and environmental hazards and optimize the land use. One possible approach is to produce biomass on the platform by utilizing quick growing plants, ensuring a faster recycling and decay process. Other methods will involve creation of a biologically active living soil environment and management practices. These activities are divided into short-term and long-term management practices.

Short-term activities mainly include plantation of quick growing plants (African *dhaincha*), wherever the season permits once chamber filling has been completed. When they are about 60 cm long, the plants will be cut and mixed with the dredged spoil and covered by about 15 cm topsoil. *Dhaincha* plantation could be repeated for better soil enrichment. If the season does not permit *dhaincha* cultivation, straw/water hyacinth will be used. The topsoil will be taken from the exterior surface of confinement dykes, placed there in excess during the construction of the dykes. This operation should be carried out during the second dry season after the short-term settlement of the dyke section and the dredge fill material has taken place.

Long-term activities include research and creation of a biologically active living soil environment, along with associated management practices. The need and demand for village platforms could be limited in the long-term and consequently local people may not be interested to dedicate their land for homestead platforms. Therefore, the long-term research program concerning the agricultural use of dredge spoil becomes a prerequisite for the project. Preliminary studies indicate that depth of dredged spoil is a critical factor for its quick agricultural use. It is proposed to carry out this research activity as a part of the project. This research program could be carried out at the navigation disposal sites.

Costs for the green manuring program are budgeted in the EMP with the exception of the cost of topsoil which is budgeted in construction costs.

Responsibility
The consultant will be responsible for the execution of the short-term program in association with the beneficiaries. In the places where *dhaincha* cultivation is not possible due to seasonal constraints, the consultant will prepare a joint venture plan to place straw and water hyacinth simultaneously with the activities of topsoil and dyke maintenance.

BWDB will provide their agronomists and soil experts for the long-term program. They will be guided by the Bangladesh Agriculture University (BAU) and Dhaka University experts. The consultant will coordinate the program and will prepare the research plan in association with the BWDB, BAU and Dhaka University experts.

9.4.3 Drinking Water Supply

Approximately 1,250 landless households will be settled on 13 new homestead platforms (Sites 6 to 17 and 39) as a part of the project plan. To improve the basic water supply and sanitation facilities, the project will provide hand tubewells based on the standard criteria of 1 tubewell/10 HHs.

Costs for these hand tubewells are budgeted in the EMP.

Responsibility
The consultant will prepare and finalize the land use plan in association with the local people. Approval of the plan from the village platform committee and execution of the program will also be the responsibility of the consultant. BWDB will facilitate the approval and execution of the program.

9.4.4 Sanitation

In the project area, about 95% of the households have an unacceptable standard of sanitation facilities (hanging latrine and open space). This is even far below the national standard of unacceptable (52%) and sanitary latrines (48%) based on 1996 UNICEF statistics.

Field studies show that the households are willing to install sanitary latrines on their extended platforms, but they need support. In order to improve sanitation facilities, the project plans to provide water-seal latrines in all the newly-built homestead platforms.

Each household will be provided with a water-seal latrine consisting of three masonry rings and a slab. The households will install the superstructure according to their capabilities and choice.

Costs for 6,275 water-seal latrines are budgeted in the EMP.

Responsibility
The consultant will execute the program in association with the beneficiaries. BWDB will facilitate the program.

9.4.5 Landless Settlement Program

A 1,250 HHs landless settlement program, using the proposed 13 platforms at Abdullahpur Dokkhin Char and Anandapur, will be developed on the *khas* land, arranged by the Ministry of Land (MOL). The criteria for the 1,250 HHs to be settled will be based on similar projects executed by MOL. People owning neither homestead nor agricultural land will be given priority. Each household will be settled on 10 decimals of land and will be provided a cash grant.

The platforms will be enhanced with tree plantation, soil enrichment, latrines and tubewells (Sections 9.4.3 and 9.4.4). A cash grant for the 1,250 HHs landless settlement is budgeted in the EMP.

Responsibility
The proposed landless settlement will be carried in association with MOL, and finally it could be a project of MOL. The deputed personnel from MOL and BWDB will prepare the settlement

plan in consultation with the Deputy Commissioner. The consultant will facilitate the preparation of settlement plans. Approval of the plan from the village platform committee and execution of the program will be the responsibility of the MOL through the Deputy Commissioner at Kishoreganj (Abdullapur Dokkhin Char) and Habiganj (Anandapur).

9.4.6 Fisheries Enhancement Measures

Important opportunities exist for enhancing fish production in the project area. These relate to fisheries management, creation of fish sanctuaries, introduction of floating cage culture practices and a rare species re-introduction program in the isolated river loops.

Fisheries Management Measures
These measures relate to the establishment of genuine fishers association (FA) which will have exclusive monopoly ownership of specific fishing grounds and transfer of said fisheries from leaseholding system to the NFMP *nitimala* regime. Assistance will be given by the project to train the FAs in biological fisheries management practices and developing fisheries harvesting and conservation plans.

Fish Sanctuaries
These will be created in critical habitats, especially overwintering habitats for broodstock (*duars, beels*) and fishpass access lanes.

Floating Cage Culture
This will be introduced in association with pond culture (as a measure to prevent losses during monsoon flooding and increase grow-out periods) and as fattening operations for wild caught fish or hatchery/nursery-sourced fingerlings. The advantage of floating cages in areas prone to intensive monsoon flooding over other types of aquaculture practices should be tested in a pilot project modality prior to dissemination.

Rare Species Reintroduction Program
The isolated river loops created by the loop cuts may retain regulated hydrological connections with the mainstream river channel. This may allow long-term utilization of these water bodies for fisheries enhancement purposes, and prevent encroachment for agricultural use. The river loops could be used as partial grow out facilities for selected fish species which have become rare or extinct in the region. The intention is to attempt to reintroduce these species into the Northeast Region. An on-site induced breeding hatchery could also be constructed where broodstock of *nandina*, *angrot*, *sarputi*, *pangas*, *mohasol* and other species will be kept. Fry from induced breeding will be raised in floating cages in the river loops and then liberated as juveniles (20 to 30 cm size class) into the mainstream river channel during the pre-monsoon and monsoon flood periods.

Due to inadequate data and information, costs for these enhancement programs are not budgeted in the EMP. For example, the morphological behaviour of isolated loops, and the right of use including institutional aspects need to be evaluated and finalized before preparation of enhancement programs. It is proposed to develop this program based on primary data. This data will be collected during the implementation stage under the monitoring plan.

Responsibility
The consultant in consultation with DOF will prepare the enhancement program, mode of implementation and institutional aspects during the monitoring stage.

9.5 Contingency Plan

Any unplanned occurrence whose results are seriously detrimental to one or more of the Important Environmental Components (IECs) is considered a hazard. The following hazards have been identified:

- failure of confinement dykes;
- effluent leakage through pipes;
- accidental injury, and
- oil spillage from dredges.

With regard to these hazards, the international contract will specify that a contingency plan complete with emergency response equipment and trained personnel will be mandatory. Penalty clauses are to be applied to the contractor for failure to meet these obligations.

9.5.1 Failure of Containment Dyke

Three times daily (start-up, mid-day and shut-down), for the whole duration of operations, all earth structures, dykes and outlet channels will be inspected for evidence of slope failure and piping and repairs will be made before operation resumes. Spills resulting from the failure of the embankment chamber or the erosion of an outlet channel will be contained with sand bags. To that effect, a number of bags, depending on the size of the disposal chamber, will be stored on site. Jute bags will be used as they are inexpensive and environmentally sound.

9.5.2 Effluent Leakage

All operating pipelines will be visually inspected three times daily (start-up, mid-day and afternoon) along their whole length. If any spill is observed, immediate action will be taken to fix the leaking joint and remove the spoil. If warranted, temporary suspension of work will be requested until corrective measures are implemented. Leakage from pipeline joints will be prevented by ensuring that the dredging contractor has enough spares. A low range wireless communication system will be provided by the contractor for communications between the observers in the field and the dredge operator.

9.5.3 Accidental Injury

The contractor will be responsible for keeping a safe work place. By-standers will be prevented from interfering with work at hand. An efficient supervision of earthworks will be implemented to prevent unauthorized works on private properties outside the project area.

9.5.4 Oil Spillage from Dredgers

The contractor will ensure that the dredge is in working order so as to prevent oil spills. Procedures for handling fuel are to be developed to that effect. Oil spills will be contained within the perimeter of the dredge by placing water hyacinths on a bamboo cum jute mat support.

9.5.5 Navigation Lighting

To prevent endangering to or obstruct of navigation, the contractor will ensure placement of proper lights at night, between sunset and sunrise, on all dredges, barges. Floating pipeline markers will also be installed to warn river users during the day.

All costs for the contingency plan are the responsibility of the contractor and therefore, they are not budgeted in the EMP as they are included in the project capital costs.

9.6 Monitoring Plan

The monitoring plan includes monitoring programs (Sections 9.6.1 to 9.6.6) carried out by the Consultant during the construction phase of the project . The monitoring plan also includes the long-term benefits monitoring program (Section 9.6.7) carried out by a monitoring consultant in association with GOB during the first 9 years of the project.

However, it should be noted that the long-term benefits monitoring program costs are not budgeted in the EMP.

The monitoring plan includes the following components:

- Baseline Surveys and Data Program;
- Water Quality Monitoring Program;
- Fisheries Monitoring Program;
- Agriculture Monitoring Program;
- Social and Gender Monitoring Program;
- Physical Process Monitoring Program, and
- Long-Term Benefits Monitoring Program.

9.6.1 Baseline Surveys and Data Program

The initial phase of the development of a comprehensive monitoring plan includes:

- design of the monitoring framework;
- identification of the parameters or indicators to be measured, and data sources;
- collection of baseline parameters from the data sources (surveys, etc.), and
- selection of parameters/indicators sampling frequency for monitoring.

As monitoring progresses, the current values of the parameters are compared to the baseline values and the impacts are inferred from the results of the analysis.

This process is not specific to EMP monitoring, but also to other project activities, such as progress of the project or of its individual components, since KKRMP project management will follow the Result Based Management (RBM) approach. This approach emphasizes results and products rather than activities and input in the management of the project. Results are measured by performance indicators which may be direct measures or indirect measures of the results. Data sources are also identified for each indicator.

With respect to baseline data and information, NERP has already collected and processed, in the context of the KKRMP feasibility study, a wealth of data and information. In the early phase of the project, it is proposed to evaluate the existing pre-project baseline data to determine its completeness and adopt for a particular parameter or indicator, an alternate data collection approach if the associated existing data is deemed insufficient or deficient. A description of the baseline data and information readily available and supplementary data required in the early stage of the implementation is provided in Annex I - Environmental Impact Assessment.

Considering that most of the basic data required for EMP monitoring as well as performance monitoring of other project activities are land related, the possibility of adopting a Geographic Information System (GIS) approach to process the data will be investigated early in the implementation stage of the KKRMP.

9.6.2 Water Quality Monitoring Program

During dredging operations, at each disposal site, turbidity, water temperature and oxygen content upstream and downstream of the effluent outlet will be measured regularly. Turbidity measurements will be carried out in situ, with a portable turbidimeter. At each site, four stations will be clearly identified in the river and respectively located 100 m, 500 m, 1000 m, and 2000 m downstream from each active outlet. These stations will be located within the visible turbidity plume originating from the outlet. One sampling station will be located 50 m upstream to evaluate the background level. Each station will be sampled (one integrated sample from the bottom to the surface) 3 times daily. Once a day, current speed and water depth will also be measured at each sampling station. Measurements at the four stations downstream of the work area will be regularly compared with background upstream observations. Boundaries and tolerance thresholds will be based on values measured in the surrounding environment, along with hydrodynamic characteristics that influence dispersion of suspended solids. As a general rule for all the sites, it is recommended that dredging operations be temporarily suspended when turbidity measured 500 m downstream of the outlet exceeds the mean upstream value by 4 times or more or when the oxygen content decreases significantly, 75% or less. Temporary suspension of work will be requested until conditions return to normal. The dredging methods will be modified if the tolerance limits are frequently exceeded.

Costs for the water quality monitoring program are budgeted in the EMP.

9.6.3 Fisheries Monitoring Program

The fisheries monitoring program, during construction, will consist of a follow up of fish catch and fish production in the river and in representative *beels* and floodplains and will include the following main activities:

- monitoring of the Koyer Dhala fishpass structure;
- monitoring of siltation rate in selected *beels*, and
- monitoring of migratory fish movements.

In addition, behaviour and movement of dolphins will be documented through detailed monitoring.

Costs for the fisheries monitoring program including a monitoring shed at the Koyer Dhala multi-purpose regulator, are budgeted in the EMP.

9.6.4 Agriculture Monitoring Program

Agriculture monitoring will focus on changes in land use and will consider changes in fertility status of the soils. NERP has already completed a semi-detailed land use survey where present use and crops presently grown in each plot have been recorded. The monitoring team will identify any changes in land use which would occur during the construction phase of the project. Mitigation measures will be suggested to the land users and an enhancement program will be proposed. Any change in soil fertility due to the spreading of dredged material will also be noted.

The soil structure, physical and chemical properties, habitat of abiotic complexes, environmental gradients and productivity of the dredged spoil should be examined and monitored. Accordingly, appropriate and cost efficient technologies should be developed on the basis of available resources for the improvement of soil structure and productivity and other environmental gradients.

Cost for the agriculture monitoring program are budgeted in the EMP.

9.6.5 Social and Gender Monitoring Program

This component of the Monitoring Plan includes all activities related to socio-anthropological studies, gender assessment and programming, social surveys, public consultations, local institutional assessment, community participation, and social impact monitoring.

The Social and Gender Monitoring Program includes the following activities:

- analysis of social profiles of site communities;
- interaction with concerned communities in laying out platforms, land dedication and formation of village committees;
- implementation of elements of EMP that concern communities;
- application of surface and slope protection measures;
- creation of community-level institutions to maintain the platforms, and
- support of women labor groups in getting organized, in negotiating working conditions, in establishing the value of work performed.

Costs for the social and gender monitoring program including costs of monitoring stations, are budgeted in the EMP.

9.6.6 Physical Process Monitoring Program

This program primarily involves monitoring physical impacts related to the channel excavation and re-alignment work. The main components include baseline measurements of river discharges, water levels and suspended sediment concentrations, and monitoring physical changes to key habitats. Knowledge of river discharges is a requirement for assessing impacts on water quality and dredging.

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There are 3 main components of physical process monitoring:

- hydrometric measurements;
- hydrographic surveys, and
- morphology surveys.

Hydrometric Measurements
During the construction season, discharges and suspended sediment concentrations will be measured at 12 locations, 5 of which will be in addition to BWDBs regular program. These measurements will be continued until the water levels exceed the top of the bank in the monsoon season, and will be used to provide baseline data for assessing changes to water levels and the division of flow along the river before, during, and after the project is completed. The suspended sediment concentrations will be used to help assess the performance of the dredge spoil confinement chambers. The sediment data will also be used for assessing sediment production from other construction activities such as the manual excavation work. Sediment measurements will be carried out as far downstream as Astagram, 40 km below the Issapur loop cut, in order to assess any potential downstream impacts from project implementation. Details on location, responsibility, type of measurements, duration, and purpose for each station are provided in Annex I - Environmental Impact Assessment (EIA).

Hydrographic Surveys
Hydrographic surveys will be made at bi-weekly intervals during construction to assess changes in bottom topography at critical habitat sites downstream of dredging operations. Bed material samples will also be collected to assess possible alteration of the sediment composition. These surveys will be used to assess whether construction activities such as dredging, channel re-alignment or bank protection works are impacting on the extent and quality of important aquatic habitat. For example, it has been suggested that channel re-alignments at the loop cuts could cause deep *duars* to be in-filled, which could adversely affect fisheries habitat. This monitoring will provide the information data for determining possible mitigation and compensation requirements.

Morphology Surveys
Morphologic monitoring will also be carried out in May and November of each year over the duration of the project's construction. This will involve preparing contour maps of the channel bottom from Markuli to Astagram. The surveys will be compared to assist in interpreting the overall morphologic impacts of the project over time. The surveys will be continued at least 40 km downstream from the Issapur loop cut in order to provide an adequate data for assessing the extent of downstream impacts.

Costs for physical process monitoring plan are budgeted in the EMP.

9.6.7 Long-Term Benefits Monitoring Program

The long-term benefits monitoring program will be designed and implemented to monitor the long-term impacts of the project on the socioeconomic environment of the KKRB. The long-term impacts are related to benefits in agriculture, fisheries, navigation, employment and income. A tentative methodology, to be confirmed during the early phase of the implementation, is proposed following.

Agriculture
The expected outcome of the KKRMP with respect to agriculture is an increase in the production of *boro* paddy. Result indicators and data sources are:

- *boro* paddy estimates from sample area surveys (eg. sample sites considered in the KKRMP analysis on agriculture) and *thana* annual statistics on agriculture, and

- extent of inundated land during pre-monsoon floods. In the KKRMP feasibility study, this parameter has been evaluated indirectly, by hydraulic modelling and spot elevations surveys. In mid-1996, RADARSAT was launched and the imagery of this satellite is ideal to identify water. The possibility of using the digital data of this satellite to map the extent of flooded areas should be investigated in the early phase of the project.

Fisheries
The expected outcome of the KKRMP on fisheries is an increase in the fish catch in *beels* and *khals*. The result indicator is fish catch and the data sources are:

- sample surveys of selected *beels* and *khals*;
- market studies;
- volume of export of regional fish processing plants, and
- DOF annual catch assessment surveys and annual *thana* fisheries survey.

Navigation
Boat traffic (transportation volume of goods and number of passengers) is expected to increase as a result of the KKRMP implementation. The overall impact will be a reduction in river transportation costs. The result indicators to be monitored are:

- number and size of boats on the river network obtained from surveys of major landings;
- number of passengers and volume of cargo, obtained from BIWTA annual statistics and interviews with representatives of boat owners associations, and
- cost of trading good imports obtained from market studies for trading goods.

Employment and Income
One of the major expected benefits of the KKRMP is an increase in employment and income. A measure of this benefit is the number of agricultural labor and labor rates. The sources of information are sample area surveys of agricultural labor and their pay rates, and *thana* statistics on employment and income.

Long-Term Benefit Monitoring Costs
This component of the Monitoring Plan has been costed under the assumption that the program will run for a period of 9 calendar years. It will start with the start of the KKRMP implementation phase, when existing baseline data will be analyzed and supplementary data collected as required, and will end 2 years after the end of the intervention. Thereafter, it will be under the responsibility of GOB. The cost of the program under external funding is estimated as Tk 62.4 million. This cost is not included in the economic analysis as it is not offset by benefits. Detailed cost estimates are presented for this component in Annex L - Project Management Plan.

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9.7 Training Plan

The training plan will be conducted by the project team throughout the project phases. Training and workshops are planned for the project participants at beneficiary, platform committee, *thana*, district and divisional levels. Training and education will take place in pre-construction, construction and post-construction phases. These mainly include the following:

- project concept, components and impacts;
- land dedication procedure, responsibilities and obligations;
- environmental issues, hazards, impacts and responsibilities;
- land use planning, topsoil management and productivity;
- establishment of nursery, plantation, re-use and responsibilities;
- platform protection, maintenance and responsibilities;
- development procedure of various committees and their functions;
- organization and strengthening of beneficiary and village committees, and
- relationship between local, *thana*, district and national level.

Costs for the training plan are budgeted in the EMP.

9.8 Beneficiaries Participation in the EMP

Based on the experience of the pilot dredging project both the project authorities and the landowners dedicating land for homestead platforms will sign project agreements, outlining the responsibilities and obligations of each party. The agreement shall specify the project's liability for failure of the dyke, in addition to other technical components which will be built during different phases of construction. At all times the project shall take consideration of the community's views within technical limitations. Beneficiary HHs shall assure provision of earth for chamber and outlet construction, top soiling and dyke repairing. Landowners shall provide 5 m of space outside the dyke for tree plantation. Beneficiary HHs shall assure their contribution of labor and materials to soft dyke protection 3 years after the platform has been completed. Community beneficiaries shall assure protection of project materials during the construction and post-construction periods.

9.9 EMP Costs

Total EMP costs, during the construction phase, are estimated to be Tk 57.6 million. A breakdown of the costs by component is shown in Table 9.1. These costs were estimated on the basis of *FPCO Guidelines* and pilot project experience. Detailed quantity and cost estimates are provided in Annex I - EIA.

Table 9.1 also shows that annual EMP costs, during the O&M phase, are estimated to be Tk 1.75 million during Years 8 to 10, Tk 1.58 million during Years 11 to 13 and Tk 1.40 million during Years 14 to 30. These costs were estimated by prorating implementation costs based on the number and size of disposal sites during the O&M phase of the project.

Table 9.1: EMP Cost Summary

EMP Components	EMP Cost during Construction (million Tk)	Annual EMP Costs during O&M Phase (million Tk)		
		Years 8 to 10	Years 11 to 13	Years 14 to 30
Compensation	0.66	0.05	0.05	0.04
Mitigation	20.63	0.52	0.52	0.45
Enhancement	28.91	1.13	1.01	0.91
Monitoring	6.90			
Training	0.50			
Total	**57.60**	**1.75**	**1.58**	**1.40**

10. ORGANIZATION, MANAGEMENT AND CAPACITY DEVELOPMENT

It is critical to understand that KKRMP is a 30-year project, consisting of a seven year implementation phase and a 23 year O&M phase. The organization and management arrangements for implementation are expected to proceed through existing GOB and other institutions. However, past poor performance with O&M and associated cost recovery in the water sector in Bangladesh have led CIDA and ADB, who are the expected financiers for implementation, to be uncomfortable with relying on the existing institutional environment for the O&M phase. Accordingly, it is expected that new institutional arrangements for O&M will be required for the project to proceed.

This chapter develops an organization structure for the implementation of the KKRMP, which is in agreement with GOB's philosophy that projects should be managed through existing institutions, offers a process for achieving sustainable O&M including cost recovery, provides descriptive examples of some North American institutional models for management of rivers and describes the requirements for capacity development.

10.1 Organizations Relevant to KKRMP Objectives

Table 10.1 identifies the existing institutions and organizations that have most relevance for the objectives and intended results of the KKRMP. Therefore, these will most likely be the focus of capacity development activities. Table 10.1 also shows outputs (products) which must be maintained during the O&M phase, the activities necessary to maintain them and the agencies or institutions responsible for the O&M.

10.2 Proposed Institutional Organization for the Implementation Phase

According to the existing institutional context (Chapter 4), Bangladesh Water Development Board (BWDB) will be the lead implementing agency for the KKRMP. However, the BWDB is largely a civil engineering organization and it rests within a single ministry. Successful implementation of KKRMP will require coordination with other GOB Ministries, departments and agencies, as well as with NGOs and private organizations working in the area. These include the Bangladesh Inland Water Transportation Authority (BIWTA), the Ministry of Land (MOL), the Local Government Engineering Department (LGED), the Department of Public Health Engineering (DPHE), the Department of Fisheries (DOF), the Department of Environment (DOE), the Department of Agricultural Extension (DAE) and the Bangladesh Bureau of Statistics (BBS). Each will be involved in their own area of expertise, but expected to liaise and coordinate with others. There is also a need for full stakeholders participation.

Table 10.1: Institutional Requirements to Meet KKRMP Objectives

OBJECTIVES	OUTPUTS or PRODUCTS that must be maintained for benefits to continue after KKRMP	RESPONSIBILITIES and ACTIVITIES necessary to sustain production of OUTPUTS	RELEVANT BANGLADESH ORGANIZATIONS
River Stability	Two loop cuts, river training works, structures	River surveys, reports, annual dredging of silted reaches, monitoring, and responsive maintenance for levees, dykes, embankments, inlets, outlets etc.	
	Improved fisheries production	Monitoring, development and execution of fisheries enhancement program.	DOF
Year-round River Transportation (purpose)	Class II channel in Kalni-Kushiyara River	Annual dredging to maintain 2.4 m draught during the dry season.	BIWTA
		Assessment and collection of fees from additional river traffic and marketed food production enabled by KKRMP, for dedication to dredging costs.	BIWTA
Improved Agricultural Production (purpose)	The outputs are direct results from the stability of the river	Monitoring of crop damages and crop production	DAE
Improved Human Settlements (purpose)	Secure village platforms above flood levels	Systematic monitoring and maintenance by land owners and villagers.	Village committees, Deputy Commissioners, TNOs, NGOs
		Construction of confinement dykes, homestead platforms and growth centres.	BWDB, LGED
		Short and long-term green manuring, plantation programs and monitoring.	DAE, Department of Forestry.
		Health, sanitation, drinking water, habitat and basic education services and maintenance.	Village committees, DPHE, LGED, NGOs,
Economic Activity Enhancement (goal)	Increased employment & income	Monitoring of the project area from sample surveys.	BBS
		Monitoring and generation of employment activities on the homestead platforms.	BRDB, NGO's, MOSW&WA
All Objectives	Coordinated management of the KKRMP	Appraisals, recommendations to facilitate decisions on river basin committee structures. Coordination by authority at the level of ministerial secretary across sectors and agencies relevant to flood protection, dredging and revenue generation to pay for it, transport, habitat, basic needs, poverty alleviation.	MOWR, MOS, MOL, Min. of Establishment, Min. of Finance, MOE&F, MOF&L, MLGRD&C, MOSW&WA and their departments or administration units responsible in the KKRB, plus others.

For implementation, it is proposed that the project institutional organization include the following components:

- a National Steering Committee (NSC);
- a Project Implementation Office (PIO);
- three Field Offices;
- two or more sub-divisions per Field Office;
- advisors to the PIO and Field Offices;
- Non Governmental Organization (NGOs);
- Project Committees at the district and *thana* levels, and
- Stakeholder Committees.

The proposed project organization is shown on Figure 10.1. The proposed composition and function of each of these organizations is briefly defined in the following sections. A more detailed description of the roles and responsibilities of the relevant institutions is presented in Annex L - Project Management Plan.

10.2.1 National Steering Committee

The National Steering Committee (NSC) is the highest level formation for overall policy planning, coordination and management of the KKRMP where elected representatives, concerned ministries and funding agencies should be represented. The NSC is chaired by the Secretary of the Ministry of Water Resources (MOWR). Other members of the committee are representatives, not below the rank of Joint Secretary, from MOL, MOS, MLGRD&C, MOF&L, MOE&F, MOA, Ministry of Planning, MOF and MOSW&WA. It is expected that ADB and CIDA, who are expected to assist in funding the project interventions, may also be represented on the NSC.

The NSC will be responsible for all policy decisions. The Committee will assess the number and type of GOB officials to be deputed to the project and make arrangements accordingly.

10.2.2 Project Implementation Office

The Project Implementation Office (PIO) will be the focal point for day to day implementation of the project. It is proposed that the PIO be headed by a Project Executive Director with the rank of Chief Engineer (CE) of the BWDB. He will be responsible for implementation, and will directly liaise with the NSC; but he will direct field operations through a Director who will be a BWDB Superintending Engineer (SE) based in the Project Executive Director's office. The office of the Project Executive Director will be the headquarters for project officials deputed from GOB partner agencies. These officials will be deputed from the following Ministries/agencies:

- Ministry of Land (MOL);
- Bangladesh Inland Water Transport Authority (BIWTA);
- Local Government Engineering Department (LGED);
- Department of Public Health Engineering (DPHE);
- Bangladesh Rural Development Board (BRDB);
- Department of Women Affairs (DOWA);
- Department of Fisheries (DOF);
- Department of Environment (DOE);
- Department of Agricultural Extension (DAE), and
- Bangladesh Bureau of Statistics (BBS).

10.2.3 Consultants

Consultants will provide assistance to the PIO during implementation.

10.2.4 Field Offices

Actual implementation of activities will be done through 3 Field Offices located respectively in the lower, middle and upper reaches of the Kalni-Kushiyara River. Each Field Office will be headed by a BWDB Executive Engineer (XEN), who will directly report to the Director. The Field Office will also include deputed personnel from MOL, LGED, DPHE, DOF, DOE, DAE and BBS and members of the consultants.

Each Field Office will have one or more Sub-Divisions depending on the number of construction sites and the volume of work. Each Sub-Division will be headed by a BWDB Sub-Divisional Engineer (SDE).

10.2.5 Project Committees

In order to ensure the smooth implementation of the project, participation and assistance of the field level GOB officials and the people's representatives is imperative. This is also necessary in the context of social acceptance of the project and conflict resolution. Project Councils are proposed in this context, as recommended in GOB *Guidelines for People's Participation in Water Development Projects* (MOWR, 1994).

District Project Committees
For each district in the project area, there will be a District Project Committee (DPC). The DPC will in the future be headed by the elected chief of the District Council. Until such a Local Government system is formalised, the Deputy Commissioner (DC) will be the head of the DPC. All district level officials of the GOB partner agencies will be members of the DPC, while the XEN will function as the Member-Secretary of the DPC.

Thana Project Committees
At the *thana* level, the Thana Nirbahi Officer (TNO) will be the head of the Thana Project Committee (TPC) until the *thana* level Local Government structure is formalised. *Thana* level officials of the partner GOB agencies will be members of the TPC, while the SDE will be its member-Secretary. Representatives of the stakeholder community at the grass roots level, such as a Platform Society, will also be members of the TPC.

10.2.6 Local Stakeholders Committees

The local stakeholder community will have their own committees at the grass roots level. This will assume the form of a platform society at the village level for new platform development, or a beneficiary committee formed around a water management structure (e.g. Koyer Dhala). They will directly liaise with the TPC as well as the SDE.

10.2.7 Non Governmental Organizations

Although the presence of NGOs in the project area is at present minimal, NGOs will be approached to participate in the community development aspects of the project as sub-contractors to the Consultant under the technical assistance (TA).

10.3 Results of December 1997 Seminar

On December 8-9, 1997, a "Seminar on Kalni-Kushiyara River Management Project" was held in Dhaka. Its objectives were:

1. To present KKRMP, highlighting its multi-sector nature and placing emphasis on the issues of institutional arrangements during implementation and operation and maintenance phase and cost recovery.
2. To seek input from the participants on the preferable institutional arrangements for the implementation and O&M phases.
3. To seek input from the participants on possible O&M cost recovery sources.

More detail on the seminar is provided in Annex K.

Main O&M Findings
For O&M, there were two main relevant findings from the seminar:

1. Although there was general agreement on the elements of institutional arrangements for implementation, there was a divergence between GOB and CIDA/ADB on the type of institutional structure required to ensure sustainability during the O&M phase of the project. ADB's position is that for the O&M phase, the project requires a policy and institutional arrangement that would ensure sustainability of the project; based on experience, the status quo would not provide this insurance. On the other hand, the position of GOB is that O&M phase activities could be addressed through existing institutional arrangements.

2. There was a consensus on the following issues for a cost recovery system:

   - there was support for fees, levies and taxes in order to ensure sustainability;
   - the approach must be integrated, with improved coordination between all stakeholders;
   - there must be participation and a sense of ownership by beneficiaries;
   - there must be appropriate legislation, laws and regulations - either new or improved - to ensure payments are made;
   - there must be transparency and accountability, and
   - there must be political will and commitment.

Key Issues and Concerns
Relevant key issues and concerns, for which there were varying degrees of consensus amongst the participants, were as follows:

- there is a need for administrative and technical linkages - both horizontal (multi-sector) and vertical (local, regional and national);
- there must be independent control of management over resources and revenue;
- cost sharing between parties - e.g. landowners, transportation operators, GOB, etc. must be based on benefits received as well as ability to pay;
- dredging must be contracted out, and
- opportunities for cost recovery exist from navigation, land transfer taxes, platform fees, fishery fees, and license fees from water bodies.

10.4 Further Effort Needed to Develop Organization for O&M

Following on from the December 1997 seminar, it is envisaged that the process of reaching a sustainable organization for O&M will involve two areas of technical assistance to KKRMP. The first TA would help define the type of organization suitable to the main stakeholders; this would be done prior to project implementation. The second would help develop the defined organization; this would be done during implementation.

ADB Project Preparation Technical Assistance
To assist with development of appropriate O&M institutional and cost recovery arrangements, ADB is planning to undertake a Project Preparation Technical Assistance (PPTA) prior to project implementation. Because the final institutional arrangements must be bought into by GOB and ADB, it is assumed that the PPTA would essentially be a facilitating process whereby ideally agreement is reached, or at least substantial progress is made. The objective of the PPTA would be to determine and initially define institutional arrangements and a cost recovery mechanism that ensure project sustainability.

Annex K provides suggestions for activities to be included in the Terms of Reference for the PPTA.

Advisory Technical Assistance - Capacity Development
A successful ADB PPTA would provide a definition of the new institutional and other *capacity* that GOB would strive for over time. The process of moving from the current institutional arrangements to the newly defined arrangements is termed development of capacity, or capacity development. Development of new capacity is recognized as a long-term process, perhaps requiring 10 to 15 years or more. Capacity development is also a dynamic process, achieved through iteration. To further ensure sustainability, it is appropriate that donors consider assisting GOB with the development of agreed new capacity in parallel with implementation of KKRMP.

In this context, Section 10.6 and Annex K provides a possible approach to capacity development for KKRMP, including needs, priorities, general and specific thrusts, and institutional and community development. It is assumed that this process - or some other process accepted by stakeholders - would form the basis of and Advisory TA that would take place in parallel with implementation. In any case, it is emphasized that successful capacity development is a necessity for sustainability of this project, which cuts across many Ministerial boundaries.

10.5 Examples of River Management

It is recognized that management of the Kalni-Kushiyara system will require institutional arrangements that are ultimately developed by stakeholders–primarily Bangladeshis. However, in order to provide other perspectives and facilitate dialogue between participants in development of operation and maintenance of an improved Kalni-Kushiyara system, some models of existing arrangements in North America were examined on a preliminary basis. These models are summarized in Table 10.2 and the following paragraphs.

Table 10.2: Summary of Selected River Management Models in North America

Name/Country/River	Organization	Mandate	Work Carried Out	Cost Recovery Method
Mississippi River Commission/USA/ Mississippi	7-person executive body, directed by US Army Corps of Engineers, USACOE (Country-wide federal government institution, staffed largely by professional engineers)	Manage the main channel for flood control and navigation	Monitor hydrotechnical status of river; forecast required annual works; construct, rehabilitate and maintain dykes; dredge to maintain minimum navigation channel depth. Work done by four different USACOE Districts	Navigation Dredging: Federal government provides annual appropriations from general taxation revenues. Navigation rehabilitation or facilities replacement: financed from fuel-tax levy on barge-cargo traffic. Flood Control: capital work financed 50-50 from federal and local government; O&M from local government only.
Coast Guard, Public Works, & Harbour Commission/Canada/ Fraser	Coast Guard and Public Works are local offices of country-wide federal government institutions, staffed by a variety of professionals; Harbour Commission is local corporation responsible for complete port management	Maintain minimum navigation channel depth; *transitioning* to maintaining required navigation channel	Coast Guard/Public Works: Monitor channel depths; dredge - through contracting to private sector. Harbour Authority: needs analysis, manage dredging, cost recovery planning	Currently: financed partly from federal government through annual budget appropriations, and from sale of dredge spoil. Near future: full recovery of costs from sales of dredge spoil and user fees/charges for various harbour infrastructure and property
Santa Cruz County/USA	Flood Control District (administrative), operating under County Board (elected)	Protect floodplain occupants from flooding	Monitor, and construct and maintain flood control works - primarily dykes	Recovered through a variety of taxation methods
Grand River Conservation Authority/ Canada/Grand	Government body composed of members from each municipality in the watershed, and staffed with professionals	Manage land and water resources in the watershed; reduce flood risk	Set policy, develop plans, prepare budgets, arrange financing, and collect fees. Through contracting out: river channel improvements, dyking, bank stabilization, flood proofing, and purchase of flood-vulnerable lands	O&M budgeted annually based on precedent, known conditions and surveys as required. Funded 50% by the Authority, and 50% by the Provincial Government
Tennessee Valley Authority/USA/ Tennessee	Federal Corporation, staffed by a variety of engineering and other professionals	Development and management of river for power production, navigation, flood control, recreation and water quality	Monitor dam conditions and safety; monitor water availability, quality and levels in reservoirs and river channels. Develop, maintain and improve infrastructure as required.	Financed annually by federal government appropriations. Local entities fund O&M of completed projects from local general revenues. Federal fuel tax for commercial navigation goes to national trust, to pay for future new projects.

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10.5.1 Lower Fraser River, Canada

Organization and Mandate

The lower Fraser River annually deposits about 1.3 million cubic metres of sediment in the shipping channel used by international cargo vessels. Previously a regional office of the federal Public Works Department was responsible for managing and funding the removal of this sediment to ensure safe navigation. Recently, however, the Canadian Coast Guard - whose overall mandate includes maintenance of maritime safety and facilitation of maritime trade and commerce - has been responsible for managing the navigable channel, including maintaining a specified minimum channel depth and breadth, and obtaining partial cost recovery. While the Coast Guard sets standards and specifications for dredging, Public Works Canada now acts as the Coast Guard's Project Manager and Engineer to monitor the channel, and determine and manage the amount of annual channel dredging work done on the Fraser.

Funding, Contracting, and Cost Recovery

The Coast Guard sets priorities for spending by needs and region, so the Fraser River region receives its annual appropriation from central Coast Guard.

Two types of contracts are let. The first is an "on-demand" type, whereby high spots in the river are removed as required by a contractor, who has pre-negotiated a rate for dredging. The second is a major contract to dredge the navigable channel as required to remove deposition from the annual flood. For the major contract, the contractor agrees to remove a specified amount of material within a specified timeframe. This timeframe is sufficient for the contractor to recover some costs by selling some of the dredge spoil. Typically, between 40 and 60 percent of the total spoil is sold. This cost recovery is factored into the contract, thus reducing the funding obligation of government.

Currently, a process is underway to further devolve management of and funding for the dredging program to a local authority, who ultimately will not have financial support from Government. However, in addition to continuing to fund dredging through sales of spoil, the local authority has a mandate to lease harbour infrastructure and property to the private sector, and collect harbour dues from commercial shipping vessels. Importantly, the local authority is also planning to become more efficient by designing its dredging program to be responsive to the real-time needs of navigation. This means, for example, that dredging will be a function of the size of ships that are forecast to use the channel over a specific timeframe. This will result in less dredging when larger vessels are not expected.

10.5.2 Mississippi River Commission, USA

Organization and Mandate

The Mississippi River Commission is an executive body originally formed to facilitate improvement of the lower 1,500 km of the river. The Commission's initial mandate was to develop and manage the navigable channel, improve navigation safety, prevent destructive floods, and promote commerce. Since its inception in 1879, it has undergone changes in responsibility. Current Commission duties include: general investigations to determine needed improvements, construction of new facilities, and maintenance and operation of existing systems. Much of this

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is done under the Mississippi River and Tributaries Project, which has already developed extensive flood control, navigation and bank stabilization works. The Commission's geographic mandate includes the entire main channel of the Mississippi River. Several US Army Corps of Engineer Districts carry out the work of the Commission. Major tributary rivers are managed in a similar manner, but with different District Engineering offices.

Funding, Contracting, and Cost Recovery

Annually, each Engineering District monitors the river and submits to the Commission its forecast of required dredging based on the surveys and experience of the District staff. The Commission then requests the federal Government for an appropriation of the aggregate total of required dredging from all Districts. The government has always provided the required funding.

If extraordinary conditions arise–such as increased sedimentation or abnormal flood damage to infrastructure–the Commission can request a supplemental appropriation; to-date, this has always been provided.

There is no cost recovery for O&M from beneficiaries of the Mississippi River and Tributaries Project, which is still ongoing and applies to the main Mississippi River channel. However, any new projects developed other than for navigation require 50% local capital funding, and 100% local O&M funding. For navigation, there is a surcharge on fuel used by tow boats (the main commercial traffic that moves barges), and this goes into a special account, which is overseen by a separate executive group. Although this account could be used for dredging, it has historically been used either for maintenance of existing navigation locks or construction of replacement locks and dams.

10.5.3 Tennessee Valley Authority, USA

Organization and Mandate

The Tennessee Valley Authority (TVA) is a USA Federal Government corporation. It was founded to help economic recovery in the Tennessee Valley in the 1930s, and much of its focus has been on development and management of energy supply. Its mandate was later broadened to include flood control, navigation, recreation and water quality. Most recently, TVA has become self-financing–from power revenues–and no longer requires Federal Government financing, except for specialized economic development initiatives.

Funding, Contracting, and Cost Recovery

TVA has built a number of different types of flood control projects over the years. Federal appropriations have always paid the initial costs. Once completed, ownership of the local projects has been transferred to a local entity to operate and maintain. Even so, annual costs have come from local general revenues.

TVA does not charge for navigational use of its waterways. However there is a Federal fuel tax for commercial navigation. Proceeds from this tax go into a National Waterways Users Trust Fund to pay for future capital projects on the inland waterway system.

On certain capital local projects, the first two or three years of operation are built into the initial cost. During this period, operation of the project is confirmed and some experience is gained on actual operating costs. These few years can be invaluable in demonstrating to local shareholders what they can expect from the project. Concurrently, this period is used to finalize initial funding plans for future O&M.

10.5.4 Grand River Conservation Authority, Canada

Organization and Mandate

The Conservation Authorities Act of the Province of Ontario is legislation that addresses land-use practices and flood control measures by incorporating watershed-based resource management planning and flood control measures into local government planning. The legislation recognizes that only a watershed-wide organization can respond to natural resources challenges that cross political boundaries. Formed under this legislation, the Grand River Conservation Authority manages land and water resources in the Grand River watershed, which covers an area of about 6,000 square kilometers with a population of about 750,000. The Authority is composed of members from each local government in the watershed. The Authority sets policy, develops plans, prepares budgets, arranges financing, and collects fees in partnership with its member governments – who each have appointed representation in the Authority - and the Provincial Government of Ontario. A primary goal of the Authority is to reduce flood risk, which is accomplished through river channel improvements, dyking, bank stabilization, flood proofing, and purchase of flood-vulnerable lands. For flood control issues, the Authority is staffed by a variety of professionals, whose responsibility includes identification and planning for flood control works.

Funding, Contracting, and Cost Recovery

New projects are funded 50% by the Provincial Government, 40% directly by the involved local governments, and 10% through a levy from the Authority. Operation and Maintenance is budgeted annually based on precedent, known conditions and surveys as required. It is funded 50% by the Authority, and 50% by the Provincial Government. Detailed design and construction work are normally contracted out.

10.5.5 Santa Cruz County Flood Control District, USA

Organization and Mandate

Flood control work in the State of California is governed by the California Water Code, and controlled by elected Boards of Supervisors in each county (local government). The Board of Supervisors for Santa Cruz County governs the County unincorporated area, and is the executive and legislative governing body of the County of Santa Cruz. The Board directs overall operations of various county departments and districts by establishing policies and approving the budgets and financing for all of County government and certain special districts. One such special district – for Flood Control - is responsible for developing and maintaining flood control and drainage in populated areas[1]. The Board of Supervisors direct Flood Control District activities, but each District has representation on the Board for issues related to their District.

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1 Relative to the KK project, the geographic size of projects is small in Santa Cruz County; they are responsible for intensive maintenance of about 20 km of channel.

Funding, Contracting, and Cost Recovery

Due to historical changes in legislation, and to diminishing government budgets, the Districts fund flood control works in a variety of ways:

- For long-established areas, by collecting taxes specifically for flood control and drainage improvements (this is not allowed for new developments under current legislation).
- For new developments, by collecting a fee on an improved unit area basis.
- For land use within a watershed, by collecting fees based on how the land is used; this is also on a unit area basis, except for housing, which is charged a flat fee.
- For general O&M, by receiving part of county-wide taxes designated on a percentage basis for addressing watershed issues such as stream improvements.

10.6 Capacity Development

The Need for Capacity Development

The economic life of KKRMP is 30 years. After 7 years, and at the end of the intervention phase, external support will be phased out. At that time, all Bangladesh stakeholders will take charge of the project for its O&M phase from Project Years 8 to 30. The work to be carried out annually during the O&M phase will in most respects be similar to the intervention itself, but at a reduced scale. It will consist of monitoring the river's behaviour and response to the project intervention; annual maintenance dredging of up to 1 million m^3; land dedication for new or extended platforms, followed by their construction and maintenance; and maintenance of bank protection, levees, and structures. However, there is a risk - or even a probability - that without a targeted capacity development approach, the organization that is developed for implementation is disbanded when the project intervention is completed.

The long-term KKRMP management structure must be designed to ensure that the relevant agencies and organizations continue to be represented, especially after external funding and assistance is withdrawn. In order to carry out both implementation and O&M, a coordinated approach between the institutions directly involved is imperative. For this task, some of these institutions have weaknesses (Table 5.6) that need to be addressed so that they have the capacity to take charge of the project, especially during the O&M phase.

Based on experience with O&M of water resource development projects in Bangladesh, the structure of the project organization during the O&M phase must be defined <u>before</u> implementation. Failure to do this has resulted in lack of ownership by beneficiaries. Fortunately, the work to be carried out during the O&M phase is very much of the same nature as in the implementation, albeit much reduced, so the structure will likely keep the same components, less the funding agencies and consultants. Therefore, it is appropriate at this point to set priorities for capacity development. This will lay the initial groundwork for preparing a capacity development plan, which should be in place by the beginning of implementation.

A Capacity Development Approach

Capacity is the ability of individuals and organizations to perform functions effectively, efficiently and sustainably. It centres on institutional development by attending to organizational governance and internal structure, accountability, roles, responsibilities, processes, systems and facilities, within which people plan, manage and implement work. Institutional development commonly focuses on strengthening the performance of single organizations or networks of closely related institutions. However, based on the consultant's experience, and that of others engaged in similar work, a broader capacity development approach is needed to ensure sustainability of the KKRMP. This approach must be applied to both institutional and community development for the institutions, agencies, organizations, groups and individuals which will need to be able to continue generating the benefits of the Project when external funding is expended.

An example of a broader capacity development (CD) approach is one that is jointly promoted by OECD/DAC, CIDA and ADB (OECD/DAC, 1994; ADB, 1996). They support a capacity development approach that extends principles of institutional development to situations where various kinds organizations, their networks and people have responsibilities to perform related functions. This is the situation for the KKRMP, where Government agencies with responsibilities across many sectors must cooperate with other private, non-governmental and community based organizations. That CD model includes training of individuals and groups, including improvements in the other factors of an individual's working environment that enable effective utilization of what was learned in training. The approach also considers external socioeconomic, legislative and regulatory constraints networking among complementary organizations and adjusting to competing ones. This is a model that could be adopted for the KKRMP. Further details on this approach are provided in Annex K - Capacity Development.

Capacity development is inherently an iterative process, and this would enable phasing of responsibilities (including financing), from the KKRMP to governmental, private, NGO and community groups. The process begins with consultations as well as participatory identification and confirmation of priorities. It proceeds then with developing participatory approaches through assessments, detailed planning, implementation, monitoring and reporting. This may also require going through this process cycle iteratively. Given KKRMP complexities and the fact that some functions needed to sustain its results and benefits are not being performed today, an overall time frame to develop capacities adequate for sustainability may require 10 to 15 years or more.

General Thrust for Capacity Development

Capacity development activities of the KKRMP should begin with initial assessments of the priorities for capacity development. These priority setting activities need to pay attention to the following functions:

- Overall coordination of management of water resources throughout the KKRMP, based on existing institutions as much as possible;

- Managing the deposition, development, utilization, protection and maintenance of large amounts of spoils from loop cut construction and river dredging. This function should identify the organizations and people involved, the systematic processes to be established and the skills and knowledge required;

- Continuous monitoring and reporting of river morphology and associated dredging to maintain the river channel depth and velocities required to reduce pre-monsoon flooding and increase river traffic;

- Monitoring of increases in river traffic as direct results of the KKRMP, assessments of appropriate revenue generation (taxes, licensing, tariffs, fees etc.), designing and implementation of systems for collection of these revenues and their application to ongoing costs for river maintenance during and after the Project, including: who will assess, what criteria are to be applied and how, who will pay and how, where the proceed will go?;

- Decentralized effective protection and maintenance of various flood control structures, that along with a cleared river channel, are necessary and sufficient for stopping pre-monsoon flood destruction of crops at least 4 years out of every 5, including - what, when, by whom?, and

- Representative coordination through federation of village and other committees at community level to successively higher levels within the Kalni-Kushiyara river basin - what levels, how, what legal political and legal implications?.

Specific Thrust for Capacity Development

The following sections identify the specific areas where it is expected that capacity development will be required. These areas should be analyzed more in depth both prior to and immediately after formation of the project organization. A distinction is made, herein, between institutional development, addressed to the relevant government institutions, and community development, addressed to platform beneficiaries.

In the following paragraphs, a reference is made to a "capacity development (CD) component" of the project. This refers to an externally-funded technical assistance that would take place once approval-in-principle of the project is received.

Institutional Development

O&M Financing: From past experience, a number of water resource development project deteriorate or fail outright because funds are either not allocated or insufficiently allocated to carry out O&M. This weakness has been recognized by MOWR who has identified the main reasons as the lack of participation from the impacted (adversely or beneficially) people in the project. MOWR has recommended involvement of the impacted people at all stages of development from project identification through O&M, so that beneficiaries get a sense of ownership and as a result operate and maintain their projects in the best possible way (*GOB's Guidelines* as noted above).

In the specific case of the KKRMP, the capacity of the platform beneficiaries to fund the costs of O&M work is limited by their income, one of the lowest in Bangladesh. At best, the beneficiaries will be in a position to protect and maintain their platforms from their own resources, in anticipation that these resources will increase as a result of reduced crop damage. For other maintenance work (levees), the beneficiaries can contribute as labor.

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The possibility of collecting fees from additional river traffic and marketed food production, or from selling spoil material for private land (e.g. industrial) development, should be assessed by the CD component, in order to recover part of the dredging costs. Other avenues to generate funds from beneficiaries should also be explored. Supplementary funds will almost certainly be required for O&M, and these will most likely have to be budgeted by GOB; sustainability of the project will require a firm GOB commitment in this regard.

O&M Implementation: O&M implementation will be carried out by BWDB for dredging for channel stability as well as for levees and structures. The O&M implementation for navigation dredging will be carried out by BIWTA. During the intervention phase, BWDB and BIWTA staff deputed to the project will be trained by the consultants to assume responsibility for the river monitoring (Chapter 9), and to take responsibility for the river management program (Chapter 7). This training must be part of the CD plan, and include focussed sustainability measures.

It should also be noted that during the course of the implementation some of the agencies participating directly to the KKRMP are likely to receive external support for capacity development and institutional strengthening. As an example, the World Bank is currently developing a project with GOB to strengthen the capabilities of BIWTA for navigation dredging.

The program includes Operation Improvement, Institutional Development, Financial Recovery, and Strategic Plan components.

Land Acquisition: The MOL under the respective DCs, together with the concerned government departments at the respective *thana* levels, will execute land acquisition through purchase from individual landowners and allocation of the required *khas* lands. When the detailed engineering survey has been completed, these offices should survey land ownership of private landowners and of others using *khas* land within the areas requiring land acquisition. The Land and Water Use Directorate of the BWDB should appoint staff to work with field teams in land documentation, survey, community briefing and preparation so that they take charge of the process in the long-term.

Impacts and Benefits Monitoring: During implementation, project impacts will be monitored in four sectors of the economy, agriculture, river transportation, fisheries and employment and income (Chapter 9). This impact monitoring will thereafter be under the responsibility of DAE (agriculture), DOF (fisheries) and BBS (river transportation, employment and income). For river transportation, it is estimated at present that monitoring will be carried out more efficiently by BBS who has a Statistical Officer and support staff in each *thana* rather than by BIWTA who has no field representation.

During implementation, the deputed staff of the agencies responsible for monitoring should be trained in impact monitoring, development of the baseline framework, pre-project surveys and development of the database and surveys and data processing. This should be done under the CD component and should include focussed sustainability measures.

Community Development

Community Management Capacity: Although they are not unlike other committees in rural Bangladesh, the village committees in Gazaria and Kakailseo (Annex J - Pilot Dredging Project) did not perform well in matters where they were required to serve civic interests beyond their own economic or political interests. Nevertheless in the future, a committee selected by the community will be necessary for the management of platforms. The committee will only be functional when it can command support from the village's politically influential leadership. The CD component must build on lessons learned in the pilot project, both during and after the feasibility study. As a start, a number of lessons learned and ideas are provided in Annex D - Social.

Women's Empowerment: In the remote project area, women have not been exposed to any of the development programs, widely found in other rural areas of Bangladesh. They have no form of gender-specific groups or organizations, and no access to education, technical knowledge or credit. Women have no effective role on the platform committees in the pilot communities (Annex D). In an extended component of the Pilot Dredging Project, presently under consideration by CIDA, women as platform beneficiaries will be specifically targeted in groups with a savings and credit component. They will be exposed to training in improved horticulture practices, nutrition, platform protection and hygiene and sanitation. Selected platform beneficiary women will be trained in the construction of ring seal latrines, while others will be supported to develop tree nurseries.

Through their group activities and improved incomes, it is expected that women's capacity in decision-making and community participation will be strengthened. It is anticipated that during the course of the pilot project extension, a suitably, gender-orientated organization will be attracted to the project area. Implementation of such a program requires that female community organizers are fielded and supported in the project area. If the pilot project does not proceed to implementation, these activities should be included in the CD component of the KKRMP.

Products of Capacity Development

The initial products of capacity development activities will be the agreed and approved priorities for investments of the resources of the KKRMP as well as the organizations and people that will be the focus of capacity development. These will be followed by detailed plans to justify and obtain approvals for the required resources. The products of capacity development implementation will be functions, organizations, systems, groups and people whose performance is observably improved in relation relating to the KKRMP objectives.

Cost Estimate for Capacity Development

A cost estimate for the capacity development component of the project is presented in Table 10.3. Details of this estimate are provided in Annex L - Project Management Plan. However, this is not included as a direct project cost (e.g. not included in Table 7.13), but is expected to be funded under a technical assistance.

It is emphasized that successful capacity development is a necessity for sustainability of this project, which cuts across many Ministerial boundaries.

Table 10.3 Cost Estimates for Capacity Development

Organization	Institutional Development ('000 Tk)	Community Development ('000 Tk)	Total Capacity Development ('000 Tk)
GOB	7,431	3,648	11,079
Consultants	62,465	120,654	183,119
Total	**69,896**	**124,302**	194,198

11. PROJECT ASSESSMENT

11.1 Introduction

This Chapter assesses the proposed KKRMP (Alternative 1) from an economic, financial, environment and social viewpoint. The assessment is based not only on quantitative analyses, but also on those impacts that can only be described in qualitative terms. A summary assessment is also conducted using a Multi-Criteria analysis approach. Then, a project assessment in relation to other proposed projects, in the Northeast Region, is presented and project risks are discussed. Finally this chapter concludes with recommendations for the implementation of the KKRMP project.

11.2 Project Initiatives

The proposed Kalni-Kushiyara River Management Project is a multi-faceted project which would establish the pre-requisite socioeconomic and physical conditions required to initiate a sustainable development process for the targeted population. The objectives, scope, sectors benefiting, and major thrust are summarized in the Input-Output Matrix shown in Table 11.1

Table 11.1: Input-Output Matrix

Project	Physical Intervention	Objective	Scope	Benefit	Major Thrust
River Management Project	Dredging	Mending the river	Flood confinement	Crops, Homestead	Growth
			Drainage	Crops	Growth
			Navigation	Transportation	Growth
	Disposal of dredged spoil	Creating new platforms	Settlement	Landless settlement	Equity
			Community use	School, Growth centre, Recreation	Equity
		Improving existing platforms	Liveability	All strata of population	Equity
	Loop cut	Channel improvement	Flood confinement	Crops, Homestead	Growth
			Drainage	Crops	Growth
			Navigation	Transportation	Growth
	River training	River stabilization	Channel	Transportation	Growth
			Liveability	All strata of population	Equity

11.3 Economic Assessment

This section presents a summary of the economic assessment of the KKRMP based on the project costs and economic benefits analyses discussed in Annex E-Economics.

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11.3.1 Methodology

The *Guidelines for Project Assessment* (FPCO, 1992a) have been produced by the FPCO with the aim of standardizing the methodology and assumptions applied in the economic analysis undertaken by different FAP studies. They are based on widely accepted techniques for the appraisal of water resource development projects and provide a good basis for achieving the degree of uniformity and comparability between FAP studies.

The FPCO *Guidelines for Project Assessment* outline the detailed costing procedures for capital, operation and maintenance (O&M) costs, the financial and economic prices to be used and areas for which benefits/disbenefits are to be analyzed. The FPCO *Guidelines* also illustrate the multi-criteria analysis which provides a comprehensive basis for conducting a comparison of expected impacts in economic quantitative and qualitative terms.

For comparative purposes, all costs and benefits are valued in constant (non-inflated) 1995 prices for the duration of the analysis. The exchange rate assumed is Tk 41 = US$1.

Additionally, since commodity conversion factors (CCFs) are required to convert the (distorted) market value of specific commodities into (undistorted economic) border price equivalents, these are also provided in the *Guidelines*. NERP economists used the methodology outlined in the *"Special Study on Economics: Estimates of Economic Prices of Selected Commodities for Use in FAP Planning Studies"* (FPCO, 1992c) to subsequently determine the appropriate commodity conversion factors in terms of 1995 constant prices.

Other methodological procedures employed also generally adhere to the *Guidelines* and internationally-accepted principles. This requires the estimation of incremental benefit and cost streams over the entire economic life of the project. This is done by identifying and valuing all of the costs and benefits which will arise in the future with project (FW) scenario and comparing them with the situation as it would be in the future without project (FWO) scenario. The difference is the incremental net benefit arising from the proposed project investment (Gittinger, 1982). The economic life of the project is here considered to be 30 years including the pre-construction and construction periods.

The principal economic decision criteria employed are the Net Present Value (NPV) and Economic Internal Rate of Return (EIRR), both calculated on the incremental net benefit resulting from the FW and FWO scenarios.

Net Present Value
Net Present Value (NPV) is the sum of the discounted incremental net cash flow stream of the project. It is the cumulative present worth of the incremental national income generated by the investment. For a project to be economically feasible, the NPV must be positive for a pre-determined discount rate which reflects the opportunity cost of capital in Bangladesh (=12%/year excluding inflation).

Economic Internal Rate of Return
Economic Internal Rate of Return (EIRR) is that discount rate which when applied to the stream of incremental benefits and costs as reflected in the net cash flow of a project produces a zero net present value. It is the maximum (real, non-inflationary) annual rate of interest that a project could pay for the resources used if the project is to recover all of its costs and still break even.

For a project to be economically feasible, the EIRR must be equal to or greater than the opportunity cost of capital (or "cut-off" rate) which in Bangladesh has normally to be greater than 12%/year, excluding inflation.

A sensitivity analysis was also conducted to measure the reliability and robustness of the estimates, and to identify the benefit and cost items which have the greatest influence on the overall economics of the project.

11.3.2 Economic Project Costs

Capital Costs
The KKRMP includes the following components:

- Constructing loop cuts at Issapur and Katkhal;
- Re-excavating the reach between Kalma and Ajmiriganj by dredging;
- Constructing flood-resistant village platforms from the dredged spoil;
- Constructing bank protection works at various sites;
- Constructing levees along low banks to reduce spills;
- Constructing regulating structures for multi-purposes uses, and
- Conducting maintenance dredging for improved navigation up to Fenchuganj.

Capital Costs estimating procedures followed the FPCO *Guidelines*. Detailed quantity and cost estimates have been provided in Annex C - Engineering and Annex I - Environmental Impact Assessment. Physical contingencies equal to 15% of base construction costs as per the FPCO *Guidelines* were used to cover unforeseen costs. Engineering design and supervision costs were estimated at 12% of base construction costs and physical contingencies. All capital costs are presented in terms of June 1995 constant prices using deflators determined by the Bangladesh Bureau of Statistics (BBS).

Total financial capital costs for the KKRMP during Years 1 to 9 are estimated to be about Tk 2,788 million (1995 prices). These capital costs are inclusive of land costs and EMP costs (both mitigation and enhancement programs), but exclusive of loan costs. A comparable economic capital cost estimate of about Tk 2,368 million was obtained by: a) excluding land compensation costs; and b) shadow pricing various construction costs using the updated conversion factors given in Annex E (Appendices E.1 and E.2). A financial and economic capital cost summary is provided in Table 11.2.

Operation and Maintenance Costs
The annual operation and maintenance (O&M) costs include:

- annual maintenance dredging;
- village platforms maintenance, and
- physical components maintenance.

The annual O&M costs, including 15% contingencies, for the annual dredging and platforms have been calculated based on the adapted estimating procedure for capital costs (Chapter 7).

Following the FPCO *Guidelines*, O&M costs for physical components including 15% contingencies, have been calculated as a percentage of capital cost; including 6% for embankment and drainage channels, 3% for structures, 10% for river bank protection and training and 3% for slope protection.

In Year 8, the KKRMP O&M financial costs are Tk 134.5 million/year but then gradually drop to about Tk 104.1 million/year during Years 18-30 (Table 11.3). The corresponding annual economic O&M costs at project maturity in Year 18 is about 93.7 million/year (Table 11.4).

A standard Conversion Factor (SCF) of 0.9 has been used to convert the financial O&M costs into economic O&M costs. Conversion factors for project inputs are presented in Annex E (Appendices E.1 and E.2).

Table 11.2: Capital Cost Summary

Item		Financial Cost (mTk)	Conversion Factor	Economic Cost (mTk)	1	2	3	4	5	6	7	8	9
Channel Dredging		603.36	0.9	543.02	0.00	0.00	0.00	54.30	195.49	293.23	0.00	0.00	0.00
Channel Realignment	Manual	10.78	0.9	9.70	0.00	0.00	0.00	0.00	9.70	0.00	0.00	0.00	0.00
	Dredging	24.60	0.9	22.14	0.00	0.00	0.00	0.00	22.14	0.00	0.00	0.00	0.00
Issapur Loop Cut	Dredging	254.00	0.9	228.60	0.00	0.00	160.02	68.58	0.00	0.00	0.00	0.00	0.00
	Manual Earthwork	105.61	0.9	95.05	0.00	0.00	95.05	0.00	0.00	0.00	0.00	0.00	0.00
	Slope Protection-Soft	5.25	0.9	4.73	0.00	0.00	4.73	0.00	0.00	0.00	0.00	0.00	0.00
	Slope Protection-Hard	84.03	0.75	63.02	0.00	0.00	0.00	63.02	0.00	0.00	0.00	0.00	0.00
	Drains-Stairs	0.95	0.75	0.71	0.00	0.00	0.00	0.50	0.21	0.00	0.00	0.00	0.00
	Levelling	1.53	0.9	1.38	0.00	0.00	0.00	1.38	0.00	0.00	0.00	0.00	0.00
	Closure	3.96	0.9	3.56	0.00	0.00	0.00	3.56	0.00	0.00	0.00	0.00	0.00
Katkhal Loop Cut	Dredging	264.05	0.9	237.65	0.00	0.00	95.06	118.82	23.76	0.00	0.00	0.00	0.00
	Manual Earthwork	79.41	0.9	71.47	0.00	0.00	28.59	35.73	7.15	0.00	0.00	0.00	0.00
	Slope Protection-Soft	10.53	0.9	9.48	0.00	0.00	3.79	4.74	0.95	0.00	0.00	0.00	0.00
	Slope Protection-Hard	92.92	0.75	69.69	0.00	0.00	0.00	27.88	34.85	6.97	0.00	0.00	0.00
	Closure	17.47	0.9	15.72	0.00	0.00	0.00	0.00	15.72	0.00	0.00	0.00	0.00
	Temporary Bank Protection	6.62	0.9	5.96	5.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Permanent Bank Protection	42.39	0.75	31.79	0.00	0.00	0.00	0.00	31.79	0.00	0.00	0.00	0.00
Madna Closures		1.45	0.9	1.31	0.00	0.00	0.00	1.31	0.00	0.00	0.00	0.00	0.00
River Training		110.67	0.77	85.22	0.00	0.00	0.00	0.00	25.56	59.65	0.00	0.00	0.00
Levees		10.86	0.9	9.77	0.00	0.00	0.00	0.00	0.00	9.77	0.00	0.00	0.00
Homestead Platforms	Confinement Dyke Construction	96.50	0.9	86.85	0.00	0.00	0.00	9.55	39.08	38.21	0.00	0.00	0.00
	Slope Protection-Soft : First Year	16.41	0.9	14.77	0.00	0.00	0.00	1.62	6.65	6.50	0.00	0.00	0.00
	Slope Protection-Soft : Three Years	28.41	0.9	25.57	0.00	0.00	0.00	0.00	1.02	4.86	8.44	5.63	5.63
	Slope Protection-Hard	111.18	0.75	83.39	0.00	0.00	0.00	0.00	8.34	37.52	37.52	0.00	0.00
	Dyke Repairs	1.93	0.9	1.74	0.00	0.00	0.00	0.00	0.19	0.78	0.76	0.00	0.00
	Drains-Stairs	13.20	0.75	9.90	0.00	0.00	0.00	0.00	1.49	4.46	3.96	0.00	0.00
	Levelling	5.23	0.9	4.71	0.00	0.00	0.00	0.00	0.99	1.98	1.74	0.00	0.00
	Topsoil	22.99	0.9	20.69	0.00	0.00	0.00	0.00	4.35	8.69	7.66	0.00	0.00
	Effluent Outlet-Construction	1.30	0.9	1.17	0.00	0.00	0.00	0.18	0.53	0.47	0.00	0.00	0.00
	Effluent Outlet-Filling	1.30	0.9	1.17	0.00	0.00	0.00	0.00	0.18	0.53	0.47	0.00	0.00
Drainage Regulators		23.17	0.82	19.00	0.00	0.00	0.00	0.00	11.40	7.60	0.00	0.00	0.00
EMP	Mitigation	20.63	0.9	18.57	3.71	7.43	1.86	1.86	1.86	1.86	0.00	0.00	0.00
	Compensation	0.66	0.9	0.59	0.00	0.00	0.06	0.12	0.18	0.24	0.00	0.00	0.00
	Enhancement	28.91	0.9	26.02	0.00	0.00	1.82	2.60	5.20	5.20	7.29	3.90	0.00
	Training	0.5	0.9	0.45	0.09	0.09	0.05	0.05	0.09	0.05	0.05	0.00	0.00
	Monitoring	6.9	0.9	6.21	1.24	1.24	0.62	0.62	1.24	0.62	0.62	0.00	0.00
BASE COST		**2109.66**		**1830.75**	**11.00**	**8.76**	**391.63**	**396.42**	**450.10**	**489.18**	**68.50**	**9.53**	**5.63**
Physical Contingencies(15%)		316.45		274.61	1.65	1.31	58.75	59.46	67.52	73.38	10.28	1.43	0.84
SUB-TOTAL		**2426.11**		**2105.37**	**12.65**	**10.07**	**450.38**	**455.88**	**517.62**	**562.56**	**78.78**	**10.96**	**6.47**
Study Cost		291.80	0.9	262.62	26.26	52.52	39.39	39.39	39.39	26.26	26.26	13.13	0.00
SUB-TOTAL		**2717.91**		**2367.99**	**38.92**	**62.60**	**489.77**	**495.27**	**557.01**	**588.82**	**105.04**	**24.09**	**6.47**
Land Acquisition	Issapur Loop Cut	37.80											
	Katkhal Loop Cut	24.38											
	Levees and Structures	2.40											
	Navigation	0.36											
	Anandapur	1.56											
	Abdullahpur	3.52											
TOTAL		**2787.93**		**2367.99**	**38.92**	**62.60**	**489.77**	**495.27**	**557.01**	**588.82**	**105.04**	**24.09**	**6.47**

Table 11.3: O&M Cost Summary : Financial

Item		1 - 6 (mTk)	7 (mTk)	8 (mTk)	9 (mTk)	10 (mTk)	11 (mTk)	12 (mTk)	13 (mTk)	14 (mTk)	15 (mTk)	16 (mTk)	17 (mTk)	18 - 30 (mTk)
Construction	Dyke			4.17	4.17	4.17	3.75	3.75	3.75	3.33	3.33	3.33	3.33	0.73
	Dredging			82.00	82.00	82.00	73.80	73.80	73.80	65.60	65.60	65.60	65.60	65.60
	Protection			2.14	2.14	2.14	1.92	1.92	1.92	1.71	1.71	1.71	1.71	0.00
	Dyke O&M			0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.01
	Topsoil			2.44	2.44	2.44	2.20	2.20	2.20	1.96	1.96	1.96	1.96	0.00
	Drains			0.89	0.89	0.89	0.80	0.80	0.80	0.71	0.71	0.71	0.71	0.00
	First Year			0.15	0.15	0.15	0.13	0.13	0.13	0.12	0.12	0.12	0.12	0.00
	Third Year			0.35	0.35	0.35	0.31	0.31	0.31	0.28	0.28	0.28	0.28	0.00
	Outlet Both			0.22	0.22	0.22	0.20	0.20	0.20	0.18	0.18	0.18	0.18	0.04
	Earthwork		1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
	Bank Protection		15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30	15.30
	Regulators		0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
	Slope Protection(hard)		5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30
	Total	**0.00**	**22.76**	**115.20**	**115.20**	**115.20**	**105.95**	**105.95**	**105.95**	**96.72**	**96.72**	**96.72**	**96.72**	**89.14**
	Physical Contingencies(15%)	0.00	3.41	17.28	17.28	17.28	15.89	15.89	15.89	14.51	14.51	14.51	14.51	13.37
EMP	Mitigation			0.57	0.57	0.57	0.51	0.51	0.51	0.45	0.45	0.45	0.45	0.45
	Compensation			0.06	0.06	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04
	Enhancement			1.13	1.13	1.13	1.02	1.02	1.02	0.90	0.90	0.90	0.90	0.90
	Total	**0.00**	**0.00**	**1.75**	**1.75**	**1.75**	**1.58**	**1.58**	**1.58**	**1.40**	**1.40**	**1.40**	**1.40**	**1.40**
	Physical Contingencies(15%)	0.00	0.00	0.26	0.26	0.26	0.24	0.24	0.24	0.21	0.21	0.21	0.21	0.21
TOTAL		**0.00**	**26.17**	**134.49**	**134.49**	**134.49**	**123.65**	**123.65**	**123.65**	**112.84**	**112.84**	**112.84**	**112.84**	**104.12**

Table 11.4: O&M Cost Summary : Economic

Item		1 - 6 (mTk)	7 (mTk)	8 (mTk)	9 (mTk)	10 (mTk)	11 (mTk)	12 (mTk)	13 (mTk)	14 (mTk)	15 (mTk)	16 (mTk)	17 (mTk)	18 - 30 (mTk)
Construction	Dyke	0.00	0.00	3.75	3.75	3.75	3.38	3.38	3.38	3.00	3.00	3.00	3.00	0.66
	Dredging	0.00	0.00	73.80	73.80	73.80	66.42	66.42	66.42	59.04	59.04	59.04	59.04	59.04
	Protection	0.00	0.00	1.93	1.93	1.93	1.73	1.73	1.73	1.54	1.54	1.54	1.54	0.00
	Dyke O&M	0.00	0.00	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.01
	Topsoil	0.00	0.00	2.20	2.20	2.20	1.98	1.98	1.98	1.76	1.76	1.76	1.76	0.00
	Drains	0.00	0.00	0.80	0.80	0.80	0.72	0.72	0.72	0.64	0.64	0.64	0.64	0.00
	First Year	0.00	0.00	0.14	0.14	0.14	0.12	0.12	0.12	0.11	0.11	0.11	0.11	0.00
	Third Year	0.00	0.00	0.32	0.32	0.32	0.28	0.28	0.28	0.25	0.25	0.25	0.25	0.00
	Outlet Both	0.00	0.00	0.20	0.20	0.20	0.18	0.18	0.18	0.16	0.16	0.16	0.16	0.04
	Earthwork	0.00	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
	Bank Protection	0.00	13.77	13.77	13.77	13.77	13.77	13.77	13.77	13.77	13.77	13.77	13.77	13.77
	Regulators	0.00	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
	Slope Protection(hard)	0.00	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77
	Sub-Total	**0.00**	**20.48**	**103.68**	**103.68**	**103.68**	**95.36**	**95.36**	**95.36**	**87.05**	**87.05**	**87.05**	**87.05**	**80.23**
	Physical Contingencies(15%)	0.00	3.07	15.55	15.55	15.55	14.30	14.30	14.30	13.06	13.06	13.06	13.06	12.03
EMP	Mitigation	0.00	0.00	0.51	0.51	0.51	0.46	0.46	0.46	0.41	0.41	0.41	0.41	0.41
	Compensation	0.00	0.00	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
	Enhancement	0.00	0.00	1.02	1.02	1.02	0.92	0.92	0.92	0.81	0.81	0.81	0.81	0.81
	Sub-Total	**0.00**	**0.00**	**1.58**	**1.58**	**1.58**	**1.42**	**1.42**	**1.42**	**1.26**	**1.26**	**1.26**	**1.26**	**1.26**
	Physical Contingencies(15%)	0.00	0.00	0.24	0.24	0.24	0.21	0.21	0.21	0.19	0.19	0.19	0.19	0.19
TOTAL		**0.00**	**23.56**	**121.04**	**121.04**	**121.04**	**111.29**	**111.29**	**111.29**	**101.56**	**101.56**	**101.56**	**101.56**	**93.71**

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Phasing & Disbursements
There are essentially 4 proposed Phases for the implementation and O&M of the project intervention:

- Years 1-2: Pre-Construction, which includes cadastral surveys, topographic surveys, detailed engineering design, tender documentation, awarding of contracts, and land acquisition;

- Years 3-4: Construction, which focuses on the Loop Cuts, Dhaleswari Dredging and closely related activities;

- Years 5-7: Construction, which focuses on Channel Dredging and Channel Re-alignments, River Training and Levees. This includes most dyking, platform development, slope protection, and EMP activities, and

- Years 8-30: O&M activities, including EMP construction and protection of homestead platforms, as well as additional dredging and platform development.

11.3.3 Economic Benefits

The specific benefits evaluated in the economic analysis include the following:

- Agricultural Production;
- Socioeconomic Infrastructure
- Fisheries, and
- Navigation.

Graph 11.1 shows the relative contribution of each sector to the total KKRMP economic benefits projection.

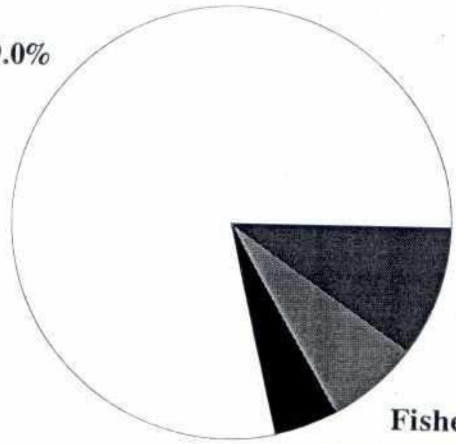
Agricultural Production
The largest beneficial impact of the proposed Kalni-Kushiyara River Management Project would accrue to the agricultural crops sector. Essentially, *boro* (dry season) crop damage due to over-bank spills, inundation and breaches in the river banks during the pre-monsoon season would be reduced and flood free lands would be increased. These pre-monsoon flood control benefits to agriculture would, therefore, essentially come from the following changes:

- the proportion of damage-free to damaged area will increase and thereby reduce pre-monsoon flood losses which, in turn, will subsequently increase the average yield per hectare of land, and

- changes in the area under a particular crop will arise due to a shift in production from one crop to another.

The total physical cultivated areas for the present conditions, FWO, and FW scenarios are respectively estimated to be 279,850, 276,945, and 277,424 hectares. This represents over 80% of the total study area.

Graph 11.1: Relative Contribution of Sector Benefits to Total Kalni-Kushiyara Economic Benefits Projects



Expected net returns for the FWO and FW scenarios were determined for 3 different pre-monsoon floods of respectively 1:2, 1:5 and 1:10 year return periods. The net return (called the gross margin) for each crop for each of these scenarios was determined by subtracting the respective costs-of-production from the expected gross revenue. The difference in the expected net returns is an estimate of the incremental flood control economic benefits to agriculture under each of the 3 flood return periods.

The resulting net returns were then used to determine the expected average annual agricultural benefits attributable to the proposed project. These calculations indicate that the average annual project economic benefits to the agricultural sector should amount to about Tk 374 million per annum (Table 11.5). On a per-hectare basis, this translates into about Tk 1,348 per annum (or, at the current exchange rate, about US$ 33/year/ha). As a point of reference, this would be about 14% of a typical gross margin/year/ha.

Table 11.5: Phasing of Average Agricultural Annual Economic Benefits

	Year 1-3	Year 4	Year 5	Year 6	Year 7-30
Expected Annual Agriculture Economic Benefits (million Tk)	0	150	224	299	374
Benefits Phasing (%)	0	40	60	80	100

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The two loop cuts are scheduled to be completed in January-February of Year 4, before the possible occurrence of pre-monsoon floods. The immediate effect will be a lowering of water levels in the Kalni River below Ajmiriganj, offering partial flood protection. The proposed KKRMP project will then provide 40% of the pre-monsoon flood protection benefits immediately after the completion of the loop cuts. Consequently, 40% of agricultural benefits are expected to accrue beginning in Year 4. These benefits would then climb at about 20% per year and reach their maximum in Year 7. This is a relatively quick start-up and maturation of the anticipated agricultural benefit stream (Table 11.5).

Socioeconomic Infrastructure
The expected benefits of the proposed project to the socioeconomic infrastructure of the region are numerous and varied. They include the following:

- Kalni-Kushiyara river bank flood protection;
- Additional river bank protection & related land development;
- Village platform (VP) flood and wave protection;
- VP homestead gardens, fruit trees and slope protection;
- VP homestead grain drying;
- Quality of life Improvement, and
- Reduction of O&M for existing projects.

Some of these expected benefits represent a "package" of attributes and therefore are only very imperfect proxy variables. Other variables are those which knowingly do not account for all of the expected benefits being quantified. The quantitative socioeconomic infrastructure benefits should only be treated as order-of-magnitude indicators.

For this study, 16 underlying benefits were quantified to reflect the total socioeconomic value of all benefits. These were subsequently grouped into 7 component benefits which after analysis were found to contribute to the aggregate economic benefits estimate approximately as follows:

• Kalni-Kushiyara River bank flood protection;	16%
• Additional bank protection & related land development;	14%
• Village platform flood & wave protection;	23%
• Homestead gardens fruits, fruit trees and slope plantation;	26%
• Homestead grain drying;	4%
• Quality of life improvement, and	15%
• Additional protection to existing projects	2%
TOTAL	**100%**

As shown on Table 11.6, adding up the 7 component benefits over the 30 year projected life of the project provides monetary estimate of the annual incremental socioeconomic infrastructure economic benefits.

The benefit gradually climbs over the life of the project, ultimately levelling off in Year 26 at about Tk 76.3 million per year. As such, this would be the second largest direct benefit of the project at about 10% of total of the project benefits.

Table 11.6: Summary of Expected Socioeconomic Infrastructure Annual Economic Benefits

Year	K-K River Bank Protection (mTk)	Additional River Bank Protection (mTk)	Village Platforms				Existing Projects (mTk)	TOTAL (mTk)
			Flood & Wave Protection (mTk)	Garden & Other (mTk)	Grain Drying (mTk)	Quality of Life (mTk)		
1	0	0	0	0	0	0	0	00
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	3	0.1	3.8	0	0.5	1	0.4	9.06
6	5	1.5	5.6	0.5	0.8	2	0.8	16.04
7	6	4.7	7.5	0.7	1.1	3	1.0	24.42
8	8	6.1	9.4	9.5	1.4	4	1.3	39.65
9	8	7.1	10.0	12.2	1.5	5	1.3	45.13
10	8	8.2	10.6	13.5	1.7	6	1.3	49.27
11	8	8.2	11.2	14.1	1.8	7	1.3	51.57
12	8	8.2	11.8	14.7	2.0	8	1.3	53.95
13	8	8.2	12.4	15.4	2.1	9	1.3	56.33
14	8	8.2	13.0	16.0	2.2	10	1.3	58.71
15	8	8.2	13.6	16.7	2.4	11	1.3	61.09
16	8	8.2	14.2	17.3	2.5	12	1.3	63.47
17	8	8.2	14.8	18.0	2.7	13	1.3	65.87
18	8	8.2	15.4	19.0	3.1	14	1.3	68.61
19	8	8.2	15.4	20.0	3.1	15	1.3	70.97
20	8	8.2	15.4	21.1	3.1	16	1.3	73.00
21	8	8.2	15.4	21.7	3.1	16	1.3	73.61
22	8	8.2	15.4	22.2	3.1	16	1.3	74.14
23	8	8.2	15.4	22.7	3.1	16	1.3	74.67
24	8	8.2	15.4	23.3	3.1	16	1.3	75.20
25	8	8.2	15.4	23.8	3.1	16	1.3	75.73
26-30	8	8.2	15.4	24.3	3.1	16	1.3	76.29

Source: Annex E - Economics

Fisheries

The project is expected to impact on fisheries in the following ways:

- it will facilitate migration by increasing the depth and wetted surface area of the main river during the dry season and reducing the rate of beel siltation;
- loop cuts will eliminate 6 *duars* which will have an adverse effect on fish populations (although these *duars* are in the process of natural siltation anyway);
- although there will be no reduction in the seasonally-flooded area, the hectare-months of inundation could be reduced by a few weeks during the pre-monsoon season and, in turn, this could have a marginally adverse impact on fish biodiversity, and
- installation of a fishpass at Koyer Dhala will enhance fish production in the Kodalia Fishery.

The present conditions, FWO and FW scenarios are based on primary data, including data from the NERP Fishing Effort Survey and the Catch Assessment Survey conducted in the Kalni-Kushiyara River system area over a two-year period.

Production projections for each habitat for both the FWO and FW scenarios were obtained by multiplying the area of each habitat with the corresponding production per hectare of area. Total capture represents the aggregate of riverine, floodplain and *beel* in terms of catch per unit of effort (i.e., kilograms per hectare per year).

The incremental production represents the difference in total fisheries' production in the FW and FWO scenarios, as presented in Table 11.7.

Table 11.7: Projected Changes in Fish Production

Habitat Group	Present Production (tonnes)	FWO Production (tonnes)	FW Production (tonnes)	Impact FW vs Present (tonnes)	Impact FW vs FWO (tonnes)
Riverine	2,251	2,141	2,748	497	607
Floodplain and *Beels*	48,265	46,407	46,523	(1,742)	116
Floodplain culture Ponds	4,036	3,834	4,440	404	606
TOTAL	**54,552**	**52,382**	**53,711**	**(841)**	**1,329**

Fish species' market prices were taken from the Fish Market Price Survey (NERP, 1996c). This information was obtained from a two-year survey conducted by NERP fisheries' specialists. The available species of fish have been grouped into carp species, catfish and other large species, *golda chingri* and small fish. Fish market prices have been converted to 1995 constant prices using the fisheries sector deflator determined by the Bangladesh Bureau of Statistics (BBS). The updated standard conversion factor (SCF) has been used to reflect the fish market prices in terms of their economic price, (i.e. SCF = 0.90). The estimated weighted average market price is Tk 50/kg live weight for open access capture fish, and Tk 75/kg for pond culture fish (Annex H - Fisheries).

Harvest costs have been determined for open access capture in both the river and floodplain (floodplain plus *beels*) and pond cultures. Costs have been converted from a per hectare basis to a per kilogram basis using the same methodology than the one adopted in the Dampara Water Management Project, Feasibility Study (NERP, 1997). These costs take into account the amortized cost of gears and boats, other material costs such as bamboo and rope, lease costs, guarding, maintenance, and labor. The fisheries harvest cost estimates are summarized in Table 11.8.

Table 11.8: Fisheries Harvest Cost Estimates

Habitat Group	Financial Harvest Costs (Tk/kg)	Economic Harvest Costs (Tk/kg)
Riverine	6.8	5.9
Floodplain and *Beels*	20.3	17.7
Ponds	45.6	39.7

Applying the economic prices to the projected production change provides an estimate of the additional net revenue earned from fisheries production when the project is implemented (Table 11.9).

Table 11.9: Expected Fisheries Net Economic Revenue Benefits

Habitat Group	Production Increase (tonnes)	Economic Price (Tk/kg)	Economic Harvest Cost (Tk/kg)	Net Economic Revenue Benefits (million Tk)
Riverine	607	45.0	5.9	23.7
Floodplain and *Beels*	116	45.0	17.7	3.2
Ponds	606	67.5	39.7	16.8
TOTAL	**1,329**			**43.7**

The annual fisheries production is expected to increase when the project is implemented. The annual expected net economic revenue benefits for fisheries will be Tk 43.7 million at maturity (Year 9).

It is expected that the fisheries economic benefits would be gradually phased in from 0% during Years 1 to 5; 20% during Year 6; 40% during Year 7; 80% during Year 8 and 100% during Years 9 to 30 (Table 11.10).

Table 11.10: Phasing of Expected Fisheries Annual Economic Benefits

	Years 1-5	Year 6	Year 7	Year 8	Years 1-9
Expected Annual Fisheries Economic Benefits (million Tk)	0	8.7	17.5	35.0	43.7
Benefits Phasing (%)	0	20	40	80	100

Navigation

The proposed project would provide for a Class II navigation channel (defined as 2.4 m LAD and 50 m wide) throughout the dry season between Fenchuganj and Astagram.

The potential navigation benefits of the project are based on estimated cost savings and projected cargo volumes. The summation of the cost savings generated from different types of cargo movement is considered the total navigational impact of the project.

The expected cost savings are generally based on the estimated differences between wet and dry season freight rates. This is calculated as the differences between inland waterways transportation (IWT) type craft rates operating at 2.4 m LAD versus dry season rates for country boats. Other possible cost savings include the increase in the dry season traffic cargo movement on the Kalni-Kushiyara River which would be diverted from other channels and roads.

A summary of the base data employed to project future cargo transportation benefits, for the proposed intervention, is provided in Table 11.11. The economic unit navigation cost savings are calculated by applying the Standard Conversion Factor (SCF =0.9) to the financial unit cost saving.

Table 11.11: Navigation Benefit Parameters

Item	Unit Cost Saving (Tk/tonne)		Dry Season Baseline Quantity (tonnes) Year 1	Annual Growth of Cargo Movement Years 2-30 (FW) (%)		
	Financial	Economic		2-10	11-20	21-30
Fertilizer Demand	67.5	60.8	21,760	3%		
Fertilizer (Rehandled)	12.5	11.3	2,176			
Fertilizer (Trans-Ship.)	122.5	110.3	36,000	constant		
Fertilizer (Through-Ship)	36.0	32.4	160,000			
Rice	64.5	58.1	30,000	function of population		
Bldg. Materials	64.5	58.1	72,690	3%	4%	5%
POL Items						
Urban	64.5	58.1	3,123	3%	4%	5%
Rural			7,287	3%	3.5%	3.5%
TOTAL			**10,410**			
Other Food Items	64.5	58.1	19,600	function of population		
Consumer Goods & Miscellaneous	64.5	58.1	30,820			
Rehandling Factor	64.5	58.1	10% non-fertilizer			

The detailed economic simulations are provided in Annex G - Navigation and indicate that the following expected cargo transportation annual economic benefits should arise (Table 11.12).

Table 11.12: Expected Cargo Transportation Annual Economic Benefits

Year	Navigation Benefits (million Tk)	Year	Navigation Benefits (million Tk)
1-4	0.0	17	25.9
5	(20%) 4.3	18	26.4
6	(40%) 8.6	19	26.9
7	(100%) 21.9	20	27.4
8	22.2	21	28.1
9	22.6	22	28.7
10	22.9	23	29.4
11	23.3	24	30.1
12	23.7	25	30.8
13	24.1	26	31.5
14	24.6	27	32.3
15	25.0	28	33.1
16	25.5	29	34.0
		30	34.9

Source: Annex E - Economics

Although passengers should realize some savings, most of these are likely to be time-related rather than actual reduced travel costs. However, this benefit is not included in the economic assessment, because the available data does not distinguish between passengers on purely local routes and those on longer runs where savings may be achieved.

The proposed project would also make it physically possible to accommodate additional international transit traffic through the Kalni-Kushiyara River reach. Recent traffic volume is about 24,000 tonnes/year but, based on historical data, traffic could increase to over 250,000 tonnes/year as the population in the Northeast Hill States of India has doubled since 1961-62 when the transit traffic was 113,000 tonnes (Table 3.14). This may enhance regional annual economic benefits by between Tk 2.4 million to Tk 25 million, assuming a GOB levee of Tk 100/tonne, a reasonable assumption. However, this benefit is also not included in the economic assessment because changes in future freight traffic through the Kalni-Kushiyara system will depend on international agreements, rather than on projections.

11.3.4 Economic Analysis

The economic cost-benefit stream of the proposed KKRMP is provided in Table 11.13 and is illustrated in Graphs 11.2 and 11.3. The resulting estimate of the economic Net Present Value (NPV) of the incremental net benefit stream, employing a 12% annual discount rate over 30 years, is Tk 531.0 million. This positive and relatively large NPV indicates that from an economic perspective, the proposed KKRMP should be a feasible economic investment opportunity for Bangladesh.

Similarly, Table 11.13 shows the imputed Economic Internal Rate of Return (EIRR) is estimated to be 17.2% per annum, which is considerably higher than the designated "cut-off" rate of 12% per annum. The EIRR estimate also indicates the KKRMP is an attractive economic investment opportunity.

The projected incremental net benefits stream of the project has been calculated by subtracting the cost stream from the benefits/disbenefits stream.

Capacity and Community Development
The rroject will incur an additional cost of Tk 194.2 million in the way of capacity and community development which has not been included in the economic analysis. Benefits generated from these activities are very difficult to quantify. It has been assumed that EIRR and NPV are not applicable to these activities. They are part of Canada's contribution to the development of Bangladesh and the experience gained may be used elsewhere.

Long-Term Benefits Monitoring
The cost of long-term benefits monitoring (Tk 62.4 million) is not part of the financial capital costs and has, therefore, not been considered in this economic analysis.

Sensitivity Analysis
The economic analysis is based on uncertain future events and imperfect data. Consequently, a sensitivity analysis must be conducted to assess systematically the reliability and robustness of the Base Case estimates. It is particularly important to identify the benefit and cost items which have the greatest influence on the overall economics of the project, as well as the extent of their influence. There are really 4 reasons why the Base Case should be subjected to extensive sensitivity testing:

- Predicting the future is always somewhat speculative;
- Inaccurate and incomplete data;
- "Intangibles" are very difficult to quantify, and
- Inherent methodological limitations.

The implications on the NPV and EIRR regarding some of the most significant sensitive analyses are summarized in Table 11.14.

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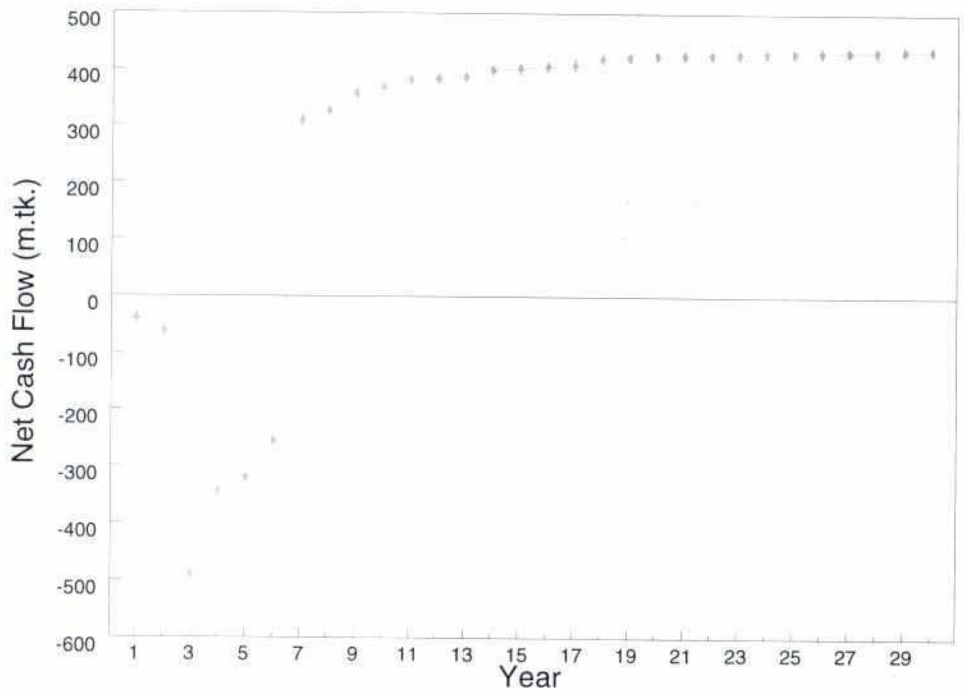
Table 11.13: Summary of Annual Cost and Benefit Streams and Discounted Cash Flow Analysis

Year	Capital & O&M Costs (million Tk)	Benefits (million Tk)					Net Cash Flow (million Tk)
		Agriculture	Navigation	Fisheries	Infrastructures	Total	
1	38.92	0	0	0	0	0	(38.9)
2	62.60	0	0	0	0	0	(62.6)
3	489.8	0	0	0	0	0	(489.8)
4	495.3	150	0	0	0	150.00	(345.8)
5	557.0	224	4.3	0	9.06	237.36	(319.4)
6	588.8	299	8.6	8.7	16.04	332.46	(256.5)
7	128.6	374	21.9	17.5	24.42	437.61	309.0
8	145.1	374	22.2	35.0	39.65	470.6	325.5
9	127.5	374	22.6	43.7	45.13	485.2	357.7
10	121.0	374	22.9	43.7	49.27	489.7	368.6
11	111.3	374	23.3	43.7	51.57	492.4	381.1
12	111.3	374	23.7	43.7	53.95	495.14	385.9
13	111.3	374	24.1	43.7	56.33	497.94	386.7
14	101.6	374	24.6	43.7	58.71	500.75	399.2
15	101.6	374	25.0	43.7	61.09	503.58	402.0
16	101.6	374	25.5	43.7	63.47	506.43	404.9
17	101.6	374	25.9	43.7	65.87	509.30	407.7
18	93.7	374	26.4	43.7	68.61	512.52	418.8
19	93.7	374	26.9	43.7	70.97	515.38	421.7
20	93.7	374	27.4	43.7	73.00	517.42	424.2
21	93.7	374	28.1	43.7	73.61	519.15	425.4
22	93.7	374	28.7	43.7	74.14	520.52	426.6
23	93.7	374	29.4	43.7	74.67	521.52	427.8
24	93.7	374	30.1	43.7	75.20	522.74	429.0
25	93.7	374	30.8	43.7	75.73	524.00	430.3
26	93.7	374	31.5	43.7	76.29	525.31	431.6
27	93.7	374	32.3	43.7	76.29	526.09	432.4
28	93.7	374	33.1	43.7	76.29	526.91	433.2
29	93.7	374	34.0	43.7	76.29	527.76	434.0
30	93.7	374	34.9	43.7	76.29	528.64	434.9
PV(12%)	1,808.5	1,847.9	104.3	161.4	225.9	2,339.5	
Distribution (%)		79	4.5	6.9	9.7	100	
NPV(12%)							**531.0**
EIRR (%)							**17.2**

Graph 11.2: Net Cash Flow Over Project Life Time



Graph 11.3: Project Costs and Benefits Over Project Life Time

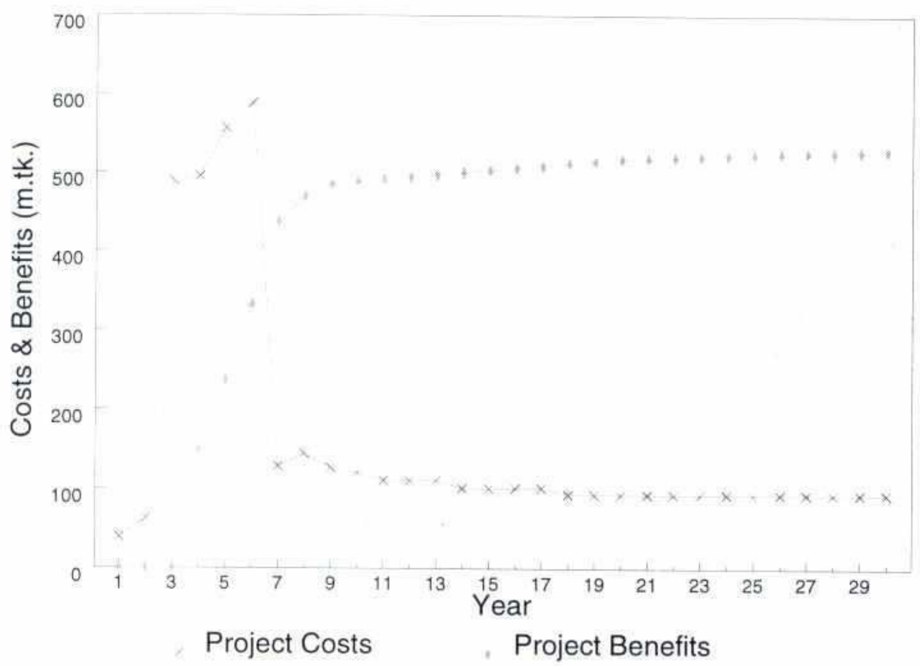


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Table 11.14: Summary of Sensitivity Analysis

VARIABLE		NPV @ 12% (million Tk '95)	EIRR (%/year)
BASE CASE (most likely)		531.0	17.2
1.a	Capital costs increase by 20%	253.6	14.1
1.b	O&M costs increase by 20%	453.7	16.5
1.c	Capital & O&M costs increase by 20%	169.3	13.4
2.a	Post-construction dredging costs increase by 100%	237.3	14.5
2.b	Post-construction dredging costs increase by 180%	2.4	12.0
2.c	Post-construction dredging costs decrease by 50%	574.6	18.2
3.a	Cost and Benefits of village platform development excluded	451.4	17.1
3.b	Village platform "social" benefits increase by 100%	747.0	19.0
4.a	Net agricultural benefits decrease by 20%	161.5	13.6
4.b	Net agricultural benefits decrease by 28%	13.6	12.1
4.c	Net agricultural benefits increase by 20%	900.6	20.8
5.	Rare flood event in Year 10 (<5% probability of exceedence)	408.7	16.0
6.a	Agricultural benefits do not mature until Year 10	377.0	15.5
6.b	All benefit streams delayed 2 years	26.7	12.2
6.c	Only net agricultural benefits delayed 2 years	104.9	12.9
7.a	Study costs are excluded from analyses	702.3	20.0
7.b	Exclude two-year preparation period	731.0	17.5
8.	Passengers and trans-shipments included in navigation benefits	637.5	18.0
9.a	Fishery benefits based on Present and not FWO	260.2	14.9
9.b	Agriculture benefits based on Present and not FWO	(143.0)	10.5
9.c	Agriculture & fisheries benefits based on Present versus FW	(325.6)	7.9
10.a	Capital costs increase by 20% and net agricultural benefits decrease by 20%	(200.3)	10.3
10.b	Capital costs increase by 20% and agricultural benefits do not mature until Year 10	15.0	12.1
10.c	Capital costs increase by 20% and agriculture benefits based on Present and not FWO	(290.5)	8.2
10.d	Capital costs increase by 20% and fishery benefits based on Present and not FWO	(52.5)	11.6
11.	No Issapur Loop Cut (denoted "Alternative 2")	254.5	15.2

Each sensitivity analysis is briefly discussed following:

1. If capital and O&M costs all increase by 20%, an approximately 1:1 relationship means that the EIRR would also drop by about 20%, from 17.2% to about 13.4%. If capital cost increases by 20%, EIRR drops to 14.1%. A 20% increase in the O&M cost would drop the EIRR to 16.5%.

2. The extent to which dredging will be required during the post-construction period is also somewhat ambiguous. The construction phase work could make the river more self-cleaning and actually decrease subsequent dredging requirements. Or, conversely, these requirements could be even higher than presently expected. A doubling of post-construction dredging costs would drop the EIRR to 14.5%; a 50% decrease in these same costs would increase the EIRR to about 18.2%. An increase in dredging cost by 10% would drop the EIRR by 0.25%. The EIRR reaches the break even point (12%) if post-construction dredging cost increases by 180%.

3. It is particularly difficult to accurately quantify all of the costs and benefits associated with the proposed village platforms; particularly the so-called "intangibles" like "quality of life", security, space, and so on. Our efforts to do so are, knowingly, inaccurate and incomplete. Thus, exclusion of all costs and benefits associated with village platforms leaves the EIRR almost unchanged at 17.1%. Conversely, if estimated village platform benefits were actually two times of current estimated value (which is possible), the EIRR would jump to 19.0%.

4. With agriculture making up some 79% of total projected net benefits, one would also expect the EIRR to be very sensitive to any change in these realized benefits. Thus, a 20% decrease in projected agricultural benefits would decrease the EIRR to about 13.6% while a 20% increase in these benefits would increase the EIRR to about 20.8%. If net agricultural benefits drop by 28%, the EIRR touches the break-even point at 12.1%. Like project costs (Item 1 above), the relationship between EIRR and net agricultural benefits is found to be linear. This 1 to 1 relationship also approximately applies to the variables which are used to determine net benefits: the area, yield and crop price.

5. It has also been suggested that a rare flood event (with a low probability of occurrence) could greatly affect the EIRR. But eliminating all the agricultural benefits for 1 year in mid-stream (about Year 10) does not suggest that this would be a catastrophic occurrence over the life time of the project. Consequently, the EIRR would drop to about 16.0%. At the same time, this does not consider the cumulative impact if structures were actually destroyed or huge amounts of sediment were deposited by such an event.

6. If projected benefit streams were delayed, the impact on the EIRR would also be seriously affected. If agricultural benefits did not mature until Year 10 (instead of Year 7), the EIRR would drop to about 15.5%. And if all benefits were delayed 2 years (agriculture, fishing, navigation, and social infrastructures), then the EIRR would drop to as low as 12.2% per annum. If only net agricultural benefits are delayed by 2 years, EIRR would drop to 12.9%. Again, this is typical of a project of this nature and simply underlines the importance of employing a realistic time-line in these projections.

7. Scheduling, what is or is not considered as a "sunk cost", and the time frame employed also all impact on the EIRR calculations. For example, if additional "study costs" had been excluded from the economic analysis, the EIRR would jump to 20.0% and the NPV@12% over 30 years would jump to Tk 702.3 million. On the other hand, if the two-year preparation period had not been considered the first two years of "the project", then the NPV@12% over 30 years would have been expected to jump even further (to Tk 731.0 million). In general, with a fixed total time frame of 30 years (as per *Guidelines*), the longer the construction period the more a proposed project will be penalized since the projected benefit streams are then truncated even more severely.

8. Additionally, it has been suggested that projected navigation benefits in the Base Case may well be under-estimated. For example if dry season passenger traffic was equal to even 75% of monsoon season passenger traffic, then this would suggest that passenger traffic would climb by 800,000 people. Thus, even if each passenger saved or generated (e.g. through crew salaries) just 20 additional Tk from this economic activity, it would amount to Tk 16

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million/year (Twenty taka is about 50% of a farm laborers daily wage). If in-transit cargo traffic also doubled (from 24,000 to 48,000 tonnes/year) @ Tk 180/tonne, this would amount to yet another Tk 4.4 million/year. When all of these potential economic benefits are considered the EIRR increases to about 18% and the NPV to about Tk 637.5 million.

9. Yet another issue is sustainability. In the absence of the project, it is anticipated that the FWO scenario will see deteriorating conditions vis-a-vis the Present conditions. This is particularly true of some fisheries and some aspects of agricultural production. Thus, if the fisheries benefit evaluation was conducted in terms of the FW scenario and the Present conditions, the EIRR would drop to about 14.9%. And, similarly, if the same FW versus Present methodology was employed to project agricultural benefits, the EIRR would drop to a relatively low 10.5%. Considered together, the EIRR plummets to 7.9%. This really underlines the point that a "do-nothing" approach is not a viable long-term option.

10. Combinations of adverse events have also been considered. In particular an increase in capital and O&M cost of 20% coupled with a 20% decrease in agricultural benefits cause the EIRR to drop below 12% to 10.3%. The same increase in capital and O&M cost but assuming that the agricultural benefits do not materialize before Year 10 causes the EIRR to drop to 12.1%, still making the project feasible.

11. Finally, initial studies suggested that an alternative project design which did not construct the proposed Issapur loop cut might be a better socioeconomic option (denoted Alternative 2). This alternative proposes eliminating the Issapur loop cut but keeping all the other components; including river dredging between Madna and Ajmiriganj, channel realignment, local protective works and levees, navigation dredging and installation of structures at specific locations. Alternative 2 would rely on more channel re-excavation and maintenance dredging in the reach between Issapur and Kadamchal, as well as some additional dredging to keep the Dhaleswari River channel navigable.

    In this case, the economic capital cost is determined to be about Tk 2,030 million. A financial and economic project cost summary for Alternative 2, scheduled over 30 years, is provided in Annex E - Economics.

    At the same time, expected annual net agricultural benefits are expected to drop by Tk 48.5 million. This is about a 13% drop. The results of this analysis show that EIRR drops to 15.2% and the NPV@12% over 30 years drops substantially down to Tk 254.5 million. What this essentially says, however, is that from an economic perspective the Base Case (Alternative 1) is better because it will generate a larger total net return. From an economic perspective, the base case can be considered as a better alternative.

Overall, these sensitivity analyses underline the fact that the degree of imprecision typical of this type of analysis is approximately ± 15%. (See Various UN, ADB, and World Bank documents). This means that the resulting EIRR should be within the following range:

Real EIRR =17.2% ± 2.6%

14.6% < EIRR < 19.8%
LOW <EIRR < HIGH

These sensitivity analyses, therefore, generally reinforce the principal conclusion of the economic analysis. That is:

"From an economic perspective, the proposed Kalni-Kushiyara River Management Project appears to be a very feasible economic investment opportunity for the Government of Bangladesh".

11.4 Financial Assessment

There are 3 particularly important financial considerations:

- Financial Impact on Project Beneficiaries;
- Poverty Alleviation Impact, and
- Financial Impact on Government.

11.4.1 Project Beneficiaries

Table 11.15 present the profile of the KKRMP study area.

Table 11.15: Kalni-Kushiyara River Management Project Study Area Profile

Project Area	3356 km² (335,600 ha.)
% of Bangladesh	2.27
Total Cultivated Area	279,850 ha
Population (1995 est.)	1,890,000
% of Bangladesh	1.58
Population Rate of Growth (av./yr.)	1.77%/year
% Urban and % Rural	8. 9% and 91.1% respectively
No. of Villages	2,412
Population/Village	783
No. of Households	286,683
Rural Households (est.)	257,620
Households/Village	119
Average No. of persons /Household	5.7
Average Farm Size	1.1 ha.
Average Per Capita Income/year	Tk 7,470
Farm Wage Rate/Day (approx.)	Tk 40
Absolute Poverty (<2,122 cal./day)	65% of population
Hard Core Poverty (<1,805 cal./day)	50% of population
Level of Schooling ≥ Primary	27.7%
Persons/Tubewell	112
Income Distribution	Bottom 20% : 6%; Top 10% : 40%
Employment Structure (person-year equivalents):	Agriculture 700,000 Fisheries 100,000 Water Transportation 20,000 Earthwork/Construction 60,000 Process/Trade 85,000 Services/Other 35,000 **TOTAL** **1,000,000**
Average Annual Rate of Inflation (Rural CPI, 90-95)	4.5%/year
Project Capital Cost per Beneficiary Household	Tk 10,822

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Agriculture
Potential project beneficiaries in the agricultural sector in the project area are profiled in Table 3.2. The estimated total number and average farm size actually cultivated (i.e. hectares owned + rented) is presented in Table 3.3. The total cultivated area is 279,850 hectares; about 83% of the total project area (Table 11.15).

The principal project beneficiaries will be these 257,600 households who cultivate owned and owned+rented land. Small and "landless" farms cultivate on average about 0.2 ha; small farms 0.7 ha; medium-sized farms about 1.9 ha; and larger farms about 6.3 ha. These are average physical size; with a cropping intensity of about 1.0, the area actually cropped/year is approximately the same. Farm budgets for each of these 4 farm types are summarized in Table 11.16.

The following presents the farm budget highlights comparing the FW and FWO scenarios at project maturity (Year 30):

- The proposed project should make a significant difference to gross farm income (at project maturity): Tk 359 (21%) for landless farms; Tk 1,916 (18%) for small farms; Tk 6,495 (19%) for medium-sized farms and Tk 23,270 (20%) for large farms;

- The project overall impact on total farm family income is a function of how dependent they are on the farm as a source of total family income. Smaller farmers generally have a greater dependence on non-farm sources of income. Thus, we find that the estimated change in the family income of "landless" farmers is a minute 1.6%, but this climbs very considerably as farm size increases: a 5.9% increase for small farmers; a 12.2% increase for medium-sized farmers; and a 14.4% increase for large farmers;

- Incremental gross farm income per person would, at the same time, be highly skewed in favour of larger farmers. For the landless, it is only Tk 63 whereas for small farms it climbs to Tk 336; Tk 1,139 for medium-sized farms; and Tk 4,083 for large farms. This is essentially due to 2 main factors: 1) simply the scale of the operation; and 2) degree of owner-equity and land rental requirements; 11

- The overall change in the family labor required is almost negligible: 1 day/year for landless and small farms; 6 days/year for medium-sized farms; and 10 days/year for large farms. It is anticipated that 30% of this change will be a female labor requirement;

- These farm budgets clearly reveal the impact of scale, equity, and the existence of relatively onerous land rental agreements on resulting gross farm incomes. Given the acute wealth and income inequities that already exist, this simply reflects the on-going transfer of income from the poor to the relatively wealthy;

- This budgeting also reflects an almost universal characteristic of public investment projects which focus (at least in part) on the rehabilitation or enhancement of privately-owned natural resources, e.g. irrigation and drainage. Part of this public investment is invariably capitalized into private wealth, the distribution of which is already skewed in favour of the wealthier land owners in the FWO scenario. This is why complimentary initiatives often act as a counterweight, and

- Finally, although not illustrated in this static farm financial balance sheet, it must be emphasized that the proposed project will also significantly reduce income variability and thus enhance seasonal food security and longer-term investment opportunities. Despite not being quantified, this too is a very real on-farm financial benefit, specially for the small and medium-sized farms which represent 50% of the total households in the project area.

Socioeconomic Infrastructure
It is estimated that up to 25,000 households and related infrastructure could be directly affected by the proposed project just in terms of less flood damage, additional village platforms, and so on. The direct impact of this in terms of income/household is estimated to be about 10% or about Tk 3,000/year. This should be particularly beneficial to women, both in terms of quality of life in the home (nutrition, sanitation, etc.) and in terms of greater economic empowerment (rice harvesting, gardens, fruits, etc.).

Fisheries
In the project area a relatively large number of households depend on fishing and fish trading as a source of primary and secondary income (Annex D - Social). Two-thirds of all households report at least some income (sales or consumption) from fishing and the fish trade. This is generally very small-scale production which often serves as an important source of protein for the family. An estimated 100,000 full-time employment equivalents are involved; approximately 10% of the total labor force in the region. Thus, if the proposed project eventually augments fish production by 2.4% (as projected), this should effectively increase employment and income by a similar percentage. This is, effectively, a livelihood for an additional 2,000 or so families.

Navigation
In the project area, there are approximately 20,000 full-time employment equivalents involved in the water transportation sector. Projected increases in cargo and passenger movements (plus cost savings) with the project could effectively increase this number by 5 to 10% or about 1,000 people. This, of course, is the long-term change over and above the short-term construction-related employment and income impacts.

11.4.2 Government Receipts and Expenditures

Table 11.17 shows the tentative GOB expenditures and net impact on foreign exchange components for capital and O&M costs, including an ADB service charge of 1% on the loan. The table has been prepared based on the available information from ADB, BWDB and ERD and could be modified during the finalization of Development Credit Agreement (DCA) and TA.

There are two particular government concerns:

- Government Expenditures and Net Impact on Foreign Exchange, and
- Cost Recovery Potential.

Government Expenditures and Net Impact on Foreign Exchange
The portion of capital and O&M costs attributed to GOB includes:

- GOB contribution to study costs (Tk 28.85 million) in terms of personnel and expenses;
- land acquisition (Tk 70.02 million);
- construction of confinement dykes and soft protections (Tk 162.54 million including 15% physical contingency), and

Table 11.16: Annual Farm Budget Analysis

Item	Landless(0.2ha)			Small Farm(0.7 ha)			Medium Farm(1.9 ha)			Large Farm(6.3 ha)		
	Present	FWO	FW	Present	FWO	FW	Present	FWO	FW	Present	FWO	FW
Gross Value of Production (Tk)	6,330	6,146	6,833	22,154	21,511	23,915	57,748	55,324	62,454	176,265	168,973	190,311
Total Cash Costs (Tk)	2,011	2,059	2,057	7,039	7,207	7,200	20,989	20,857	21,492	81,236	80,796	82,905
Cost of Rent (Tk)	2,528	2,401	2,754	8,849	8,402	9,637	0	0	0	17,063	17,021	17,500
Gross Farm Income (Tk)	1,820	1,692	2,051	11,368	10,712	12,628	36,760	34,467	40,962	128,018	114,646	137,916
Incremental Gross Farm Income[1] (Tk)			359			1,916			6,495			23,270
Total Family Income[2] (Tk)	22,371	22,243	22,602	32,943	32,288	34,203	55,491	53,198	59,693	174,977	161,605	184,875
Percent Change in Family Income (%)		-0.6%	1.6%		-2.0%	5.9%		-4.1%	12.2%		-7.6%	14.4%
RETURN PER FAMILY MEMBER												
Average No. in Family	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Gross Farm Income/Person (Tk)	319	297	360	1,994	1,879	2,215	6,449	6,047	7,186	22,459	20,113	24,196
Incremental Gross Farm Income/Person (Tk)			63			336			1,139			4,083
RETURN TO FAMILY LABOR												
Family Labor (person days)	37	37	38	114	115	116	245	245	251	390	391	401
Gross Farm Income/Person Day (Tk)	**49**	**45**	**55**	**100**	**93**	**109**	**150**	**141**	**163**	**328**	**293**	**344**
Incremental Gross Farm Income/Person Day (Tk)			10			16			26			58
Percent of Households (%)		42			36			14			8	
Percent of Cultivable Land (%)		0			14			23			63	

Notes:
1. Based Data from Annex E, Appendix E.1, Tables 18 to 20.
2. Based Data from Kalni-Kushiyara River Household Survey

- O&M, excluding the cost of platform protection and maintenance assumed to be covered by the beneficiaries.

The total capital cost of KKRMP is estimated to be Tk 2,787.93 million of which GOB contribution is about Tk 261.41 million. The Technical Assistance (TA) cost is estimated to be Tk 329.16 million and mainly includes the study costs excluding the GOB share, EMP process and construction. The remaining Tk 2,197.36 million (79%) is attributed to the ADB loan. The loan repayment schedule has been calculated by dividing the loan in 60 instalments to be repaid over a 40-year period with a grace period of 10 years. The ADB Service Charge of 1% has been added to the twice-yearly payments.

Based on the above estimates, the resulting net cash flow of GOB expenditures over the life of the project and repayment period, broken down into local and foreign components, is presented in Table 11.17. The Table also presents the cash flow of platform protection and maintenance which should be covered by the beneficiaries. However, should the beneficiaries be unable to take care of protection and maintenance in whole or in part, the shortfall will have to be covered by GOB to prevent degradation of the infrastructure and the expenditures included in the cost recovery program.

Cost Recovery Potential

Potential cost recovery must carefully be considered to determine the long-term financial sustainability of the project. This can be measured by:

CRI = T/E

where:

CRI = Cost Recovery Index
T = Taxes and other charges on project beneficiaries
E = Project Expenditures by government

Historical Context and Current Situation: Cost recovery started in Bangladesh in 1963 through imposition of water rates under the East Pakistan Irrigation Ordinance. Since that time, for various reasons, attempts at cost recovery for O&M have met with little success. Nonetheless, GOB has for some time been concerned, and has been committed to developing a sustainable cost recovery program.

More recently, a part of the BWDB Systems Rehabilitation Project (SRP) in the 1990s has focused on cost recovery. Under SRP, a pilot project was undertaken to test a model for cost recovery of O&M on the Karnafuli Irrigation Project (KIP), Ichamati Unit. A key feature of the pilot project was user participation, through formation of water user groups, to improve O&M performance. It was planned to replicate the success of the pilot project throughout Bangladesh. Initial issues facing the pilot project were discussed at a workshop in Dhaka in 1994. At the workshop, a consensus was reached on two important issues: "..cost recovery is an essential component in the integrated water management system and as such it cannot be implemented in isolation"; and, "..water rate as determined for cost recovery is no more a tax, but a service fee for delivery of water" (SRP, 1994[1]).

1 BWDB Systems Rehabilitation Project, "Proceedings of the National Seminar on Implementation of Pilot Cost Recovery Program in KIP (Ichimati Unit)", August 23, 1994, Dhaka.

Table 11.17: GOB and Platform Beneficiaries Expenditures

Years	GOB Capital Cost (Local Currency) (mTk)	O&M Costs (Local Currency): GOB Costs (mTk)	O&M Costs (Local Currency): Platform Beneficiaries Costs (mTk)	O&M Costs (Local Currency): Total O&M Costs (mTk)	Total GOB Capital & O&M (Local Currency) (mTk)	GOB (Foreign Currency): ADB Loan (mTk)	GOB (Foreign Currency): Loan Repayment Schedule (mTk)	GOB (Foreign Currency): Loan With Service Charge (mTk)	GOB Cost Recovery (Local Currency): Scenario 1 (mTk)	GOB Cost Recovery (Local Currency): Scenario 2 (mTk)	GOB Net Cash Flow (Capital+O&M+ADB Loan with Service Charge-GOB Cost Recovery) Scenario 1: Local Currency (mTk)	Scenario 1: Foreign Currency (mTk)	Scenario 1: Total (mTk)	Scenario 2: Local Currency (mTk)	Scenario 2: Foreign Currency (mTk)	Scenario 2: Total (mTk)
1	58.90				58.90						58.90		58.90	58.9		58.90
2	19.77				19.77						19.77		19.77	19.77		19.77
3	4.33				4.33	494.70					4.33		4.33	4.33		4.33
4	18.60				18.60	512.58					18.60		18.60	18.6		18.60
5	64.06				64.06	543.36					64.06		64.06	64.06		64.06
6	66.25				66.25	577.21					66.25		66.25	66.25		66.25
7	13.68	26.17		26.17	39.85	66.57					39.85		39.85	39.85		39.85
8	8.63	128.89	5.60	134.49	137.52	2.94			11.10	11.10	126.42		126.42	126.42		126.42
9	7.19	125.11	9.38	134.49	132.30				14.90	14.90	117.40		117.40	117.4		117.40
10		125.11	9.38	134.49	125.11				16.00	16.00	109.11		109.11	109.11		109.11
11		113.71	9.94	123.65	113.71				53.70	16.60	60.01		60.01	97.11		97.11
12		112.89	10.76	123.65	112.89				54.60	17.50	58.29		58.29	95.39		95.39
13		112.06	11.59	123.65	112.06				56.40	19.30	55.66		55.66	92.76		92.76
14		100.42	12.42	112.84	100.42		73.22	94.64	57.30	20.20	43.12	94.64	137.76	80.22	94.64	174.86
15		99.59	13.25	112.84	99.59		73.22	93.91	58.20	21.10	41.39	93.91	135.30	78.49	93.91	172.40
16		98.76	14.08	112.84	98.76		73.22	93.19	60.10	22.90	38.66	93.19	131.85	75.86	93.19	169.05
17		97.94	14.90	112.84	97.94		73.22	92.47	60.90	23.80	37.04	92.47	129.51	74.14	92.47	166.61
18		88.39	15.73	104.12	88.39		73.22	91.74	61.80	24.70	26.59	91.74	118.33	63.69	91.74	155.43
19		87.56	16.56	104.12	87.56		73.24	91.00	63.70	26.60	23.86	91.00	114.86	60.96	91.00	151.96
20		86.87	17.25	104.12	86.87		73.24	90.27	64.50	33.51	22.37	90.27	112.64	53.36	90.27	143.63
21		86.87	17.25	104.12	86.87		73.24	89.54	65.50	33.51	21.37	89.54	110.91	53.36	89.54	142.90
22		86.87	17.25	104.12	86.87		73.24	88.81	65.60	33.51	21.27	88.81	110.08	53.36	88.81	142.17
23		86.87	17.25	104.12	86.87		73.24	88.07	66.60	33.51	20.27	88.07	108.34	53.36	88.07	141.43
24		86.87	17.25	104.12	86.87		73.24	87.34	66.70	33.51	20.17	87.34	107.51	53.36	87.34	140.70
25		86.87	17.25	104.12	86.87		73.24	86.61	67.80	33.51	19.07	86.61	105.68	53.36	86.61	139.97
26		86.87	17.25	104.12	86.87		73.24	85.88	67.90	33.51	18.97	85.88	104.85	53.36	85.88	139.24
27		86.87	17.25	104.12	86.87		73.24	85.14	72.90	33.51	13.97	85.14	99.11	53.36	85.14	138.50
28		86.87	17.25	104.12	86.87		73.24	84.46	78.00	33.51	8.87	84.46	93.33	53.36	84.46	137.82
29		86.87	17.25	104.12	86.87		73.24	83.68	78.10	33.51	8.77	83.68	92.45	53.36	83.68	137.04
30		86.87	17.25	104.12	86.87		73.24	82.95	83.20	33.51	3.67	82.95	86.62	53.36	82.95	136.31
31-43							73.26	77.83				77.83	77.83		77.83	77.83
Total	261.41	2272.17	333.34	2605.51	2533.58	2197.36	2197.36	2521.49	1345.50	603.31	1188.08	2521.49	2910.92	1930.27	2521.49	3541.81

Notes
1. Total O&M Costs is based on Table 11.3
2. Cost Recovery Scenarios are based on Table 11.18
3. Actual Loan Repayment Schedule is made in 60 instalment at 6 month intervals based on ADB criteria. Annual schedule includes two instalments.

A one-year final evaluation of SRP took place in 1997. At a workshop to disseminate information on progress of the evaluation, the issue of progress on cost recovery was addressed. It is informative and relevant to KKRMP to quote from a paper (SRP, 1997[2]) on this workshop:

> "One specific economic issue which the evaluation has considered is the experience of SRP in introducing cost recovery as part of the management of sub-projects. There has been one sustained trial in cost recovery, in KIP. The experience of this trial is almost wholly negative, with great problems establishing a system and levels of payment into the BWDB which were low from the start and have declined to almost zero".

In fact, there was some cost "recovery"; farmers were paying a fee to the designated collectors (pump managers), but this money did not get passed on to BWDB. The workshop paper goes on to conclude:

> "...the KIP experience on cost recovery provides no support for the wider introduction of such measures as a means to generate income to cover O&M costs. This is despite KIP being an irrigation scheme, where benefits of acquiring water are more direct and material. At present the organizational base, social legitimacy and legal basis for cost recovery are all absent and it is likely that the costs of collection will be greater than the sums collected. The chances of successfully developing cost recovery in flood control and drainage schemes, where benefits are less direct and the means of collection less apparent, can consequently be considered minimal".

<u>December 1997 KKRMP Seminar</u>: Background and objectives of this seminar are provided in Chapter 10 and Annex K. From the seminar, following were the key findings, for which there was a consensus, with respect to O&M cost recovery for KKRMP:

- there was support for fees, levies and taxes in order to ensure sustainability;
- the approach must be integrated, with improved coordination between all stakeholders;
- there must be participation and a sense of ownership by beneficiaries;
- there must be appropriate legislation, laws and regulations - either new or improved - to ensure payments are made;
- there must be transparency and accountability, and
- there must be political will and commitment.

From this, it is clear there is a consensus that O&M costs should eventually be recovered, but that substantial institutional, social, and political/legal change is needed.

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[2] BWDB Systems Rehabilitation Project, "Final Evaluation Study, Summary of Progress, Results & Conclusions", September 1997.

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Again with respect to cost recovery, other key issues and concerns, for each of which the participants had varying views, were identified:

- there must be independent control of management over resources and revenue;
- cost sharing between parties - e.g. landowners, transportation operators, GOB, etc. must be based on benefits received as well as ability to pay;
- dredging must be contracted out, and
- opportunities for cost recovery exist from navigation, land transfer taxes, platform fees, fishery fees, and license fees from water bodies.

These issues and concerns provide specific areas where institutional, social, and legal change is likely needed if costs are to be recovered. Hence, although there is agreement on the need for change, there are differences on exactly what the changes should be, or at least on their extent.

Prospects for KKRMP: Given the experience of SRP, and the results of the December 1997 KKRMP seminar, new approaches are necessary.

The two important issues to be addressed when formulating a cost recovery policy are: 1) the proportion of the cost expended on a project to be repaid; and 2) the proportion of the benefit received by individuals (which may be far higher than the cost) to be recovered through direct charges or increased taxes.

Presuming that it is the annual O&M cost of the project which must be recovered on an on-going basis, the 2 key issues are:

- Organizational structure and adequate financial arrangements to continue with the maintenance dredging, and

- Organizational structure and adequate financial arrangements to ensure maintenance of the village platforms.

This can be facilitated by carefully equating annual component benefits to annual component costs; determining respective user capacities-to-pay; and then developing appropriate collection and re-investment mechanisms. In this context, one inherent difficulty with multiple use resource management projects, is the impracticality of withholding benefits if a "free rider" refuses to pay. Another difficulty is developing a practical cost-sharing arrangement.

Since there is opportunity in KKRMP to recover costs not only from beneficiaries of agriculture but also from navigation and perhaps fisheries, new commercial/industrial development along the river, and improved socioeconomic infrastructure (the platforms), there is room for optimism.

The annual O&M financial costs that would need to be recovered are an average of about Tk 109 million from project Years 7 through 30 (Table 11.3).

It is inevitable that government will be required to pay for O&M of KKRMP. With the status quo, government can expect to pay for almost all O&M. With creativity and will, government can reduce their share by recovering costs from project beneficiaries. As explained earlier in Chapter 11, it is expected that KKRMP will help facilitate economic development through increased incomes and availability of a year-round Class II navigation channel. Economic development provides opportunity for cost recovery by government, either through taxation or other levies. For KKRMP, it is therefore, assumed that government will share O&M costs on a diminishing basis over the life of the project.

Although several sources of cost recovery have been identified, a cursory financial analysis regarding the projected benefits to agriculture, navigation, fisheries, and socioeconomic infrastructure suggests that policy-makers may have difficulty establishing a full O&M cost recovery policy simply because reoccurring O&M costs are relatively high. They could amount to as much as 20% of annual long-term benefits and this is a relatively high percentage of user benefits to try to recover.

Although it is apparent that recovering costs directly from benefitted farmers is not feasible, collection of land taxes is known to work in Bangladesh. Hence, there is an opportunity to increase land tax within the benefitted area of KKRMP. Ideally, increased taxes should be related to some simple designation or classification of benefit, e.g. land elevation or protected land versus unprotected land. In reality, this approach will almost certainly be difficult due to the uncertain nature (from the farmer's viewpoint) of benefits of flood control. Take for example a lowland farmer in the project area. The project is designed to protect his/her land against pre-monsoon floods, which may not occur for several years at a time, or alternatively could in any year be more severe than the project is designed for, resulting in crop loss. In either case, the farmer would be reluctant to pay a special levy since project benefits are not apparent. Therefore a simpler formula could be applied, for example, based on cultivated area.

Also, land taxes may not be appropriate, at least in the first years of the O&M phase. In recent years, at the request of international lending agencies, GOB has reduced or eliminated altogether subsidies on agricultural inputs such as fertilizers, etc., placing a supplementary burden on the farmers expenses. Under these conditions, imposing a land tax may worsen excessively their plight.

Navigation benefits of the project will be apparent to most users, primarily ferry passengers and cargo transporters. Accordingly, there is opportunity to recover costs from each of these project beneficiaries through direct levies.

With the return of a dependable, year-round water transport link between the isolated eastern and mainstream western states of India, there is opportunity for GOB to promote international transit traffic. Currently, most cargo is shipped overland between these Indian states; it is certain that cost of shipment via the Kalni-Kushiyara water system will be lower. The same argument applies to inter-country shipments between Bangladesh and India. In both cases, beneficiary users will incur lower costs, and a levy could be applied based on, for example, trip fares for passengers and cargo tonnage for freighters.

It is expected that economic development facilitated by KKRMP will result in new commercial and industrial enterprises. In both cases, there would be opportunity for cost recovery through taxation or other levies.

In general, cost recovery from the fishery sector would require ownership of the fish resource so that there is economic incentive to pay for a realized benefit. This is not currently the case in Bangladesh. Further, in KKRMP, project benefits to fisheries are essentially secondary; that is, other than the Koyer Dhala fishpass structure, project interventions are designed to produce

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benefits in sectors other than fisheries. Accordingly, cost recovery in this sector is unlikely, or at least would be very small.

Although ways of recovering costs from socioeconomic infrastructure can be identified, they are difficult to quantify and are believed to be small. Moreover, a significant fraction of the beneficiaries are among the poorest in the region, and therefore should perhaps be the last ones to be taxed.

An Indicative Distribution of O&M Cost Recovery Across Sectors: It is beyond the scope of this investigation to analyze and/or recommend how O&M costs should/would be recovered from various sectors. However, to illustrate a conceptual model of cost recovery, an indicative distribution was generated between agriculture and navigation, with the balance falling to government.

As a starting point, and as a reference, it is useful to review the allocation of project economic benefits:

- agriculture 79%
- navigation 4.5%
- fisheries 6.9%
- socioeconomic infrastructure 9.7%

It is clearly impractical to expect agriculture to pay 79% of O&M costs. However, an initial strategy could be to assume a land tax increase based on some percentage of the increase in average annual gross margin of Tk 374 million (Tk 1,348 per hectare) resulting from KKRMP interventions. A ten percent tax on this would total Tk 37.4 million and represent about Tk 135 per hectare. Based on annual farm gross revenues and incomes, this appears to be not unreasonable, even for the most vulnerable landless and small farmers. Tk 37.4 million represents about 34% of the annual Tk 109 million O&M cost.

Revenue from navigation would be obtained from levies in three different areas: national cargo, passengers, and Indian transit. Annex G (Navigation) describes each of these, and makes assumptions on levy rates and future tonnage based on historical information and future conditions and opportunities.

Table 11.18 which illustrates two different scenarios combines agriculture and navigation information. Average assumed levies are as follows:

Agricultural land tax	= Tk 135/ha (flat rate over benefitted area)
Cargo levy	= Tk 5/tonne, applied to increasing traffic load
Passenger levy	= Tk 0.5/passage, applied to increasing passenger load
Indian Transit	= Tk 100/tonne (assumed rate and constant volume in time)

Table 11.18 uses the tax and levies combined with projected increases in cargo and passenger traffic to develop cost recovery scenarios for the 23-year period following implementation; it was assumed that the balance of total cost recovery would come from GOB. Scenarios 1 and 2 respectively include and then exclude land tax, which is the dominant income generator. In any case, with the assumptions noted, GOB must be prepared to carry the majority of O&M costs until at least project year 15; in the last 10 project years, GOB's portion would range from 29 to 41 percent.

Table 11.18: Tentative O&M Cost Recovery

Year	Land Tax	Cargo Levy		Passenger Levy		Indian Transit		Platform. Beneficiaries		Total Cost Recovery	
	('000 Tk)	(tonnes)	('000 Tk)	No	('000 TK)	(tonnes)	('000 Tk)	No	('000 Tk)	With Land Tax (million Tk)	Without Land Tax (million Tk)
8	0	437,800	2,189	342,600	137	30,000	3,000	22	5,600	11.1	11.1
9	0	443,800	2,219	348,500	139	30,000	3,000	44	9,380	14.9	14.9
10	0	449,900	2,250	354,500	142	40,000	4,000	44	9,380	16.0	16.0
11	0	457,300	2,287	360,000	144	40,000	4,000	48	9,940	53.7	16.6
12	37,125	464,800	2,324	365,700	146	40,000	4,000	52	10,760	54.6	17.5
13	37,125	472,600	2,363	371,400	149	50,000	5,000	56	11,590	56.4	19.3
14	37,125	480,600	2,403	377,300	151	50,000	5,000	60	12,420	57.3	20.2
15	37,125	488,900	2,445	383,300	153	50,000	5,000	64	13,250	58.2	21.1
16	37,125	497,500	2,488	388,500	155	60,000	6,000	68	14,080	60.1	22.9
17	37,125	506,100	2,531	393,600	157	60,000	6,000	72	14,900	60.9	23.8
18	37,125	515,100	2,576	399,200	160	60,000	6,000	76	15,730	61.8	24.7
19	37,125	524,300	2,622	404,700	162	70,000	7,000	80	16,560	63.7	26.6
20	37,125	533,800	2,669	410,300	164	70,000	7,000	84	17,250	64.5	27.3
21	37,125	545,400	2,727	415,500	166	80,000	8,000	84	17,250	65.5	28.4
22	37,125	557,100	2,786	420,700	168	80,000	8,000	84	17,250	65.6	28.5
23	37,125	569,500	2,848	426,000	170	90,000	9,000	84	17,250	66.6	29.5
24	37,125	582,300	2,912	431,300	173	90,000	9,000	84	17,250	66.7	29.6
25	37,125	595,700	2,979	436,800	175	100,000	10,000	84	17,250	67.8	30.7
26	37,125	609,700	3,049	441,900	177	100,000	10,000	84	17,250	67.9	30.8
27	37,125	624,100	3,121	447,000	179	150,000	15,000	84	17,250	72.9	35.8
28	37,125	639,200	3,196	452,200	181	200,000	20,000	84	17,250	78.0	40.9
29	37,125	654,900	3,275	457,500	183	200,000	20,000	84	17,250	78.1	41.0
30	37,125	671,300	3,357	462,800	185	250,000	25,000	84	17,250	83.2	46.1

Note

1. Agricultural Land Tax @ Tk 135/ha over 275,000 ha
2. Cargo Levy @ Tk 5/tonne over cargo movements - FW, Table 14, Appendix E.1 - Annex E
3. Passenger Levy @ Tk 0.5/passage assuming 40% of population will avail water transport (Table 13, Appendix E.1 - Annex E)
4. Indian Transit @ Tk 100/tonnes
5. Platform Beneficiaries based on platform protection and maintenance costs

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11.5 Environmental Assessment

Residual impacts

Residual impacts predicted to remain once the EMP has been implemented (Chapter 9) and where mitigation and contingency planning have been taken into consideration, constitute the most serious environmental impacts posed by the project. This section only refers to long-term impacts which are expected to occur once the intervention is completed. Impacts during construction are of a temporary nature (Annex I-EIA) land are not covered herein.

The residual impact matrix is presented in Table 11.19. It should be emphasized that, given the extent of the project area and the number of interventions, the Land Use and Settlement Component (IEC) has been broken down into 5 sub-components in order to take into account some very site-specific impacts. Scoring of impacts is on a scale from -10 to +10 from the least to the most desirable impacts. The residual impacts have been evaluated for the long-term effect on the environment of both the improved river channel and the new regional setting and settlement pattern. The following sections present a summary of the main anticipated negative and positive impacts of the projects.

Table 11.19: Residual Impacts Evaluation Matrix

Important Environmental Components (IECS)	Improved River Channel	New Setting and Settlement Pattern
	Score	Score
River Morphology	+5	
Hydrology & Hydraulics	+5	
Open Water Bodies	+5	
Erosion & Sedimentation Processes	+5	0
Drainage	+6	0
Irrigation	+6	0
Aquatic Habitat & Fisheries	+7	
Terrestrial Habitat & Wetlands	+4	+4
Land Use & Settlement		
Issapur Loop Cut Site	+6	-4
Dhaleswari Dredging & Fill Sites		+7
Katkhal Loop Cut Site		-4
Land Dedicated Platform Sites		+8
Khas Land Platform Sites		+8
Education and Health	+7	+7
Status of Women	+7	+7
Land Quality & Productivity	+7	-4
Navigation	+6	
Employment & Economic Activity	+6	+5
Equity	+7	+6

The presence of a Improved Channel (including loop cuts and bank protection structures) as well as the resulting new hydraulic conditions are likely to positively modify the environment on the long-term at the regional level.

The presence and use of the new platforms and upgraded land as well as the settlement and land use pattern modifications due to loop cuts are likely to modify the environment at the community or local level. Localized impacts are identified in the text following:

River Morphology: The proposed project intervention will stabilize the Kalni-Kushiyara River. In particular, it will prevent the enlargement of Cherapur Khal, which would erode homestead, silt-up the Dalheswari and Baida channels, and the lower reach of the Baulai River

Hydrology and Hydraulics: The proposed project interventions will significantly improve the flooding conditions during the pre-monsoon. The Khowai River project below Habiganj might receive substantial benefit from the KKRMP. The Baulai River water levels will also be lowered during the pre-monsoon and monsoon seasons.

Open Water Bodies: It is expected that water availability will be maintained to its present level. The depth of water will increase over 2 m during the critical month of January and February particularly in the lower reach of the Kalni River.

Erosion and Sedimentation Process: River improvements are expected to impact the existing infrastructure by reducing the bank erosion current rate of 55 ha/yr, by reducing homestead damage along the river banks due to the reduction of bank erosion, by reducing high velocity spills and breaches in the river banks. It will also reduce deposition of sediment "splays" along the river banks.

Platform erosion will be mitigated by soft and hard dyke protection.

Drainage: The project will facilitate post-monsoon drainage and as a result, early plantation to an area about 14,000 ha, particularly in the lower elevation of the project area. Early plantation will make the crop less vulnerable to pre-monsoon floods and accumulated rainfall inundation.

Interference of new platforms with local drainage will be mitigated.

Irrigation: The project will make substantial positive impacts on irrigation water supplies by providing flushing regulators at two locations.

The Koyer Dhala multi-purpose regulator will be installed with flushing facilities for irrigation during the dry season. The structure will provide irrigation water supplies to the Old Kushiyara Irrigation Scheme, Jhingari Nadi Irrigation Scheme and fallow lands along the Baniachang-Ajmiriganj road during the dry season. The second regulator at Barabaira Khal will also facilitate irrigation during the dry season.

The Issapur and Katkhal loop cuts will provide easy access to surface water and consequently reduce the cost of irrigation.

Interference of new platforms with existing irrigation systems will be mitigated.

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Aquatic Habitat and Fisheries: The total fish production of the project area will increase from the future condition. An enhancement program aimed at increasing fish production in the project area is proposed.

The Koyer Dhala multi-purpose structure, includes a fishpass and will mitigate the affects of the project on fish migration from river to flood plain during the pre-monsoon season.

Terrestrial Habitat and Wetlands: The project will have substantial positive impacts on homestead vegetation by offering increased security against flooding. Homestead vegetable gardens are expected to occupy some 25% of the new platform areas. About 112 ha of new land will be available for vegetable gardening.

Land Use and Settlement: The project will create new or extend existing village platforms from the dredge spoil, providing extra space of homestead and improving living conditions.

This IEC has been broken down into 5 sub-components in order to take into account some very site-specific impacts:

- When the Issapur Loop Cut is constructed and the Dhaleswari River is closed at Issapur, dredging will be required in the Dhaleswari Channel. With the dredged spoil, a channel along the right bank of the Dhaleswari River near Madna will be filled. This activity is supported by farmers because more land will become available;

- The impacts on land use and settlement at the site of the Issapur and Katkhal loop cuts are unavoidable and of mid-magnitude, affecting locally some communities on the long-term. In order to minimize those impacts, compensation is required for approximately 160 landowners in Chowdanta and Bhatura for loss of land as their primary economic resource. In addition to compensation, a certain number of mitigative measures will be implemented, reducing the magnitude of the negative impact;

- The impact on Land Dedicated Platforms will be positive, of mid-magnitude and will benefit local communities, and

- The project intends to relocate landless families on 13 platforms. This is a positive impact of high magnitude through enhancement measures.

Over the years, homestead land has been continuously eroded by waves and this is expected to continue once the project is completed. Whereas in the past the eroded material was of the same composition as the one present in farming plots, in the future sandy dredged river spoils will be eroded and deposited on those plots resulting in significant deterioration of agricultural soils if no protection measure is taken to prevent erosion. Both soft and hard platform protection will be provided as component of the project to prevent erosion and to protect land quality and productivity.

Education and Health: Improvement in the general economic condition of the people and better living conditions will have positive impact on ability and attitude of the people toward education and will contribute in achieving the national goal for universal coverage of potable water for drinking. Protective measures for homestead platforms will allow more space for construction of latrine on a permanent basis. Thus the scope for more water-seal sanitary latrines will be expanded. This will also improve the state of sanitation through proper disposal of human waste and will have direct impact on the general state of health.

Status of Women: Improved liveability of homestead platforms will facilitate more home-based activities for women, particularly in the fields of homestead gardening, poultry rearing, and cottage industries. Homestead is literally the world of women. Safe platforms will enhance the security of women to a significant extent in both tangible and intangible terms in the sense that it will enhance the scope for more economic activities and also more conform in performing household chores.

Land Quality and Productivity: Crop damage due to over bank spills inundation and breaches in the river banks during the pre-monsoon season will be reduced and the flood-free land area will be increased. The annual rice production is expected to increase by about 82,600 tonnes, from 615,100 tonnes (FWO) to 697,700 tonnes (FW), as a result of the project, an increase of about 13.4%. Non-cereal production is expected to decrease from 34,900 tonnes (FWO) to 29,000 tonnes (FW), a reduction of about 17%. This results from a decrease of the non-cereal cultivated area and implies a decrease in the availability of non-cereal. In spite of this negative effect, the overall impact on land productivity is positive.

Navigation: One of the most important impacts of the project is on navigation and water transport as it will improve and upgrade the presently seasonal class-IV (LAD=1.5 m) navigation channel to a class-II (LAD=2.4 m) navigation channel from Fenchuganj up to Astagram to meet the Upper Meghna. This will make the Kalni-Kushiyara River navigation route an integral part of the national waterways network.

The Koyer Dhala multi-purpose structure will also re-establish navigation facilities between the Kalni River and Habiganj town.

Employment & Economic Activity: With completion of the project there will be a chain of favourable impacts on the activities of various water related production sectors, agriculture, fisheries, etc. and also the service sectors, navigation and water transport services, trade and commerce, flood-free housing further impacting on sanitation and health, education and so on.

The end result will be more production in all concerned fields of activities creating tradable surpluses leading to higher income, higher consumption and improvement in socioeconomic welfare of the communities in the area. Increase in aggregate employment and income will contribute to attain a higher standard of living (Section 11.6).

Equity: The benefits of the project will accrue to different sections of the society in varying proportions. The initiatives will benefit mostly the land-owners. However, the strategic thrusts on improved liveability of rural settlements will benefit all strata of the population with optimum equity.

Environment Assessment - Summary

The project is designed in such a way that it will promptly stop potentially irreversible environmental degradation. It is expected that this project is environmentally sustainable as long as careful monitoring and baseline data collection is carried out, people are consulted and involved in all the project implementation phases, and all proposed mitigation and enhancement programs are conducted as integral constituents of the project.

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11.6 Social Assessment

The key areas of social impact are described below.

Employment
There will be an overall increase in annual employment of 22,890 person-years.

This is comprised of:

- an increase in agriculture labor employment of 17,000 person-years, of which roughly 10% will be shared by women of the HHs;

- a net increase in employment opportunities for landless people of 5,890 person-years, composed of changes in the following areas;

  - ***Fishing Labor:*** a net increase of 2,400 person-years; in addition to this, there would be a corresponding increase in support activities such as net-making and post-catch processing, much of which is done by women.

  - ***Water Transport Labor:*** a net increase of 2,000 person-years excluding crew; in addition to this, there would be corresponding increase in support activities such as handling and re-handling of cargo, boat manufacturing and maintenance.

  - ***Non-cereal Crop Production Labor:*** a net increase of 150 person-years; this results from new land available at Madna closure, and land created from set-back distances at the two loop cuts and on Issapur platforms.

  - ***Homestead Vegetation Labor:*** a net increase of 1,340 person-years, of which more than 50% will be shared by women of the household. This employment mainly generates in the following areas;
    - water tolerant trees : 590 person-years;
    - homestead garden : 130 person-years, and
    - fruit trees : 620 person-years.

Villages along the River Banks
The overall stability of the Kalni-Kushiyara River will provide direct erosion-protection benefits to the 50 existing villages (over 13,000 HHs) within 100 m from the river banks. These villages represent about 5% of the HHs in the project area.

In addition, the project will save about 230 households including 280 ha of land from bank erosion along the Cherapur Khal.

Village Development
Over the 30-year economic life of the project, the dredged spoil will create about 84 homestead platforms (335 ha) and household facilities for 11,250 families suitable for accommodating 64,000 people. This represents about 3.4% of the population (1995) in the project area.

Landless Settlement
During implementation, re-settlement on new village platforms will reduce homeless families by 3% from 18% to 15% in the project area. This could be further reduced during O&M.

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Water, Sanitation and Health
The project will provide 11,250 water seal latrines and 335 hand tubewells to 11,250 households during the implementation (6,250 HHs) and operation and maintenance (5,000 HHs) stages. Access to safe drinking water and improved sanitation will have substantial positive impact on health and quality of life.

Conflicts
Improved post-monsoon drainage might encourage farmers to extend cultivation into deeper unprotected *haor* areas. This will bring them into conflict with fishermen who will find the fishing area reduced. However, in the analysis of crop production benefits, existing wetland areas were kept constant.

Economic Equity
The net equity impact is difficult to ascertain. Following are observations - based on information presented in this study - regarding various stakeholders who will be impacted by this project. A qualitative assessment from the viewpoint of economic equality follows each observation.

- Large land owners who represent 8% of the total population and own approximately 63% of the cultivated land will receive substantial benefits from the proposed project interventions. These large farmers, however, can generally manage their livelihood even in the face of crop damage by the pre-monsoon floods. This impact is, therefore, *regressive*.

- Small and medium farmers who represent 50% of the total population and own 37% of the remaining cultivated area often cannot sustain their livelihoods with pre-monsoon flood damage to crops. Often, they are forced to sell their land for their survival and, ultimately, become landless. The project will arrest landlessness caused by pre-monsoon flood damage to *boro* crop. *Strongly progressive.*

- Sharecroppers may also be net gainers in relation to the area cultivated by them. The sharecroppers are also typically poor farmers. *Somewhat progressive.*

- Landless people who represent 42% of the population and work mainly as agricultural laborers will benefit from the increase in agricultural employment opportunities with the increased crop production. This is *progressive*.

- Agricultural benefits derive entirely from increased rice production, not at the expense of fisheries and wetlands. *Progressive.*

- Landless people get direct benefit from the development of new village platforms and infrastructure. *Strongly progressive.*

- Families whose homestead areas will be extended and protected against wave erosion will get direct benefits from the disposed soil. *Strongly progressive.*

- Families dependent upon water transport labor will get substantial direct benefits from the project. *Strongly progressive.*

- Families either fully or partially dependent on boat manufacturing and traditional irrigation means (*doons & swing basket*) are expected to benefit from the project. *Somewhat progressive.*

- Families dependent on day-labor in the business centre and port areas will benefit directly from the project. *Progressive.*

- Families dependent upon fishing labor will get direct benefit from the project. *Progressive.*

- Families engaged in gleaning and gathering wetland products are expected to benefit due to increased crop production and reduction in pre-monsoon flood intensities. *Somewhat progressive.*

- Families whose land will be acquired for the development of the project, particularly for the loop cuts, will be impacted adversely. *Regressive.*

Gender Equity
Gender equity issues will be addressed in all project components. Gender specific impacts will be *strongly progressive*. No negative gender equity impacts are anticipated.

Poor women will use their earnings from project construction to invest in a variety of income-earning opportunities including tree nurseries, cultivation on leased land and latrine construction. Further economic opportunities will be provided for poor women in post-harvest processing and rice gleaning. Women on flood-secure and expanded homestead platforms will increase production of vegetables, fruits, livestock and poultry. Family welfare will be enhanced through improved nutrition and water and hygiene facilities. Women's enhanced income will contribute to children's educational opportunities.

Women on homestead platforms will be exposed to new knowledge and skills. Women's decision-making capacity will be improved with their increased knowledge and earning capacity. At the village level, women's labor and platform groups will be strengthened to participate in community development. Implementing agencies and male committees at village, *thana* and district levels will be provided with basic gender awareness to support women's development throughout the project. It is anticipated that over the course of the KKRMP, NGOs and government agencies will be attracted to the area to provide gender-specific programming.

11.7 Multi-Criteria Assessment

Finally, the FPCO *Guidelines* describe a methodology for assessing impacts accruing from the proposed KKRMP implementation which cannot be based solely on the benefit-cost stream of the financial and economic analyses. Impacts that can only be quantified in physical terms or described qualitatively should also be taken into account in the decision making process. The Multi-criteria analysis (MCA) provides a taxonomy and framework for including those impacts in a concise, standardized and comparable manner.

The MCA framework facilitates a direct comparison of the impacts of a project in economic, financial, quantitative and qualitative terms:

Economics Impacts
Wherever possible, impacts are valued in monetary terms and incorporated into single-valued measures, including the economic internal rate of return (EIRR) and the net present value.

Financial Impacts
Considers financial impacts on beneficiaries and government. Focuses on income changes to beneficiaries.

Quantitative Impacts
Considers related parameters such as production, employment, risk, input requirements.

Qualitative Impacts
Indexes other relevant criteria such as: consistency with government objectives, income distribution, gender, externalities, environmental issues, and other quality of life issues. This employs an ordinal ranking, "+10" being the most beneficial impact, "0" being a benign impact, and "-10" being the most severe negative impact.

The results of the multi-criteria analysis are presented in Table 11.20.

11.8 Assessment in Relation to other Proposed Projects

The KKRMP was conceived within the Northeast Regional Water Management Plan to be one of the initial components in an overall strategy of integrated development of the deeply flooded areas of the NE Region (NERP, 1993a). Initiatives, for which pre-feasibility level investigations have been completed, and with direct links to KKRMP, include:

- Kushiyara-Bijna-Inter-Basin Project;
- Surma-Kushiyara-Baulai Basin Project, and
- Upper Surma-Kushiyara Project.

Figure 11.1 shows their location.

The Kushiyara-Bijna Inter-Basin Project includes flood protection with submersible embankments downstream of Markuli, and construction of nine drainage-cum-flushing regulators and five irrigation inlets along the Kalni-Kushiyara River. Therefore, this initiative relates synergistically to the KKRMP. Some components (such as the Koyer Dhala regulator, some levees) have been incorporated directly into the KKRMP. Implementation of the remaining structures could be carried out immediately following the project's completion.

The Upper Surma-Kushiyara Project was proposed under the strategic thrust "*Enhanced Production Systems on Seasonally Flooded Lands*". The initiative is located upstream of the KKRMP and involves flood control measures along the left bank of the Upper Surma River and right bank of the Kushiyara River. The western portion of the project area would be kept open for drainage, navigation and fish passage. Some components, such as the control of major spills from the Surma River into the Kushiyara River system through Kakura Khal, would have substantial benefits to the KKRMP. Controlling these spills would reduce the magnitude of flood flows in the monsoon season and reduce sediment inflows into the Kushiyara River. Therefore, initiating this development could substantially reduce maintenance costs on the KKRMP.

Table 11.20: Multi-Criteria Analysis

1. Economic				
Variable	**EIRR (%)**		**NPV (million Tk)**	
Alternative 1 development	17.2		531.0	
Pessimistic (average of 11 sensitivities)	12.6		69.2	
Optimistic (average of 7 sensitivities)	18.7		677.8	
Most Likely Range (symmetric)	14.6 to 19.8			
2. Financial				
Agriculture	**LL**	**S**	**M**	**L**
Impact on Farm Income (%)	+21.2	+17.9	+18.8	+20.3
Impact on Total Farm Family Income (%)	+1.6	+5.9	+12.2	+14.4
Impact on Navigation Sector Income (%)	+5 to 10			
Impact on Fishery Sector Income (%)	+2.4			
Impact on Flood/Wave-Protected Households/Infrastructure (per household)	+10% (approx. Tk 3,000/HH year)			
Sustainable Financial Long-Term Plan (monetary +institutional)	Separable/recoverable			
Relatively Low Foreign Exchange Requirements	Yes			
3. Quantitative Impacts				
Indicator	Unit	Value	%	
Incremental Cereal Production (Year 15)	tonnes	221,000	13.4	
Incremental Non-Cereal Production (Year 15)	tonnes	24,000	-16.9	
Incremental Fish Production	tonnes	1,329	2.4	
Homesteads Protected from Floods/Waves	numbers	25,000	7	
Increased Long-Term Employment (% of total project area)	person-years	16,000	+1 to 2	
Construction Employment	person-years	20,000		
4. Qualitative Impacts (ranked from -10 to +10)				
Criteria	**Rank**			
Number of Direct Beneficiaries (%of project area population)	+8			
Diversity of Direct Beneficiaries (sectors, sub-regions)	+8			
Stimulus to Equality of Opportunity (employment)	+7			
Targeting of the "Poorest of the Poor"	+3			
Assistance to Regional Food Self-Sufficiency	+6			
Stimulus to Social Amenities (potable water, sanitation, health/education)	+7			
Addresses Potentially Irreversible Resource Degradation	+10			
Addresses Gender Inequities/Empowerment of the Relatively Powerless	+5			
Augments Social Capital (public land and water, facilities, and other resources)	+8			
Conducive to Local Organization & Management	+3			
High Priority Locally-Perceived "Felt Need"	+8			
Increased Conflict versus Social Harmony	+4			
Will Generate Perceptible & Widespread Improvement to "Quality of Life"	+7			

Note: LL = Landless Farmers S = Small Farmers M = Medium Farmers L = Large Farmers

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The objectives of the Surma-Kushiyara-Baulai Basin Project were to protect *boro* crops grown in the *haor* areas from winter and pre-monsoon floods, to mitigate the effect of monsoon floods on *aus* and *aman* crops and to protect infrastructure in the higher areas in the eastern portion of the region. An important aspect of this project involves improving the internal drainage system in the inter-basin west of Ajmiriganj and Markuli through the re-excavation of key drainage channels. Ancillary structures (including regulators, fish passes and navigation passes) would be provided. This initiative would expand the post-monsoon drainage benefits from the KKRMP significantly, since it would re-open the internal drainage system on the river's north floodplain. Under the KKRMP, improvements to post-monsoon drainage are limited by the past closures (such as at Markuli and Bheramohona) which essentially disconnect the river from the floodplain. Re-opening this drainage system would allow what would otherwise only be potential benefits of the KKRMP to be realized.

11.9 Project Risks

The project has risks, some of which are manageable, and some not. Important risks are as follows.

Avulsion in Cherapur Khal or Shantipur before the Intervention
Cherapur Khal is enlarging rapidly and appears to direct a substantial flow into the Baulai River system. A complete avulsion would result in the abandonment of the lower Kalni-Dhaleswari River and major erosion and sedimentation along the lower Baulai River. NERP analysis indicate that it appears unlikely that the Baulai route will capture all of the flow in the immediate future, but more likely that Cherapur Khal will enlarge until it forms a major distributary channel. Timely implementation of the project will prevent continued enlargement of the *khal*.

Social Conflict during Construction
This type of risk is ever present as some people will loose their land to the loop cuts and a large labor force will participate in the implementation. Project implementation has been organized to prevent these types of conflicts by the formation of Project Committees and Stakeholders Committees. Also, during construction, preference will be given to local labor.

A major Flood Occurs Prior to or during Project Implementation.
If the platforms are constructed and protected as per the specifications, they should not suffer significantly from a major flood event. However, this could result in a significant increase in dredging requirements. This is not manageable, and is often inherent in water resource development projects.

Future Pre-monsoon Flood Levels are not Reduced as much as Predicted.
This would result in a reduction in the main economic benefit - increased agricultural production. The study analysis has demonstrated that implementing the project will result in a reduction in pre-monsoon flood levels in the Kalni-Kushiarya River channel; and based on historical flooding, available mapping, field inspection, and judgement, it is expected that flood levels will be also lowered in cropped areas of the floodplain that are far-removed from the river channel. Although the methodology is conservative, neither the data nor technology are available to be absolutely certain about the magnitude of flood-level reduction. It should also be mentioned that the MIKE 11 hydrodynamic model has been selected by WARPO, because of its robustness and capability for detailed modelling, to evaluate all FAP projects on the same basis.

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Maintenance is not adequately undertaken.
This refers to the Operation and Maintenance described in Section 7.8. This would eventually obviate most agricultural benefits, but can be managed with successful, new capacity development and associated financial resources.

11.10 Recommendations

This inter-disciplinary assessment indicates that there are substantial net benefits generated by the proposed Kalni-Kushiyara River Management Project. It is estimated that there will be a positive net present value (calculated @12% over 30 years) of approximately Tk 531 million (US$12.3 million, May 1997) and an economic internal rate of return of 17.2% per annum.

The proposed KKRMP is attractive because it is designed to be a multiple-use project which will positively impact on a large and diverse number of beneficiaries in terms of sources of income, increased employment opportunities, relative incomes, and gender. It is also explicitly designed to assist in empowering the "poorest of the poor"; promptly stop potentially irreversible environmental degradation (with its immeasurable but high social cost); and be institutionally, financially, and environmentally sustainable.

Thus, the Kalni-Kushiyara River Management Project is, on balance, considered to be a very good public investment opportunity. It is, therefore, recommended that:

- the project be implemented as soon as possible;
- careful monitoring and baseline data collection precede and accompany actual project implementation;
- all people who will be directly impacted by the project participate in the entire project implementation process;
- all proposed mitigation and enhancement programs be implemented simultaneously and in their entirety since these are an integral part of the project, and
- fiscal and institutional O&M responsibilities be determined (to assure sustainability) prior to project implementation.

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