World Bank
Government of the People's Republic of Bangladesh

Gumti Phase II
Sub-Project Feasibility Study

DRAFT FINAL REPORT

ANNEX J

FINANCIAL AND ECONOMIC ANALYSIS

June, 1993

Mott MacDonald Limited
in association with
Nippon Koei Company Limited
House of Consultants Limited
Desh Upodesh Limited

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DRAFT FINAL REPORT

ANNEX J - FINANCIAL AND ECONOMIC ANALYSIS

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J.1 Introduction

J.1.1 Objectives and Scope

The economic analysis of alternative development proposals for the Gumti Phase II Project area comprises an appraisal at feasibility level of different options. Financial analyses of alternatives are restricted to those developments which the economic analysis identifies as more worthwhile. The objective is to determine the economic and financial viability of proposals in accordance with the FAP Guidelines for Project Assessment. In general this has been based on estimating the impact of proposed interventions on farm income, government expenditure and the overall economy.

J.1.2 The FAP Guidelines for Project Assessment

The Guidelines for Project Assessment have been produced by the FPCO with the aim of standardising the methodology and assumptions applied in the economic analyses undertaken by different FAP studies. They were originally produced with the intention of providing assistance to pre-feasibility studies, generally undertaken as Regional Plans but progressively have been modified for use by feasibility studies.

They are based on widely accepted techniques for the appraisal of water resource development projects and provide a good basis for achieving the necessary degree of uniformity and comparability between FAP studies.

The guidelines provide some specific values, criteria and principles to be applied in the economic analysis, including the following :

1. Only primary benefits to be included.
2. Analysis period : 30 years from the start of project construction.
3. Exclude residual values of project facilities and equipment.
4. Price basis: costs and benefits to be expressed in mid-1991 Taka.
5. Costs of specific measures to mitigate a project's adverse social and environmental impacts, including those associated with an environmental management plan, should be included.
6. "Sunk" costs should be excluded.
7. Physical contingencies on project costs: 25% for pre-feasibility studies, 15% for feasibility studies.
8. Discount rate of 12% to be used.
9. A standard conversion factor (SCF) of 0.87 to be used, reflecting the general divergence between "border" prices and internal market (financial) prices caused by taxes, subsidies, monopoly prices etc.
10. Conversion factors to convert financial prices of inputs to economic prices:

- unskilled labour shadow wage rate (SWR)	0.65
- urea fertiliser	1.45
- TSP	1.88
- MP	2.02
- animal draft power	0.87

-	diesel fuel	0.63
-	electricity for pumping	1.54
-	transport equipment	0.68
-	cement	0.79
-	steel	0.75
-	bricks	0.87
-	paddy	0.88
-	wheat	1.44
-	jute	1.06
-	sugar cane	0.95
-	other crops	0.87

J.1.3 Economic decision criteria:

- EIRR (Economic Internal Rate of Return)
- NPV (Net Present Value)
- Switching values: the percentage change in a given variable necessary to reduce a project's NPV to zero or the EIRR to 12% should be calculated.
- Other sensitivity analyses should be made, to test the effects of changes in possibly critical variables such as capital and O & M costs, project benefits and delays in project implementation and in the achievement of full benefits.

One change has been made to the conversion factors recommended by FPCO, which is a revision of the factor for wheat from 1.29 to 1.44, and excludes costs and conversions of wheat to flour.

The standard conversion factor of 0.87 has been used to convert financial prices of fish into their economic equivalents.

The economic analysis is based on constant 1991 prices as recommended whereas the financial analysis is based on 1992/93 farmgate prices.

J.1.4 Components of Economic Analysis

The Guidelines for Project Assessment require a more broadly based assessment of proposed interventions than one based solely on the financial and economic analysis of costs and benefits. The methodology recommended is a multi-criteria analysis which facilitates a comparison of expected impacts in economic, quantitative and qualitative terms. Where possible impacts have been evaluated within the economic analysis and include the following:

- benefits resulting from changes in cropped areas.
- benefits derived from reduced flood damage to crops, property, infrastructure, livestock and fishponds.
- costs associated with reduced fish catches.

An indication of the order of indirect costs and benefits can be obtained by presenting quantitative estimates of important parameters such as increments in crop production, declines in fish catches and changes in employment for differently affected occupations. Impacts which cannot be quantified with confidence are included via an assessment of their significance both in terms of overall importance and the extent to which proposed interventions will result in changes. In general the major concerns for flood control projects which are not easily quantified are the consequences for health, nutrition, transportation and the quality of life on one hand and the effects on the natural environment on the other.

J.1.5 Components of Financial Analysis

The principal benefit of the project is an increase in farm incomes for farmers and their families and improved employment opportunities for those engaged as agricultural labourers. Thus a major component of the financial analysis is the calculation of farm incomes at financial prices based on proposed cropping patterns and crop budgets. Potential increases in farmers' incomes are estimated with farm models for typical farm sizes. Their function is to demonstrate that project proposals are worthwhile and that farmers are indeed likely to adopt the opportunities which the project makes possible given the constraints under which existing farming practices are pursued.

J.2 Methodology for Project Appraisal

J.2.1 Sources of Data

Field surveys of the following target groups have been completed and provide the major source of data used in this study. The results of the surveys are presented in the appendices to the Agricultural Annex (E) and have covered:

	Respondents per Zone				**Total**
	A	B	C	D	
Farmer	96	96	96	96	384
Farmer Case Study	12	13	12	14	51
Landless	24	24	24	24	96
Capture Fishermen	25	37	42	65	169
Culture Fishermen	24	24	24	24	96
Women	24	24	24	24	96
Plot Surveys	60	60	60	60	240

For the purposes of field surveys and investigations the project area is divided into four zones as illustrated in Figure J.2.1. Thanas whose boundaries do not coincide with zones are listed below:

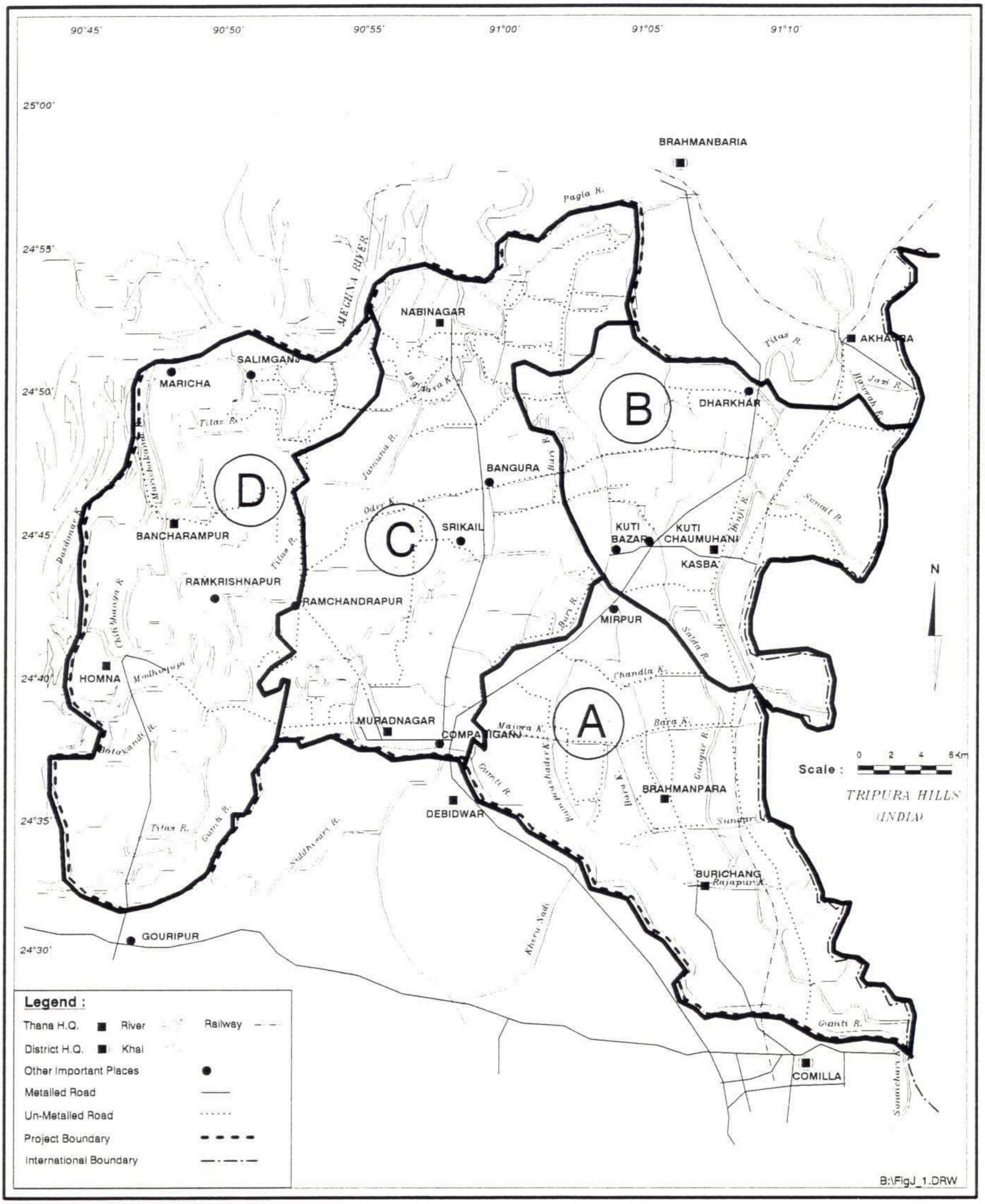
	Thanas
Zone A	Comilla Sadar, Burichang, Debidwar, Brahmanpara
Zone B	Akhaura, Kasba, Nabinagar
Zone C	Nabinagar, Muradnagar
Zone D	Homna, Bancharampur, Daudkandi, Nabinagar

The estimated area of each zone is :

	Gross	Net
Zone A	31976	24506
Zone B	26782	22412
Zone C	41400	35040
Zone D	40696	36080
Total	140854	118038

Figure J.2.1

Planning Zones (A, B, C & D)



The surveys provided specific data for use in the economic and financial analyses on wage rates, pesticide costs, hire rates for bullocks as well as the value of crop residues and animal manure. Fertiliser prices were obtained from the International Fertiliser Development Centre. Seed prices were obtained from the Bangladesh Agricultural Development Corporation for those crops which farmers normally purchase their seed (i.e. potatoes), from FPCO guidelines for jute and by multiplying the output price by 1.5 for those crops which farmers retain their own seed.

Commodity prices were collected from the Directorate of Agricultural Marketing for a five year period (1988 - 1992) from three producer markets and two wholesale markets. When information was available producer market prices were used, based on an average of the lowest three or four months of the year (i.e. harvest time) when farmers are most likely to sell their crops.

Three year averages were calculated for the periods 1989-91 and 1990-92 and are adjusted for farm to market transport. No allowance for inflation was incorporated in these calculations as no upward trend could be discerned in price data from individual markets over the period covered. Financial and economic prices for agricultural products and inputs are presented in Table J.2.1. The price of draught animals in Table J.2.1 is for a pair of bullocks less the cost of the driver. While teams of bullocks are invariably hired with a driver, the costs have been separated to avoid double counting of labour as crop labour requirements also include an allowance for cultivations with draught animals.

J.2.2 Conversion Factors for Capital and O&M Costs

Project capital and operating costs have been adjusted to economic prices by applying the conversion factors given in the Guidelines for Project Assessment to the total estimated capital and operation and maintenance costs at financial prices. Capital and operating costs for the main items (embankments, pump stations, khal excavation etc) have been broken down by main category (labour, materials, machinery, equipment etc) in terms of the percentage share of costs, and the relevant conversion factor applied for each category. The results are presented in Table J.2.2. All capital and O&M costs are adjusted to 1991 prices (factor = 0.952, construction index) for inclusion in the economic analysis.

Physical contingencies are included at 15 per cent of capital costs at both economic and financial prices. Engineering costs for detailed design and the supervision of construction are charged at 12 per cent of capital costs in financial prices and converted into economic prices by applying the standard conversion factor.

J.2.3 Economic Cost of Land Acquisition and Resettlement

The issues of land acquisition and resettlement are being studied as a separate element (FAP 15) of the Flood Action Plan Studies; FAP 15 Final Report has not yet been published. At present individuals who own land or other assets which are compulsorily purchased are entitled to compensation payments from the Government at the current market rate, which in the case of the Gumti Phase II project area has been assessed at Tk 375 000 per hectare of agricultural land. Homestead areas have been valued at Tk 1617800 per hectare which includes allowances for resettlement and the construction of new houses.

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TABLE J.2.1

Financial and Economic Prices for Agricultural Products and Inputs (Taka)

Commodities	Unit	Financial Prices (1991)	Financial Prices (1992)	Conversion Factor	Economic Prices (1991)
Main Products					
B Aus	kg	6.17	6.17	0.88	5.43
T Aus	kg	6.17	6.17	0.88	5.43
B Aman	kg	6.96	7.47	0.88	6.12
LT Aman	kg	6.96	7.47	0.88	6.12
HYV Aman	kg	6.96	7.47	0.88	6.12
L Boro	kg	5.89	6.19	0.88	5.18
HYV Boro	kg	5.89	6.19	0.88	5.18
Wheat	kg	6.53	7.18	1.44	9.40
Potato	kg	4.09	4.16	0.87	3.56
Jute	kg	7.94	7.67	1.06	8.42
Pulses: keshari	kg	12.63	12.31	0.87	10.99
mung	kg	17.62	17.05	0.87	15.33
masur	kg	20.48	21.89	0.87	17.82
mash	kg	12.11	14.57	0.87	10.54
Groundnuts	kg	13.93	13.27	0.88	12.26
Mustard	kg	13.93	13.27	0.88	12.26
Sugarcane	kg	0.70	0.70	0.95	0.67
Spices (onion)	kg	8.73	8.64	0.87	7.60
Spices (chilli)	kg	7.64	8.40	0.87	6.65
Veg. (brinjal)	kg	3.73	3.79	0.87	3.25
Veg. (tomatoes)	kg	4.50	4.50	0.87	3.92
Veg. (taro)	kg	4.26	4.99	0.87	3.71
By Products					
Rice straw HYV	kg	0.50	0.50	0.87	0.44
local	kg	0.50	0.50	0.87	0.44
Wheat straw	kg	0.50	0.50	0.87	0.44
Jute sticks	kg	1.11	1.11	0.87	0.97
Pulse straw	kg	1.50	1.50	0.87	1.31
Oilseed straw	kg	0.23	0.23	0.87	0.20
Inputs					
Human Labour	day	40.00	43.00	0.75	30.00
Bullock pair*	day	40.00	57.00	0.87	34.80
Seeds					
B Aus	kg	9.26	9.26	0.88	8.15
T Aus	kg	9.26	9.26	0.88	8.15
B Aman	kg	10.44	11.21	0.88	9.19
LT Aman	kg	10.44	11.21	0.88	9.19
HYV Aman	kg	10.44	11.21	0.88	9.19
L Boro	kg	8.84	9.28	0.88	7.78
HYV Boro	kg	8.84	9.28	0.88	7.78
Wheat	kg	9.80	10.80	1.44	14.11
Potato	kg	9.50	10.00	0.87	8.27
Jute	kg	22.00	22.00	1.06	23.32
Pulses	kg	24.00	24.00	0.87	20.88
Groundnuts	kg	19.00	19.00	0.88	16.72
Mustard	kg	19.00	19.00	0.88	16.72
Spices (onion)	kg	600.00	600.00	0.87	522.00
Spices (chilli)	kg	600.00	600.00	0.87	522.00
Veg. (brinjal)	kg	400.00	350.00	0.87	348.00
Veg. (tomatoes)	kg	400.00	350.00	0.87	348.00
Veg. (taro)	kg	400.00	350.00	0.87	348.00
Fertiliser					
Urea	kg	4.72	5.26	1.45	5.90
TSP	kg	5.78	7.60	1.88	10.76
MP	kg	4.54	7.24	2.02	8.27
Animal manure	kg	0.10	0.10	0.87	0.09
Pesticide	kg	500.00	500.00	0.87	435.00
Diesel fuel	litre	14.00	14.00	0.63	8.82

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Table J.2.2

Breakdown of Capital Costs in Financial Prices by Main Category

Share of Costs (per cent)

Item	Skilled labour local cost	Unskilled labour local cost	Transport local cost	Transport F. E. cost	Cement and Bitumen local cost	Cement and Bitumen F. E. cost	Steel local cost	Steel F. E. cost	Machinery and equipment local cost	Machinery and equipment F. E. cost	Gravel/ Bricks local cost	Total local cost	Total F. E. cost	Total
Embankments	6.0	56.0	3.0	3.0	0.0	0.0	0.0	0.0	16.0	16.0	0.0	81.0	19.0	100.0
Canals	6.0	56.0	3.0	3.0	0.0	0.0	0.0	0.0	16.0	16.0	0.0	81.0	19.0	100.0
Major drains	6.0	56.0	3.0	3.0	0.0	0.0	0.0	0.0	16.0	16.0	0.0	81.0	19.0	100.0
Drainage	6.0	56.0	3.0	3.0	0.0	0.0	0.0	0.0	16.0	16.0	0.0	81.0	19.0	100.0
Regulators	11.0	42.0	1.0	1.0	6.0	2.0	6.5	6.5	10.0	10.0	4.0	80.5	19.5	100.0
Culverts	12.0	49.0	1.5	1.5	4.5	1.5	6.5	6.5	6.5	6.5	4.0	84.0	16.0	100.0
Pump stations Civil	12.0	48.0	1.0	1.0	6.0	2.0	6.5	6.5	6.5	6.5	4.0	84.0	16.0	100.0
Pump stations E & M	5.0	1.0	1.5	1.5	0.0	0.0	0.0	0.0	45.5	45.5	0.0	53.0	47.0	100.0
Roads E/W	6.0	56.0	3.0	3.0	0.0	0.0	0.0	0.0	16.0	16.0	0.0	81.0	19.0	100.0
Roads Pavement	13.0	13.0	2.0	2.0	10.0	3.0	0.0	0.0	10.5	10.5	36.0	84.5	15.5	100.0
Bridges	12.0	47.0	1.5	1.5	7.0	2.0	6.5	6.5	6.0	6.0	4.0	84.0	16.0	100.0
Footbridges	13.0	48.0	2.0	2.0	7.0	2.0	6.5	6.5	4.5	4.5	4.0	85.0	15.0	100.0
Power supply	5.0	1.0	2.0	2.0	0.0	0.0	0.0	0.0	45.0	45.0	0.0	53.0	47.0	100.0
Buildings	15.0	14.0	0.0	0.0	17.0	6.0	6.5	6.5	3.0	3.0	29.0	84.5	15.5	100.0

Breakdown of O&M Costs in Financial Prices by Main Category

Share of Costs (per cent)

Item	Skilled labour local cost	Unskilled labour local cost	Transport local cost	Transport F. E. cost	Cement and Bitumen local cost	Cement and Bitumen F. E. cost	Machinery and equipment local cost	Machinery and equipment F. E. cost	Electricity local cost	Electricity F. E. cost	Total local cost	Total F. E. cost	Total
Embankments	22.5	57.5	1.5	1.5	0.0	0.0	8.5	8.5	0.0	0.0	90	10	100
Canals	22.5	57.5	1.5	1.5	0.0	0.0	8.5	8.5	0.0	0.0	90	10	100
Major drains	22.5	63.0	1.5	1.5	0.0	0.0	5.8	5.8	0.0	0.0	93	7	100
Drainage	11.5	87.5	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	100	1	100
Regulators	28.0	56.5	1.3	1.3	3.0	3.0	3.5	3.5	0.0	0.0	92	8	100
Culverts	28.5	63.0	1.3	1.3	3.0	3.0	0.0	0.0	0.0	0.0	96	4	100
Pump stat. Civil	28.5	57.5	1.3	1.3	0.0	0.0	5.8	5.8	0.0	0.0	93	7	100
Pump stat. E & M	29.0	29.0	1.0	1.0	0.0	0.0	20.0	20.0	0.0	0.0	79	21	100
Pump stat. Power	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.0	25.0	75	25	100
Roads	22.0	59.5	1.3	1.3	3.0	3.0	5.0	5.0	0.0	0.0	91	9	100
Bridges	28.5	56.0	1.3	1.3	3.0	3.0	3.5	3.5	0.0	0.0	92	8	100
Footbridges	28.5	63.0	1.3	1.3	3.0	3.0	0.0	0.0	0.0	0.0	96	4	100
Buildings	28.5	63.0	1.3	1.3	3.0	3.0	0.0	0.0	0.0	0.0	96	4	100

Note: Figures may not sum to total due to rounding

Estimates of Conversion Factors for Capital Cost Items

Item	Skilled labour	Unskilled labour	Transport	Cement/ Bitumen	Steel	Machinery & equpt	Gravel/ Bricks	Weighted average Conversion Factor
Conversion Factor	0.87	0.65	0.79	0.79	0.75	0.62	0.87	
Embankments	5.2	36.4	4.7	0.0	0.0	19.8	0.0	0.66
Canals	5.2	36.4	4.7	0.0	0.0	19.8	0.0	0.66
Major drains	5.2	36.4	4.7	0.0	0.0	19.8	0.0	0.66
Drainage	5.2	36.4	4.7	0.0	0.0	19.8	0.0	0.66
Regulators	9.6	27.3	1.6	6.3	9.8	12.4	3.5	0.70
Culverts	10.4	31.9	2.4	4.7	9.8	8.1	3.5	0.71
Pump stations Civil	10.4	31.2	1.6	6.3	9.8	8.1	3.5	0.71
Pump stations E & M	4.4	0.7	2.4	0.0	0.0	56.4	0.0	0.64
Roads E/W	5.2	36.4	4.7	0.0	0.0	19.8	0.0	0.66
Roads Pavement	11.3	8.5	3.2	10.3	0.0	13.0	31.3	0.78
Bridges	10.4	30.6	2.4	7.1	9.8	7.4	3.5	0.71
Footbridges	11.3	31.2	3.2	7.1	9.8	5.6	3.5	0.72
Power supply	4.4	0.7	3.2	0.0	0.0	55.8	0.0	0.64
Buildings	13.1	9.1	0.0	18.2	9.8	3.7	25.2	0.79

Other conversion factors from FPCO Guidelines	vehicles	0.68
	standard conversion factor	0.87

Estimates of Conversion Factors for O&M Cost Items

Item	Skilled labour	Unskilled labour	Transport	Cement/ Bitumen	Machinery & equpt	Pump station power	Weighted average Conversion Factor
Conversion Factor	0.87	0.65	0.79	0.79	0.62	1.54	
Embankments	19.58	37.38	2.37	0.00	10.54	0.00	0.70
Canals	19.58	37.38	2.37	0.00	10.54	0.00	0.70
Major drains	19.58	40.95	2.37	0.00	7.13	0.00	0.70
Drainage	10.01	56.88	0.79	0.00	0.00	0.00	0.68
Regulators	24.36	36.73	1.98	4.74	4.34	0.00	0.72
Culverts	24.80	40.95	1.98	4.74	0.00	0.00	0.72
Pump stat. Civil	24.80	37.38	1.98	0.00	7.13	0.00	0.71
Pump stat. E & M	25.23	18.85	1.56	0.00	24.80	0.00	0.70
Pump stat. Power	0.00	0.00	0.00	0.00	0.00	154.00	1.54
Roads	19.14	38.68	1.98	4.74	6.20	0.00	0.71
Bridges	24.80	36.40	1.98	4.74	4.34	0.00	0.72
Footbridges	24.80	40.95	1.98	4.74	0.00	0.00	0.72
Buildings	24.80	40.95	1.98	4.74	0.00	0.00	0.72
				standard conversion factor			0.87

The economic value of agricultural land acquired for project works has been taken to be the present value, at 12%, of the net income foregone from future production on the land over thirty years. If varies with cropping pattern and yield and has been calculated separately for each of the four zones within the project area. These values are presented below:

Zone	A	Tk 198750 /ha
	B	Tk 198750 /ha
	C	Tk 150000 /ha
	D	Tk 150000/ ha

The costs of homesteads which include the cost of resettlement have been converted into economic costs by applying the standard conversion factor of 0.87.

J.2.4 Costs of Minor Irrigation

Capital and annual operating costs for different types of minor irrigation equipment have been estimated on the basis of surveys of pump operators, farmers and secondary data. Details of cost calculations are in Appendix J.I. Costs have been calculated for a range of different modes including:

a. LLP 1 - 0.7/1.0 cu.sec pump irrigating 10 ha, using the same 8hp engine as a STW.

b. LLP 2 - 2 cusec pump irrigating 20 ha.

c. STW - a conventional STW using a Japanese engine. Although many STWs have cheaper Chinese engines, these are slightly less fuel efficient and have a shorter life (crankshafts usually break after 2 or 3 years, so their overall cost has been calculated to be slightly higher than the Japanese engine.

d. DSSTW - as for the STW but in an unlined pit 1.5 m deep.

e. DFMTW 1 - a 1 cu sec version of a DTW for deeper aquifers. Now that BADC is no longer installing DTWs it is likely that future private investment in this mode will be in this type of smaller well. Although most existing DTWs the larger and more costly 2 cusec wells, the cost of a smaller cheaper well has been used as the replacement cost of existing DTWs.

Capital costs include the cost of water channel construction (unlined earth). Costs of additional irrigation equipment required has not been included in the cash flow as a capital item, with replacement costs being incorporated at the end of their life. Rather capital costs for both existing and additional equipment has been annualized over the life of the well/pump at an interest rate of 12% per year (16% at financial prices). Not only is this approach more straightforward, and treats project related and non-project investments in the same way, but it is more than likely that many at least some of the equipment purchased by farmers would be second-hand and so have a different cost and replacement profile. This approach can distort IRR calculations if returns are very different from the 12% discount rate, although because the cost of irrigation equipment is not very large relative to overall project costs and benefits, the distortion is unlikely to be significant.

Operating costs are based on an irrigation water pumping requirement of 740 mm per year. Although this is about 25% less than the calculated crop water requirements for boro in Gumti, it is thought to reflect the actual amount that farmers apply. If the full crop water requirement is provided, then irrigation costs at financial prices for STW and DTW exceed the actual fees charges, leaving pump operators to make a loss. In addition it would require tubewells to operate for unrealistically long hours to supply known command areas. What farmers are doing is making a realistic compromise between irrigation costs and crop water requirements.

Average costs by mode have been calculated as, for LLP, the average between LLP 1 and LLP 2, and for STW/DSSTW, an average weighted 80% STW and 20% DSSTW. The cost of traditional irrigation has been calculated as a labour cost Tk 7,200 per ha in financial prices or Tk 5,400 at economic prices. This is substantially more than alternative sources such as LLP and STW. In fact what the farmer is paying for with his own labour is a saving on hiring a mechanical pump. Therefore the labour cost has been reduced by 50% which puts it between an LLP and STW. In practice actual labour use may be less than 180 days per ha as farmers apply less than optimal amount of water. There is evidence from Gumti that traditionally irrigated boro does yields less (and also gets lower levels of fertiliser).

Crop budgets at financial prices include irrigation costs based on fees charged in pumps surveyed in the Gumti II irrigation pump survey. For boro this was:

LLP	Tk 4090 per ha
STW	Tk 5348 per ha
DTW	Tk 5019 per ha

An overall fee for irrigating boro has been calculated using the average for different modes weighted by the proportion of modes found in the region. The cost for other crops has been calculated according to the proportion that their fees are to the boro fee. These costs are:

Boro	Tk 4377 per ha
T Aus	Tk 1425 per ha
Wheat	Tk 2257 per ha
Potatoes	Tk 3068 per ha

Only 33% of the aus fee is applied as it is assumed that most aus crops require less irrigation. For wheat and potatoes the full amount is applied to the irrigated crop budget. It is assumed that local boro only needs half the irrigation of HYV boro as it is grown in naturally wet places. In the Gumti area a flat rate irrigation fee is the normal method of charging for water, rather than a share of the crop.

For the purposes of comparing technologies and assessing the potential for groundwater use under difficult conditions a number of other technologies have been evaluated in Appendix J.I. These indicate that both DSSTW and SFMTW can provide an economic alternative to STW in situations where the water table has fallen sufficiently to reduce the efficiency of STW operation.

.8

J.2.5 The Use of the Mike II Hydrodynamic Model

The evaluation of flood mitigation projects in Bangladesh has for some time been based on classifications of flood depth known as flood phases. These are categorised as follows:

F0	-	flood depths of 0.3 M
F1	-	flood depths of 0.3 - 0.9 M
F2	-	flood depths of 0.9 - 1.8 M
F3	-	flood depths of 1.8 M (for less than nine months per year)
F4	-	flood depths of 1.8 M (for more than nine months per year)

This classification system has been in use for some time and is retained by the Regional Plan for broad level planning purposes, as both crop statistics and cropping distributions have been developed by the Master Planning Organisation for flood phases by planning unit which enable flood mitigation programmes to be evaluated on the basis of changes in flood phasing which result from proposed interventions. A drawback of the present classification, for other than broad level planning is that it relates neither to the duration of flooding nor to the frequency with which the inundation occurs. Thus, for example, an intervention which reduced the duration of flooding while at the same time had little impact on its peak depth might well enable an aman crop to be transplanted on the receding flood for which no benefit under the depth of flooding rules can be claimed. As a result FPCO have produced (but not yet officially published) a new set of guidelines which specify the maximum depths of flooding which various types of rice can withstand throughout their life cycle. These are presented in Table J.2.3.

The rules have been incorporated within the processing package of the Mike II hydro-dynamic model as follows:

- depths of flooding tolerances, as presented in Table J.2.3 are transformed into histograms of maximum allowable flooding depths by 10 day periods to accord with the 10 day analysis used by the model for a range of planting/sowing dates.

- in each decad (with three decads per calendar month) crop failure occurs on the fourth day on which the level exceeds the critical value. Hence each decad should be represented as a maximum of a four day minimum level, starting by looking three days backwards into the previous decad. Water levels were analysed at each representative river level node in terms of four day exceedances over the whole year for the 25 year run which enabled them to be expressed in terms of probabilities.

- water levels are translated into areas of land flooded to various depths by comparison with area elevation curves for each minute square (311 hectares) which are calculated by reference to the land level data base. The data base itself is simply a large number of entries of topographic heights for each minute square which is based on the 1989 1 to 16000 FINNMAP mapping, where each point represents a little over three hectares.

- areas on which crops can be safely grown are calculated by application of FPCO submergence rules over a range of conditions, which include the extreme, average and one in 3, 4, 5 8 and 10 wet years.

TABLE J.2.3

SUBMERGENCE TOLERANCE RANGE OF RICE AT DIFFERENT GROWTH STAGES

CROP	GROWTH STAGE	SUBMERGENCE RANGE	PERIOD
HYV Boro	Transplanting	10 - 20 cm	January - February
	Vegetative	30 - 50 cm	March
	Reproductive	20 - 30 cm	April
	Maturity	30 cm	May
B Aus	Seeding	Field Capacity	March - April
	Vegetative	50 - 70 cm	May
	Reproductive	30 - 50 cm	June
	Maturity	50 cm	July
HYV Aus	Transplanting	10 -20 cm	March - April
	Vegetative	30 - 50 cm	May - June
	Reproductive	20 - 30 cm	July
	Maturity	30 cm	August
LT Aus	Transplanting	20 - 30 cm	March - April
	Vegetative	50 - 70 cm	May - June
	Reproductive	30 - 50 cm	July
	Maturity	50 cm	August
LT Aman	Transplanting	20 - 30 cm	July - September
	Vegetative	50 - 70 cm	September - October
	Reproductive	30 - 50 cm	November
	Maturity	50 cm	November - December
HYV Aman	Transplanting	10 - 20 cm	July - August
	Vegetative	30 - 50 cm	September - October
	Reproductive	20 - 30 cm	October - November
	Maturity	30 cm	November - December
DWR	Seeding	Field Capacity	March - April
	Transplanting	30 - 50 cm	April - May
	Vegetative	50 - 400 cm*	June - September
	Reproductive	50 - 90 cm	October - November
	Maturity	Field Capacity	November - December

* Rise in water level has to be gradual so that the plants can keep pace.

The output from the model is consequently a list of the percentages of an area on which crops can be safely grown at specified probability levels. For many crops the list is academic as the area actually grown is determined by other factor such as access to irrigation. The model only produces areas on which crops can be theoretically grown, other things being equal. In addition, because the model is unable to represent flash floods satisfactorily, it cannot be used to assess either their impact or frequency.

J.2.6 Cropping Patterns

Cropping patterns are determined by a large variety of factors but among the more important are :

- access to irrigation in the dry season which to a very large extent decides whether or not a boro crop is grown.

- the flooding regime in the monsoon season which determines whether or not a farmer can grow transplanted high yielding aman, transplanted local varieties of aman, deep water aman or nothing.

- attitudes to risk which are generally determined by farmers' expectations of likely costs and returns but which are also a function of farmers' ability to bear losses should they arise. These are not clear cut for some farmers are in a position where crop failure is not much worse an outcome than not planting because either strategy is catastrophic in terms of providing food for their families. Other farmers are in a more fortunate position where they are able to grow sufficient food for consumption with relatively low risk crops and are unwilling to gamble this security on the chance of either higher returns or the possibility of jeopardising their holdings through incurring losses. Larger farmers are generally in a position to decide for themselves what strategy to adopt although evidence from the farmer survey suggests that the very large farmers tend to farm at lower intensities than either medium or small farmers, and invariably have other sources of income to rely on.

Changes in cropping patterns which can be anticipated are expected to result from both increased access to irrigation and changed flooding regimes. Increased irrigation invariably results in increased boro cultivation, as the crop produces high yields, good returns and is generally perceived as being less risky than most other crops except in areas prone to flash floods. Any increase in boro cultivation has widespread implications for many other crops in both the rabi and aus seasons. Some short duration crops such as pulses and oilseeds may precede a boro crop but only if they are planted on the receding flood. Wheat, potatoes and most winter vegetables are not generally harvested in time for a boro crop to be planted. The same is true of aus, mixed aus and aman and jute crops which are seeded in March, April (and May to some extent) and thus compete with the boro crop which is harvested in (late) April, May and early June. Transplanted aus and deepwater aman crops may follow boro but require an early boro harvest as well as a fast turnround in land preparation and transplanting. Consequently this sequence of crops cannot be expected to cover a very high proportion of the area. Broadcast deep water aman is another crop which can follow boro but it is more safely sowed in March or April when it is unlikely to be damaged by severe early rains (the crop cannot be broadcast into standing water) and has plenty of time to establish itself well enough to elongate with the arrival of floods (a period of about two months). Thus broadcasting aman after the middle of April becomes increasingly more risky the later it is sowed, and consequently has been restricted in the development of cropping patterns to maximum of ten per cent of the area in question.

Transplanted aman crops (HYV varieties are transplanted in July and August, local varieties in July, August and September) may follow aus crops but it is more common for them to follow the boro crop as this gives farmers plenty of time to prepare the land and tend their nurseries. In general transplanted aman crops do not compete for land with any other seasonal crops except deepwater varieties which are by definition generally grown elsewhere.

They do conflict with early sown rabi crops as transplanted aman is generally harvested in November and December, by which time the residual moisture has evaporated sufficiently to hinder germination of unirrigated rabi crops. Some farmers overcome this problem by broadcasting seed into the standing aman crop, but in general it may be concluded that increased areas of transplanted aman crops are likely to restrict the ability of farmers to grow crops in the time between the harvest of aman and the transplanting of boro.

From the above it can be seen that future cropping patterns will be mainly determined by assumptions concerning both access to irrigation and projected flooding regimes.

All existing irrigation within the project area turns under the category of minor irrigation; that is to say that there are no schemes involving major pump stations and / or extensive gravity distribution. Estimates of irrigated area in each of the project area zones have been based on the following sources:

- the farmer survey which asked whether (and how) a crop grown on each of the farmers' plots is irrigated or not

- data collected by the Bangladesh - Canada Agricultural Sector Team (AST) on numbers of and areas commanded by minor irrigation equipment by extension block and Thana.

- Thana statistics from the Development of Agricultural Extension (DAE) and the Bangladesh Bureau of Statistics on irrigation areas and modes.

A discussion of the development trends of all modes of minor irrigation based upon AST and other data sources is presented in Chapter 5 of Annex C (Groundwater Investigations) together with the 1991 irrigated areas by mode according to AST, tabulated by extension block.

In general it was found that the farmer survey produced higher irrigation coverage than either AST figures or DAE/BBS statistics.

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In the case of Zone C, it was clear that this resulted from an unrepresentative sample which happened to include too high a proposition of low lift pumps and with was clearly not representative of the whole zone. In Zones A and B, it was also concluded after comparison with AST data that the survey was overtaking the irrigation area and that a compromise between the two would be more realistic. As a result the following irrigation rates were adopted:

		Adopted	Survey	AST
Zone	A	62%	68%	50 - 60%
Zone	B	68%	78%	60 - 70%
Zone	C	40%	51%	30 - 40%
Zone	D	50%	50%	40% - 50%

This is not as drastic as it might seen because in the future with and without project projections it is assumed that irrigation rates would increase irrespective of whether the project was undertaken to 75% in Zones A B and C (although Zone C purposes of analysis in the future with and ,without projects situations irrespective of how it is provided. For the 1990 study FCDI options, areas without access to surface water are assumed to develop groundwater resources up to the level of 75% coverage in Zones A, B and C and up to 60% in Zone D. 75% coverage was selected as a likely possible maximum because it is slightly below irrigation rates already achieved in Akhaura (over 80% but which is exceptional as it enjoys artesian flows in some areas) and allows for expected growth in the future. As this maximum is applied to both the without and with project cropping patterns its selection is central in terms of the analysis in all respects except flood damage losses is a special case and is discussed in more detail in Chapter J.4) and 60% in Zone D when irrigation development will be restricted, not by any shortages of suitable groundwater resources but by some very low lying land which suffers from poor drainage. One of the conclusions of Annex C is that there are no technical restrictions to the development of groundwater anywhere in the project area although the exploitation of the resource in Zone C will require the use of both shallow force mode technology which is as yet unproven and deep tubewells which are expensive. The maximum expected rate of irrigation coverage is set at 75% (Zone D= 60%) for both raw "future without" and "future with" evaluations.

J.2.7 Flooding Regimes

Output from the hydro-dynamic model post processing runs provides maximum areas of crops which can be safely grown at various levels of risk in both the present and future with project situations. While these give a useful indication of the potential improvements which an intervention might achieve, it is necessary to establish how well the model predicts present cropped areas of transplanted aman before it can be used to predict future cropped areas. As far as the model results are concerned transplanted aman are the key crops (both HYV and LV) because these are directly controlled by the flooding regime and can be increased with little adverse affect on other crops other than the deepwater amans which they might replace.

A comparison is presented in Table J.2.4 where it can be seen that the overall fit between the project area as predicted by the model and the farmer survey is extraordinarily good (note that HYV and LT aman areas produced by the model are mutually exclusive). The results are less impressive when considered by Zone although overall the errors when expressed as a percentage of NCA appear reasonable. It is only when they are calculated as a ratio of each other that they look rather poor. One feature of the model is that in both Gumti and Noakhali it proved to be considerably more reliable in predicting large areas of T aman (over 30%) than very small. Where only small areas of T aman can be grown at present it may be that farmers have different attitudes to risk being prepared to take either smaller or greater chances depending on their circumstances. It may also be the case that because the crop can only be grown on isolated areas of high ground, farmers on these grounds are either unaware of the opportunity or have never received sufficient encouragement or advice to motivate them.

In these circumstances, it has been decided that in Zone A, 100% of the model predictions should be included in future cropping patterns whereas only 80% of predicted should be included elsewhere.

TABLE J.2.4

Model Analysis of Present Cropping Patterns

		Zone A ha	Zone B ha	Zone C ha	Zone D ha	Total ha
NCA		24506	22413	35040	36080	118039
Model Results	Risk Factor					
Max HYV Aman	1:5	8708	3711	1408	510	14337
Max LT Aman	1:5	12778	7388	5115	3996	29277
Survey Predictions (Farmer Survey)						
HYV Aman		8332	1479	2453	0	12264
LT Aman		5612	4191	4836	2526	17164
Total T Aman		13944	5670	7288	2526	29428
Ratio		1.09	0.77	1.42	0.63	1.01
Error		4.8	7.7	6.2	4.1	0.1
BBS T.Aman		11988.00	2567	6213.00	2158	22926
DAE T.Aman		13100.00	5936	2348.00	776	22160
MPO figure based on planning area 31 (pro rata)						33928

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TABLE J.2.5

Crop Budgets
Physical Input Quantities and Production per Hectare

Crop	Labour days	Draft Animals pairday	Seed kg	Fertiliser kg Urea	TSP	MP	Animal manure kg	Pest- -cide kg	Production (t/ha) Main Crop	By-Product
B Aus, local	142	45	85	100	50	0	1000	0.25	2.00	4.00
B Aus, HYV	145	45	85	100	50	0	1000	0.25	2.50	2.50
T Aus, local	155	47	30	80	40	0	1000	0.25	2.50	5.00
T Aus, HYV irri	181	47	30	140	110	35	1000	0.50	3.60	3.60
T Aus, HYV n-ir	177	47	30	140	110	35	1000	0.50	3.20	3.20
Mixed aus/aman	165	44	83	80	40	0	0	0.13	2.30	2.30
B Aman local dw	111	44	83	50	0	0	0	0.13	1.88	1.88
T Aman local dw	134	40	44	90	25	0	0	0.13	2.40	2.40
T Aman, local	146	40	44	100	50	20	0	0.25	2.60	5.20
T Aman HYV irri	171	43	30	133	95	38	700	1.16	3.85	3.85
T Aman HYV n-ir	167	43	30	133	95	38	700	1.16	3.65	3.65
Boro, local	120	25	40	128	0	0	0	0.00	3.00	6.00
Boro, HYV irrig	214	45	30	193	160	45	1000	1.00	5.40	5.40
Boro HYV p-irr.	160	45	30	193	160	45	1000	1.00	0.00	0.00
Wheat irrig.	127	45	130	115	80	30	0	0.30	2.25	2.25
Wheat unirrig.	102	45	130	80	50	24	0	0.30	1.80	1.80
Potato irrig.	194	44	1000	277	290	102	1500	3.00	15.00	0.00
Potato unirrig.	175	44	1000	277	290	102	1500	2.00	10.00	0.00
Jute	215	45	9	89	67	9	2000	0.00	1.90	3.80
Pulses: ave.	50	30	31	0	0	0	0	0	0.64	0.64
Mustard	58	37	10	192	144	40	750	0.40	0.75	0.75
Spices (chilli)	157	30	1	100	180	90	2500	0.00	4.00	0.00
Veg. (brinjal)	270	44	1	100	60	40	2500	0.30	8.00	0.00

J.2.8 Crop Input Use

Estimates of input use have been made for the following crops which were selected from an analysis of cropped areas obtained from the survey of farmers.

B Aus	Local	T Aman	Local deepwater	Wheat	Not irrigated
B Aus	HYV	T Aman	Local	Potato	Irrigated
T Aus	Local	T Aman	HYV irrigated	Not irrigated	
T Aus	HYV irrigated	T Aman	HYV not irrigated	Jute	
T Aus	HYV not irrigated	Boro	Local	Pulses	
Mixed	B Aus/Aman	Boro	HYV	Mustard	
B Aman	Local deepwater	Wheat	Irrigated	Spices (chili)	
				Vegetables (Brinjal)	

Data from both primary (farmer surveys and case studies, SERS 1991 Survey) and Secondary Sources (MPO Technical Report No 14, FAP12 reports, Gumti Feasibility Study, 1990, IFDC Publications) have been reviewed to make estimates of agricultural input use. Principal data sources were the farmer surveys and 1990 feasibility study which were checked against other secondary sources. The crop budgets are shown on Table J.2.5.

J.2.9 Crop Yields

Sources of crop yield data are discussed in the Agricultural Annex (Annex E), and a brief review presented here.

Results of the survey for the Gumti project area are given in Table J.2.6. DAE and BBS figures are averages for the thanas in both project areas over the period 1989-90 to 1991/92. Rice yields are in tonnes of paddy per hectare. In general the farmer survey yields are higher than both DAE and BBS yields although DAE yield estimates are generally higher than BBS's. The higher yield rates used in the crop budgets reflect the farmer survey as these yields are to some extent confirmed by the survey done by FAP 12 in the Meghna Dhonaghoda Irrigation Project and by the Deep Tubewell Monitoring Project which covers part of the northern area and which gave a yield of 5.5 tonnes per hectare for boro.

Future Yields

Previous appraisals of FCDI projects have commonly assumed that substantial input supply and agricultural extension programmes would accompany projects, and that farmers would use recommended doses of inputs and achieve yields appropriate to these levels of inputs. In reality, while FCDI projects and irrigation have generally been found to lead to changes in cropping patterns (due to altered flood phasing), it is not immediately apparent that they have resulted in an increase in input application or yields received for a given crop type grown under the same land and water conditions as before.

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TABLE J.2.6
Crop Yield Data:

	Farmer survey	DAE	BBS	used in budgets
B Aus, local	2.30	1.87	1.43	2.00
B Aus, HYV	2.95		1.53	2.50
T Aus, local	2.51		2.81	2.6
T Aus, HYV irri				3.6
T Aus, HYV n-ir	3.58	3.27	2.69	3.20
Mixed aus/aman	3.13		2.30	
B Aman local dw	1.8	1.73	2.19	1.88
T Aman local dw	2.62			2.40
T Aman, local	2.70	2.25	2.48	2.60
T Aman HYV irri			3.85	
T aman HYV n-ir	3.79	3.83	3.02	3.65
Boro, local	3.71	2.65	2.34	3.00
Boro, HYV irrig	5.60	4.79	4.19	5.40
Boro HYV p-irr				0.00
Wheat irrig.	2.30	1.70	1.65	2.25
Wheat unirrig.	1.99			1.80
Potato irrig.	11.86	15.07	12.61(1)	15.00
Potato unirrig.	11.42	6.63	7.65(1)	10.00
Jute	1.94	1.61	1.72	1.90
ulses: keshari	0.89		0.66	0.70
mung			0.60	
masur	0.45		0.61	0.50
mash	0.75		0.70	
Mustard	0.75	0.90	0.84	0.75
Spices (chilli)	2.62		2.76	4.00
Veg. (brinjal)	10.59		7.19	4.00

Note (1) BBS and DAE potato yields are for HYV and local and not by irrigation status.

In one of the most detailed recent evaluations of a major FCDI project (Thompson 1989), no differences were found in yields for winter crops (mainly boro) and aus between Chandpur Irrigation Project (CIP) and adjacent 'control' areas outside the project boundaries. In summarising the yield impacts of FCDI the following extract from Thompson is particularly relevant:

> "Flood protection appears to be successful in maintaining yields closer to 'normal' in unusual flood years, compared with unprotected areas, but otherwise CIP has not provided an additional benefit over the switch in cropping pattern. That is, yields in a normal year are not higher compared to outside when the same type of paddy is considered. In general this probably reflects levels of input use... fertiliser use for a given crop type is not higher inside CIP compared to outside areas. Thus CIP does not appear to have provided more effective extension services relative to non-project areas, nor has any supposed increase in wealth due to more productive agriculture been reinvested as working capital in an attempt to further increase yields."

This finding is supported by detailed analysis of farmer survey results which did not identify any improvement in yield or associated change in input use for the same crop grown on higher, and therefore less flood-prone, land. Although evaluations of completed projects by FAP 12 has in some cases identified yield improvements inside FCD project areas (see Table J.2.7), it concluded that:

> "in most projects the major impact on weighted mean paddy yields is from farmers switching to more productive types of paddy when hydrological conditions change sufficiently to permit this".

For the purposes of the economic analysis, it has been assumed that for a given crop a single yield value (and level of inputs) is applicable in both the without and with project conditions. The yield figures used have been assumed to allow for normal levels of crop damage due to flooding. Differences in yields between the with and without project cases have been assumed only in cases where flood protection would cause a reduction in the average annual level of crop damage and which are accounted for separately.

Similarly no difference is assumed between present and future yields (with and without the project). There is no evidence that there is an upward trend in the yields of individual crops. Analysis of BBS statistics by IFDC[1] indicate that although have boro yields rose by 0.3% per year from 1973 to 1979, they then declined by 0.4% per year up to 1989, despite increased use of fertiliser. This is attributed to an increasing proportion of the expanding area being grown under less suitable conditions. Boro yields best on heavy soils and these areas were the first to be cultivated with the crop. As boro expands it has in turn pushed wheat, pulses and oilseeds on to more marginal land so their yields have also suffered. Analysis of data on have aman paddy IFDC[2] shows an annual yield decline from 1972 to 1988 of 0.5%. Analysis of yields reported by BBS for the region shows a pattern of static yields for major crops over the last six years. Static and declining yields are also attributed to increasing cropping intensity, reduced flooding (which may add silt and organic matter to the soil, reduced production of pulses and use of animal manure) both of which improve soil structure and fertility.

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[1] Farm Level Fertilizer Use Survey, 1990/1 Rabi/Boro Season, I Jahan, K Sanyal, IFDC, 1993

[2] Farm Level Fertilizer Use Survey, 1989 Aman Season, Sidhu and Ahan, IFDC 1991

TABLE J.2.7

Comparison of Yield Data From different Sources

Tonnes per hectare (rice as paddy)	Farmer survey	FAP 12 (MDIP)		BBS avg. 1989-91	Used in crop budgets
		project	outside		
B Aus, local	2.30	2.08	2.04	1.43	2.00
B Aus, HYB	2.95	3.59		1.53	2.5
T Aus, local	2.51	2.99		2.81	2.6
T Aus, HYV	3.58	4.22		2.69	3.2
Mixed aus/aman	3.13	1.71	1.14		2.3
B Aman local d.w.	1.80	1.87	2.04	2.19	1.88
T Aman, local d.w.	2.62				2.40
TAman, local	2.70	3.31	1.29	2.48	2.6
TAman, HYV	3.79	4.66	2.8	3.02	3.65
Boro, local	3.71	3.15		2.34	3.0
Boro, HYV	5.60	5.04	4.47	4.19	5.4
Wheat irrigated	2.30	1.92	1.98	1.65	2.25
Wheat unirrigated	1.99	1.96	1.98	1.65	1.80
Potato irrigated	11.86	9.52	17.38	11.45	15.00
Potato unirrigated	11.42	9.52	17.38	11.45	11.00
Jute	1.94	1.26	1.02	1.72	1.90
Pulses: keshari	0.89		0.9	0.66	0.70
mung			0.9		0.60
musur	0.45		0.9	0.61	0.50
mash	0.72		0.9	0.00	0.70
Mustard	0.75	0.74	0.49	0.77	0.75
Sugarcane	38.41	32.8		32.64	na
Spicdes (chilli)	2.05	1.21	0.58	2.31	4.00
Veg. (brinjal)	8.01			7.18	8.00

This approach, both for with and without project, and present and future yields, is consistent with the FPCO Guidelines for Project Appraisal.

J.2.10 Crop Budgets

Net economic and financial returns to each of the crops included in the analysis are presented in Table J.2.8. The budgets show that in economic prices the crops which show the highest returns (excluding irrigation costs which are charged separately in the economic analysis) are the high value ones such as vegetables and spices which are likely to be restricted by market constraints and boro, HYV aman, HYV aus and to a lesser extent irrigated wheat. At financial prices returns per hectare are much reduced but as crop ranking is unchanged there is unlikely to be a conflict between farmers' wishes and the national interest. The budget for boro clearly illustrates why farmers are so keen to grow the crop and why minor irrigation has expanded so rapidly in areas with access to surface or groundwater.

Financial returns per hectare for each farm size category are presented in Table J.2.9 (while it is appreciated that per hectare returns for each farm size category are meaningless, it does enable comparisons to be made) These differ from the financial budgets in Table J.2.9 in that only cash costs are included. In these budgets net returns are determined by how much labour is provided by the farmers' family which decreases with farm size as a percentage of the total on one hand and what proportion of land preparation costs have to be purchased which increases with farm size on the other. Analysis of the farmers and case study surveys suggests that farmers hire labour and draught power in the following proportions (of the total requirement):

Farm size	Marginal	Small	Medium	Large
Draught power	0.63	0.38	0.13	0
Labour	0.05	0.40	0.75	0.9

Neither financial or economic crop budgets have included any allowances for interest charges on seasonal credit as the farm surveys (case studies) clearly indicated that very few farmers borrow from either informal or formal sources for this purpose. In addition the 10% allowance included for miscellaneous costs in accordance with FPCO guidelines is sufficient to cover the amount of credit that farmers do require.

TABLE J.2.8

Gross Income, Costs and Net Income per Hectare (Taka)

1992 Financial Prices	Gross Income			Production Costs						Net
Crop	Main Crop	By-Product	Total	Labour	Draught	Seed	Irrig.	Fert.& Pest.	Total	Income
B Aus, local	12340	2000	14340	6106	2565	787		1131	11648	2692
B Aus, HYV	15425	1250	16675	6235	2565	787		1131	11790	4885
T Aus, local	15425	2500	17925	6665	2679	278		950	11629	6296
T Aus, HYV irri	22212	1800	24012	7783	2679	278	1436	2176	15787	8225
T Aus, HYV n-ir	19744	1600	21344	7611	2679	278		2176	14018	7326
Mixed aus/aman	17181	1150	18331	7108	2508	930		790	12470	5861
B Aman local dw	14069	942	15010	4761	2508	930		328	9380	5630
T Aman local dw	17928	1200	19128	5762	2280	493		728	10190	8938
T Aman, local	19422	2600	22022	6278	2280	493		1176	11250	10772
T Aman HYV irri	28760	1925	30685	7332	2451	336		2347	13712	16972
T Aman HYV n-ir	27266	1825	29091	7160	2451	336	1077	2347	14707	14383
Boro, local	18570	3000	21570	5160	1425	371	2205	673	10818	10752
Boro, HYV irrig	33426	2700	36126	9202	2565	278	4410	3157	21574	14552
Boro HYV p-irr.										
Wheat irrig.	16155	1125	17280	5461	2565	1404	2274	1580	14613	2667
Wheat unirrig.	12924	900	13824	4369	2565	1404		1125	10409	3415
Potato irrig.	62400	0	62400	8342	2508	10000	3111	6050	33012	29388
Potato unirrig.	41600	0	41600	7525	2508	10000		5550	28141	13459
Jute	14573	4218	18791	9224	2565	198		1243	14552	4239
Pulses: ave.	10129	956	11084	2150	1710	744		0	5065	6019
Mustard	9953	173	10125	2473	2109	190		2669	8184	1941
Spices (chilli)	33600	0	33600	6751	1710	600		2796	13042	20558
Veg. (brinjal)	30320	0	30320	11610	2508	175		1672	17561	12759
Economic prices										
B Aus, local	10859	1740	12599	4260	1566	693		1324	8626	3973
B Aus, HYV	13574	1088	14662	4350	1566	693		1324	8725	5936
T Aus, local	13574	2175	15749	4650	1636	244		1098	8391	7358
T Aus, HYV irri	22049	1566	23615	5430	1636	244		2603	10905	12711
T Aus, HYV n-ir	19599	1392	20991	5310	1636	244		2603	10773	10219
Mixed aus/aman	14087	1001	15088	4959	1531	763		959	9033	6055
B Aman local dw	11535	819	12354	3322	1531	763		352	6563	5791
T Aman local dw	14700	1044	15744	4020	1392	404		856	7340	8404
T Aman, local	15924	2262	18186	4380	1392	404		1402	8336	9850
T Aman HYV irri	23580	1675	25255	5115	1496	276		2686	10531	14725
T Aman HYV n-ir	22356	1588	23943	4995	1496	276		2686	10399	13545
Boro, local	15550	2610	18160	3600	870	311		755	6090	12070
Boro, HYV irrig	27989	2349	30338	6420	1566	233		3754	13171	17168
Boro HYV p-irr.										
Wheat irrig.	21157	979	22136	3810	1566	1835		1918	10041	12095
Wheat unirrig.	16926	783	17709	3048	1566	1835		1339	8566	9143
Potato irrig.	53375	0	53375	5820	1531	8265		7033	24914	28461
Potato unirrig.	35583	0	35583	5250	1531	8265		6598	23808	11775
Jute	15991	3670	19661	6435	1566	210		1494	10676	8985
Pulses: ave.	8301	831	9133	1500	1044	647		0	3511	5622
Mustard	9194	150	9344	1725	1288	167		3252	7075	2269
Spices (chilli)	26587	0	26587	4710	1044	522		3488	10740	15847
Veg. (brinjal)	25961	0	25961	8100	1531	174		1914	12891	13069

Calculation of wieghted average for pulse budget — GUMTI

	Total area of sampled plots in farmer surveys ha.	%	Percent weight		Market price Tk/kg 1991	Tk/kg 1992	Yield t/ha
Keshari (lathyrus)	7.27	41.6%	43.4%		12.63	12.31	0.70
Masur (lentil)	5.28	30.2%	31.5%		20.48	21.89	0.50
Chola (chick pea)	0.22	1.3%					
Mung (greem gram)	0.00	0.0%					
Mash (black gram)	4.19	24.0%	25.0%		12.11	14.57	0.70
Barbati (cowpea)	0.51	2.9%					
Other pulses	0.04	0.2%					
total	17.46	100.0%	100.0%	weighted ave.	14.98	15.90	0.64

TABLE J.2.9

Financial Crop Budgets

Crop	Marginal Farmers Labour & power	Others	Cash Co:	Interest	MIscellan Costs	Total Costs	Return per ha	Return per day	Small Farmers Labour & power	Others	Cash Co:	Interest	MIscellan Costs	Total Costs	Return per ha	Return per day
B Aus, local	3159	1288	4447	0	445	4892	9448	88	4051	1288	5340	0	534	5874	8466	101
B Aus, HYV	3167	1288	4456	0	446	4901	11774	106	4113	1288	5401	0	540	5941	10734	125
T Aus, local	3318	1005	4324	0	432	4756	13169	111	4225	1005	5231	0	523	5754	12171	129
T Aus, HYV irri	3392	3667	7060	0	706	7766	16246	113	5595	3667	9262	0	926	10188	13824	144
T Aus, HYV n-ir	3381	2231	5612	0	561	6174	15170	108	5494	2231	7726	0	773	8498	12846	137
Mixed aus/aman	3164	976	4140	0	414	4554	13777	105	5448	976	6424	0	642	7067	11264	137
B Aman local dw	3009	514	3523	0	352	3875	11135	141	3955	514	4469	0	447	4916	10094	187
T Aman local dw	2830	827	3657	0	366	4023	15105	146	3823	827	4650	0	465	5115	14013	179
T Aman, local	2864	1274	4139	0	414	4553	17469	152	4076	1274	5351	0	535	5886	16136	188
T Aman HYV irri	3118	2414	5532	0	553	6085	24600	181	5487	2414	7901	0	790	8692	21993	254
T Aman HYV n-ir	3106	3491	6597	0	660	7257	21834	165	5380	3491	8871	0	887	9758	19332	229
Boro, local	1872	2953	4825	0	482	5307	16263	164	3392	2953	6345	0	634	6979	14591	216
Boro, HYV irrig	3364	7623	10987	0	1099	12086	24040	136	7120	7623	14743	0	1474	16217	19909	195
Wheat irrig.	3116	4135	7251	0	725	7976	9304	99	3913	4135	8048	0	805	8853	8427	118
Wheat unirrig.	3044	1405	4449	0	445	4894	8930	128	3348	1405	4754	0	475	5229	8595	154
Potato irrig.	3246	11161	14407	0	1441	15847	46553	295	5663	11161	16824	0	1682	18506	43894	409
Potato unirrig.	3192	7550	10741	0	1074	11815	29785	213	5208	7550	12758	0	1276	14034	27566	286
Jute	3366	1282	4648	0	465	5112	13679	77	5858	1282	7140	0	714	7854	10937	88
Pulses: ave.	1979	149	2127	0	213	2340	8744	296	1373	149	1522	0	152	1674	9411	273
Mustard	2428	2707	5135	0	514	5649	4476	138	1859	2707	4566	0	457	5023	5102	144
Spices (chilli)	2284	2916	5199	0	520	5719	27881	213	4296	2916	7211	0	721	7932	25668	284
Veg. (brinjal)	3462	1707	5169	0	517	5686	24634	107	5823	1707	7529	0	753	8282	22038	122

Crop	Medium Farmers Labour & power	Others	Cash Co:	Interest	MIscellan Costs	Total Costs	Return per ha	Return per day	Large Farmers Labour & power	Others	Cash Co:	Interest	MIscellan Costs	Total Costs	Return per ha	Return per day
B Aus, local	4776	1288	6064	0	606	6671	7669	122	4976	1288	6265	0	626	6891	7449	136
B Aus, HYV	4868	1288	6156	0	616	6772	9903	155	5130	1288	6418	0	642	7060	9615	175
T Aus, local	4939	1005	5945	0	594	6539	11386	156	5540	1005	6546	0	655	7200	10725	186
T Aus, HYV irri	7190	3667	10858	0	1086	11943	12069	203	6874	3667	10541	0	1054	11596	12416	206
T Aus, HYV n-ir	7040	2231	9271	0	927	10198	11146	192	6669	2231	8900	0	890	9790	11554	193
Mixed aus/aman	7121	976	8097	0	810	8907	9424	211	6223	976	7199	0	720	7918	10413	186
B Aman local dw	4881	514	5395	0	540	5935	9076	309	3423	514	3937	0	394	4330	10680	211
T Aman local dw	4595	827	5422	0	542	5964	13164	230	4822	827	5649	0	565	6214	12914	261
T Aman, local	4974	1274	6249	0	625	6874	15148	242	5438	1274	6712	0	671	7383	14639	289
T Aman HYV irri	7186	2414	9600	0	960	10560	20125	414	6541	2414	8955	0	895	9850	20834	374
T Aman HYV n-ir	7025	3491	10516	0	1052	11568	17523	369	6336	3491	9826	0	983	10809	18281	330
Boro, local	4418	2953	7370	0	737	8107	13463	300	4874	2953	7826	0	783	8609	12961	376
Boro, HYV irrig	9661	7623	17284	0	1728	19013	17113	350	8670	7623	16293	0	1629	17922	18204	294
Wheat irrig.	4625	4135	8760	0	876	9636	7644	152	4207	4135	8342	0	834	9176	8104	152
Wheat unirrig.	3778	1405	5183	0	518	5701	8123	204	2904	1405	4309	0	431	4740	9084	179
Potato irrig.	7333	11161	18494	0	1849	20343	42057	604	7695	11161	18856	0	1886	20741	41659	706
Potato unirrig.	6651	7550	14200	0	1420	15620	25980	415	6720	7550	14270	0	1427	15697	25903	454
Jute	7542	1282	8825	0	882	9707	9084	105	8695	1282	9977	0	998	10975	7816	126
Pulses: ave.	902	149	1051	0	105	1156	9928	267	1026	149	1175	0	118	1293	9792	306
Mustard	1517	2707	4224	0	422	4646	5479	159	1052	2707	3759	0	376	4134	5991	153
Spices (chilli)	5626	2916	8542	0	854	9396	24204	395	6515	2916	9431	0	943	10374	23226	544
Veg. (brinjal)	7351	1707	9057	0	906	9963	20357	140	11594	1707	13300	0	1330	14630	15690	236

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Models for Analysis of Incremental Crop Production cropping patterns have been developed for each option and zone within the project area using the methodology described above. Net crop income (excluding on farm irrigation costs) has been calculated for the areas of each crop grown in the present, future without and future with project situations by multiplying areas and net economic returns per hectare. The analysis has been carried out for the following cases :

1) Present (1994 in 1991 prices)

2) Future without (1) : without project conditions in the year in which full benefits would have been achieved in the with project case, generally taken to be year 10.

3) Future without (2): without project conditions in Year 30 (the final year of the analysis period).

4) Future with (1): with project conditions in Year 10

5) Future with (2): with project conditions in Year 30

For projects in which groundwater development is expected to reach its maximum potential within 10 years future without (1) and (2) are identical.

On farm irrigation costs are calculated on the basis of predicted proportions by mode (ie STW, LLP etc) of irrigation.

J.2.11 Phasing of Incremental Benefits

Incremental benefits are phased to reach their maximum 5 years after project completion in line with FPCO recommendations.

J.2.12 Methodology for Estimating Impacts on Fisheries

The main potential impacts of FCD and FCDI projects on fisheries can be summarised as follows :

Negative impacts

(i) Construction of flood control embankments and/or drainage works reduces the area of floodplain available for fish spawning, nursery and feeding grounds, reducing overall fish production potential both within and outside the FCD area. Within the area, this affects not only the capture fishery but also pond culture fishery, which depends partly on the collection of fish fry from the wild.

(ii) Construction of regulators or cross dams on rivers prevents migration of fish to and from breeding grounds, resulting in reduced stocks of affected species both within and outside specific project areas; within FCD areas, the result will be a change in the species composition, with the migratory species (principally higher value carp and prawns) being displaced by resident (generally lower value)fish species.

(iii) Access to the reduced areas of open waters within FCD schemes for the purpose of 'subsistence' fishing may be restricted, with detrimental consequences for nutrition, particularly of the poorest sections of the community who obtain a significant part of their animal protein and vitamin intake from fish caught in 'common property' waters.

(iv) Increased use of chemical fertilisers and pesticides, resulting mainly from the extension of the area of irrigated high yielding crop varieties within flood controlled areas, accelerates the contamination of natural water bodies and may lead to higher fish mortality rates.

(v) Reductions in fish stocks endangers the livelihood of professional full time fishermen, who may be obliged either to emigrate from the area or to seek employment as unskilled labourers.

Positive impacts

(vi) Improved water control reduces the risk of loss of stocks in fish ponds due to flooding, and may thereby encourage a more rapid development of fish farming, subject to availability of fish and/or shrimp fry - see (i) above. Benefits will, however, accrue mainly to land owners with adequate areas for fish ponds rather than to displaced capture fishermen or other poorer groups.

(vii) Improved control similarly improves the prospective returns from stocking and management of fish production in other water bodies such as canals and borrow pits.

Quantification of any of these impacts is subject to a high degree of uncertainty, due to:

- an absence of reliable data on current fish resources (species composition, standing stocks, etc.)
- inadequate information on present fish catches (quantities by species from different water bodies) and past trends in catches.
- limited data on catch rates achieved by different categories of fishermen (full-time, part-time or subsistence).
- inadequate information on the numbers, locations, status (cultivated or uncultivated) and yields of ponds.
- limited experience of the actual impacts of FCD schemes on the fisheries resource.

Impacts on Capture Fisheries Production

Losses of output of capture fisheries are assumed to be caused by:

- obstruction of fish irrigation and spawn by the construction of embankments and regulators
- reduction in the area of floodplains and in the duration of flooding

Reducing the area of floodplain is expected to result in a straightforward decline in their productivity in direct proportion to their loss. Obstructing migration of fish and spawn is expected to result in a change of the catch composition with substantial losses of the higher value fish species which are generally migratory.

To assess the economic impact of FCD it is necessary to:

- value the catch in terms of potential sales by fishermen.

- calculate the cost of catching in terms of gear cost and fishermen's time

Surveys by FAP 17 show that fishermen receive about 69% of the market prices for fish. Surveys in the project area collected the following data on fish catch and market prices which are corrected to fishermen's prices by deducting 31%.

	Tonnage	Market Price	Fishermen's Price
High value fish	3825	Tk 58 / kg	40.02
Medium value fish	4443	Tk 39 / kg	26.91
Low value fish	12037	Tk 27 / kg	18.63
	20305	Weighted average 24.5	

Obstruction of migratory passage reduces the value of the catch by reducing the proportion of high value carp in the catch.

Weighted average fish catch value per kg is reduced as follows when there is a :

100% reduction in high value fish	Tk 20.86 / kg
75% reduction in high value fish	Tk 21.91 / kg
50% reduction in high value fish	Tk 22.85 / kg

The cost of catching has been estimated as Tk 30 for one day of labour plus Tk 10 per day for gear with a daily catch of 3 kg. In fact most fishermen are self employed and the Tk 30 represents a low season agricultural wage (being lower than the Tk 43 used in crop budgets). It would be argued that a lower figure than Tk 30 should be used as fishermen have few alternative sources of income but it could also be said that a catch of 3 kg per day is on the high side. A catch of 2 kg and a wage of Tk 20 per day would result in a similar cost per kg of fish. As the yield potential of the floodplain falls, the amount of time needed to catch the remaining fish will increase; daily catches will decline and costs per kg fish caught will rise.

The net value of fisheries has been calculated as the ex-boat production value less the cost of catching. This has been converted into economic prices using the SCF of 0.87 for fish and gear, and labour conversion factor of 0.75. The net value of the fishery can fall below zero if average daily catches are worth less than the Tk 30 nominal wage plus Tk 10 gear cost - in this case fishermen's income falls below Tk 30. Losses of net benefits from the more productive fisheries will be split between fishermen and lessors of jalmahals, (controlled fishing grounds) who will be able to extract less rent from fishermen to the point where it is no longer worthwhile to enforce their fishing rights.

At economic prices the net value of fish after deducting catching costs declines rapidly as both catching costs increase and the proportion of high value fish is reduced.

Assuming a catch of 3 kg per day catching costs at economic prices are Tk 10.4 / kg. With a catch of 2.5 kg /day. Catching costs increase to Tk 12.4 per kg. Thus the net value of fish is calculated as follows:

Financial Price Tk/kg	Economic Price Tk/kg	Catch per day kg	Net Value **Tk/kg**
24.5	21.32	3	10.92
24.5	21.32	2.5	8.92
22.85	19.88	2.5	7.40
21.91	19.06	2.5	6.58
20.86	18.15	2.5	5.75

J.2.13 Crop Damage Due to Flooding

Crop damage statistics have been collected from both DAE and BBS thana offices for the years 1987 to 1992. Figures were provided for both planted and damaged areas where damaged areas are converted into totally destroyed areas of crops. Percentage losses were calculated on this basis for the years 1987, 88 and 89 which happen to represent a 1 in 20,k 1 in 50 and 1 in 6 to 10 monsoon flood (based on maximum water levels).

As damage was either zero or negligible in 1989, this was used as the base year, and the assumption made that flood damage is zero in a one in five wet year.

This on the basis of probabilities of 0.8 (1 in 5) 0.95 (1 in 20) and 0.98 (1 in 50) average annual expectations of damage were estimated. Calculating averages on this basis is likely to overestimate the annual expected damage as the shape of the curve is concave. However the overestimate should not be large given that there are three points on the curve between the probability of non-exceedance of 0.8 0.95 and 0.98. It is unlikely to exceed 5 per cent which is easily covered by the range of sensitivity tests. The percentages of planted areas lost are presented in Table J.2.10.

Flash flood damage is far more difficult to estimate as there is little reliable evidence with which to assess the return period of a particular flood. In general it has been assumed that flash floods which occur between July and October will be absorbed by the monsoon flood with little or no impact. Only those that occur between February and June are likely to cause damage.

Analysis of flows in the River Gumti suggest that damaging flash floods occur on average every three years. Records are insufficient to estimate their return periods, but as that field investigations have not revealed any areas in Zones A or B where boro is not planted for fear of flash floods it may be concluded that they are not annual events and that once in three years may not be unrealistic. Damage caused by flash floods has been obtained from thana offices but is not very convincing.

ΦB

TABLE J.2.10

Crop Damage : Percentage of Planted Area Lost

		Aus	B Aman	T Aman	Jute
Zone A	1987/88	6.5	0	10.1	0
(Brahmanpara)	1988/90	54	53	72	47
Burichang	1989/90	0	0	0	0
Debidwar	Annual Expectation	2.6	2.4	3.5	2.1
Zone B	1987/88	0	7.5	4	0
(Kasba)	1988/89	74	50	49.6	0
	1989/90	0	0	0	0
	Annual Expectation	3.3	2.5	2.4	0
Zone C	1987/88	0	2.1	0.3	0
(Nabinagar)	1988/89	52.1	46.7	48	45.5
	1989/90	0	0	0	0
	Annual Expectation	2.3	2.2	2.2	2.0
Zone A	1987/88	5.7	0	8	0
(Au)	1988/89	46.8	48	70	40
	1989/90	0	0	0	0
	Annual Expectation	2.2	2.2	3.4	1.8
Zone B	1987/88	0	7.5	6.5	0
(au)	1988/89	74	50	48.0	9.2
	1989/90	0	0	3.3	0
	Annual Expectation	3.3	2.5	2.1	0.4
Zone C	1989/88	2.8	1.5	26.9	1
(au)	1988/89	55.3	40	53.2	36.5
	1989/90	0	0	0	0
	Annual Expectation	2.6	1.8	3.2	17
Zone D	1987/88	15	11.5	4	9
(au)	1988/89	35.5	46.5	70	10.3
	1989/90	0	0	0	0
	Annual Expectation	2.0	2.4	3.3	0.7
Weighted Average		2.5	2.2	3.1	1.2

Percentage of Crop Area Destroyed

Thana Name	1987/88	1988/89	1989/90	1990/97	1991/92	1992/93
Brahmanpara	-	-	4.35	4.15	-	40
Burichang			1.2	4.8		40
Debidwar						20
Kasba		5.0			17.6	na
Akhaura	2.7		3.3	-	-	na

In May 1993 extremely heavy flash flooding (perhaps the worst flash floods for the last 20 years) occurred and estimates of the damage done range from 40 - 60% for Brahmanpara and Burichang if the following assumptions are made,

Probability of occurrence	0.67	0.75	0.98
	% damage inflicted		
Brahmanpara	0	5	40
Burichang	0	5	40
Debidwar	0	0	20

the annual expectation of damage is 4.6%, which is probably too high. Allowing for the concave shape of the curve flash flood damage has been taken to be 4.0% in Zone A and 3% in Zone B (the proposed polder in Zone B is on higher ground than much of the remainder of the zone and consequently less easily damaged).

J.2.14 Non Agricultural Flood Damage

Damage (or estimated costs of repair) to roads Government Property, schools markets and religious buildings was collected from the office of the Thana Engineer. In general the estimates were so enormous that they had to be evaluated by the project architect and engineering staff before they could be used. Figures for 1987 and 1988 were used on the basis that no damage to infrastructure would occur at less than a 1 in 10 year flood. The results are depressed in terms of damage per hectare of cultivated land and are presented below:

Zone	A	Brahmanpara |	Tk 24 /ha/year
		Burichang |	
		Debidwar |	
Zone	B	Kasba	Tk 36 /ha/year
Zone	C	Nabinagar	Tk 55 /ha/year
Zone	A	Complete	Tk 35 /ha/year
	B	Complete	Tk 46 /ha/year
	C	Complete	Tk 63 /ha/year
	D	Complete	Tk 151 /ha/year
Whole Project			Tk 81 /ha/year

Damage to housing was estimated using information collected in the farmer and landless surveys, which demonstrated that damage to housing is as might be expected, restricted to severe and quite rare floods. In order to verify this, topographic levels of homestead areas were obtained for a sample of villages within each zone and compared with peak water levels measured at Daudkandi, Akhaura, Comilla and Nabinagar. This demonstrated quite conclusively that houses are flood proofed to between a one in ten and one in 20 year flood. Damage statistics obtained from the surveys for the 1988 flood were then used to assess the damage. Costs of repairing houses are based on costs on Jamalpur Priority Project flood proofing which estimated the total cost at Tk 10000 per house. For the purposes of this study, only those items which are expected to be destroyed in a flood have been included and these (including labour for reconstruction) sum to Tk 4000. Assuming that half of all houses have completed 50% of their expected life and that a 20% quality discount is appropriate, this gives an overall figure of Tk 1600 per house. Costs for repairing major damage to housing are estimated at Tk 1000 per house while minor damage is costed at Tk 200 per houses.

Assuming that no damage occurs up to a one in ten year flood, costs of damage to housing was calculated on the basis of the number of houses within each zone and the damage statistics collected in the survey. The results an expressed in Tk per cultivated hectare in financial prices.

Zone	A	Tk	66 /ha/year
Zone	B	Tk	80 /ha/year
Zone	C	Tk	90 /ha/year
Zone	D	Tk	97 /ha/year

Livestock Losses

Estimates of livestock losses are based on losses per household obtained from the farmer and landless questionnaire. Assuming that no livestock will be lost in less than a one in twenty year flood (on the grounds that it will only be when their owners are sufficiently preoccupied with ensuring their own safety that they will be prepared to lose their livestock) then estimating annual livestock losses is straightforward. These expressed in terms of Tk per cultivated hectare.

Zone	A	Tk	13 /ha/year
Zone	B	Tk	11 /ha/year
Zone	C	Tk	13 /ha/year
Zone	D	Tk	9 /ha/year

Fishpond Losses

Fishpond losses are assessed as a percentage of lost production which is then applied to total fish pond production in the area in question. This involved the assumption that no losses will occur up to one in ten year flood, and that the one in fifty year damage is represented by the responses for losses in 1988 obtained from the culture fisherman' questionnaire. Annual damage levels were reduced by 20% to allow for the concave shape of the curve, given that the losses so calculated are still high in comparison with housing and livestock. It is also not clear why fish farmers, if they really face this level of loss, do not take more precautions to floodproof their ponds, by erecting bamboo fencing on top of the bank is to prevent the fish escaping of the pond is overtopped.

Annual expectations of loss thus calculated are:

Zone	A	1.3%
	B	2.0%
	C	2.8%
	D	2.3%

For the purposes of evaluating the loss pond fish are valued at Tk 35/kg (Tk 40 less Tk 5 for catching) in financial prices. Production figures for culture fishers are given in Annex F.

J.3 Development Proposals

J.3.1 Zones A and B: Controlled Flooding

Zones A and B have been combined because proposals for their development share common costs of river excavation which are essential for the implementation of projects in either zone but which if undertaken independently would seriously reduce returns. Proposals for Zones A and B are illustrated in Figure J.3.1, where it can be seen that three polders (shaded areas 1B, 2 and 3) were initially considered. Output from the hydro-dynamic model showed very little agricultural benefit was achieved in the smaller northern scheme (no 3 in Figure J.3.1) because the topography of the area is relatively low and it would not drain rainfall adequately under gravity. As a result this proposal was abandoned.

Design of the remaining two embankments was based on making maximum use of existing road embankments.

Zone A Design Considerations

The initial model run showed that the peak water level in the unprotected area, to the east of Gunghur River, rose by approximately 0.8 m when the Ghungur right embankment was in place. Further runs showed that if controlled discharge (40% of peak flow) was allowed into the protected area then this would reduce the additional rise but would also adversely affect the agricultural benefits caused by the embankment.

However, excavation of the Salda and Buri Nadi showed a considerable mitigation. With no discharge entering the protected area of Zone A, the peak (1987 and 1988) water levels showed an increase of only 30 cm. If a very severe flood did occur and the villages in the unprotected were being threatened, then opening Ghungur embankment gates would further reduce the water level by 10 cm. As the villages in the area are not particularly flood prone at the moment, it is unlikely that the additional rise will cause significant problems.

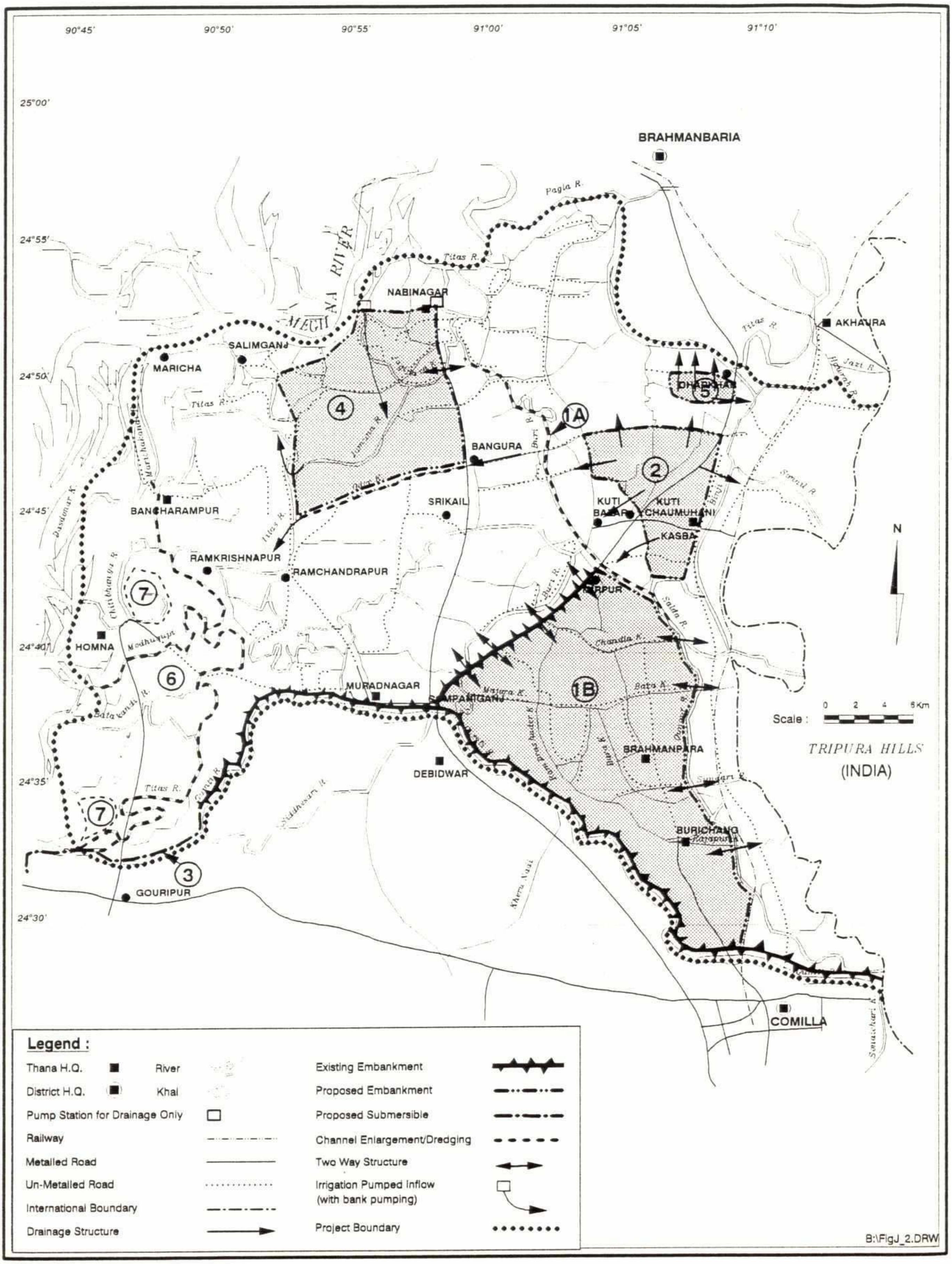
The model also showed that the flood phasing in the unprotected area is a little worse, affecting about 8% of the area of aman. However, because the additional excavation has such a significant effect on pre-monsoon flows, there appears to be no additional damage to the boro crop.

In addition to the Ghungur right bank, the proposal for Zone A included a left bank along the Salda River, up to the Comilla-Sylhet road. In order to protect the whole zone from monsoon floods, it was also proposed to seal the Comilla-Sylhet road to form the north-west boundary. Four regulators will replace road structures so that the area may be effectively drained. Also, the khals within the protected area leading to the regulators are to be re-excavated.

In order to minimise khal and floodplain fisheries losses, the regulators under the Comilla-Sylhet road will be fish friendly.

Figure J.3.1

Layout of Developments



Zone B Design Considerations

Model runs showed large improvements in the poldered area of Zone B. The main reason for this is that the polder encircles an area of relatively high ground which facilitates gravity drainage of rainfall and which is much improved by the excavation of the Buri Nadi River. The excavation of the Buri Nadi will also provide an additional benefit. At present, in a 1 in 5 dry year LLP irrigation can take place in the river up to 5 km south of Nabinagar. With the proposed excavation, an additional 12 km of river will support irrigation in a 1 in 5 dry year, serving an additional 2400 ha of LLP irrigation.

J.3.2 Zone C Proposals

The initial proposal for Zone C was to have two embanked schemes either side of the Oder Khal, each with pumped irrigation supply to the khal and river network. A distribution canal, along the line of borrow pits for the Muradnagar-Nabinagar road, was to be excavated. Also, re-excavation was required in the existing khals.

The hydraulic model runs showed that in the present situation, pre-monsoon flow generated in the Tripura hills flowed into the Buri Nadi, which conveyed it north into the Titas River, by Nabinagar. When the monsoon arrived, water levels in the Titas backed up, with the rise of the Meghna levels. Instead of going north, the direction of flow changed to the west, passing through the khal and floodplain system north of Muradnagar to discharge into the Meghna between Homna and Daudkandi.

By effectively blocking this route with the southern embankment scheme, the water was restricted to flowing through the Oder khal. This caused congestion which had an adverse effect on the area to the east of the Muradnagar-Nabinagar road, including drainage from the schemes in Zones A and B.

These adverse effects meant that the southern embankment had to be abandoned. Model runs without the southern embankment, but with the khal excavation, brought the water levels back to the without project situation.

The proposed intervention for Zone C therefore consists of an embankment for the northern area with 8 cumecs of pumped irrigation to the northern area and 14 cumecs for the southern area. Both of the pump stations will be reversible and both pump stations will be used for pumped drainage of the northern embankment. Because the full 22 cumec capacity will be used for the 8800 ha protected area, the percentage of F0 land will increase from 7% to 73%, which will give a very large rise in the amount of T aman which could be grown. The disadvantage will be the impact on floodplain fisheries in the area.

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J.3.3 Zone D Proposals

Khal Re-excavation

The most effective intervention for the Gumti Phase II area is re-excavation of khals in Zone D. This intervention can be carried out with no negative effect. This is because fisheries will incur no floodplain losses but will achieve some gains. Also, drainage of the area will be improved. Maintenance costs will not be so high because of the sediment content of the Meghna is relatively low.

The proposed location for khal excavation is given in Figure J.3.1. At present, about 4000 ha can be irrigated by LLP during a 1 in 5 dry year. This value will increase to 14000 ha with the recommended re-excavation. It should be noted that farmers are generally willing to invest in LLPs even if the guaranteed availability is less than a 1 in 5 year return period. The present and future areas are therefore likely to be greater than 4000 and 14000 ha, respectively, with a greater element of risk involved.

At present, JICA is carrying out khal excavation in the area, however, the scale of their proposed work is small compared to the proposed requirements.

Extension to Gumti North Embankment

Figure J.3.1 shows a small embankment is to be constructed between the existing embankment on the north side of Gumti River and Gouripur. The purpose of this embankment is to prevent flash floods from affecting the boro crops of the area between the Gouripur-Homna road and the River Gumti. A small (submersible) embankment has been selected as it is not considered worthwhile to protect the area against monsoon floods, when high monsoon water levels will come from the Meghna River anyway. After the month of June, the Meghna related water levels will rise in the Gumti and Titas Rivers, so the embankment will be submerged.

In addition to protecting the area from flash flooding in the boro season the embankment will also prevent sand from coming into the area, thereby reducing the required maintenance cost for re-excavation the lower titas river in the area. The model is not sophisticated or accurate enough to predict the effect downstream of Gouripur. It is expected that flooding which occurs now will not be significantly worse than at present. It will be very difficult to justify extending the embankment from Gouripur to the River Meghna as this would have to include a large structure at the Lower Titas outfall to the River Gumti, which would be extremely expensive.

Submersible Embankment Schemes

Two submersible embankment schemes were initially proposed. The effect of these embankment schemes are analysed in detail in Annex I, Appendix I.V.

It was concluded that it was not possible to include a fish gate in the design because any viable fish gate would let an unacceptable amount of water into the protected area before the boro crop could be harvested. As a result, submersible embankments are expected to cause fish losses of up to 50% of present production because access to both fish and spawn would be stopped in the months of April and May (evidence of such large losses were obtained from the existing Satdona Beel scheme).

A further disadvantage of the concept was that when water is allowed into the protected area, the rate of rise of water level is much higher (10 cm per day) than the normal Meghna level rise (5 cm per day). This means that only extra fast growing but inferior yielding varieties of deepwater aman can be grown.

Field visits to the proposed sites confirmed that submersible embankments were unlikely to be cost effective, mainly because farmers are already aware of the threat to their boro crop and endeavour to plant as early as possible, which in most years allows them to harvest before the flood. They also expressed little interest in planting deepwater rice after boro, arguing that the time available for land preparation and seeding would be insufficient and that any delay in planting would not give the plants enough time to establish themselves sufficiently well to withstand the rapid rise in water levels which the plants would experience when the embankment started to fill.

J.3.4 Full Area FCD Proposal

The FCD proposal is illustrated in Figure J.3.2. It was designed during the 1990 feasibility study from which the following description is quoted.

The emphasis has been on the minimum cost solution to the problem of flooding from the major rivers in Bangladesh and the minor rivers crossing the border from India. With the exception of the Salda/Buri Nadi channel and the side drains to east and west of the Buri embankments, no attempt has been made to improve the internal drainage of the area, it being considered that such actions would merely transfer the flooding from one area to another, with little or no overall benefit. However, large drainage channels to convey the runoff from the Tripura Hills in India to the Homna regulator have been included, as there would otherwise be unacceptable waterlogging in the Burichang and Brahmanpara areas.

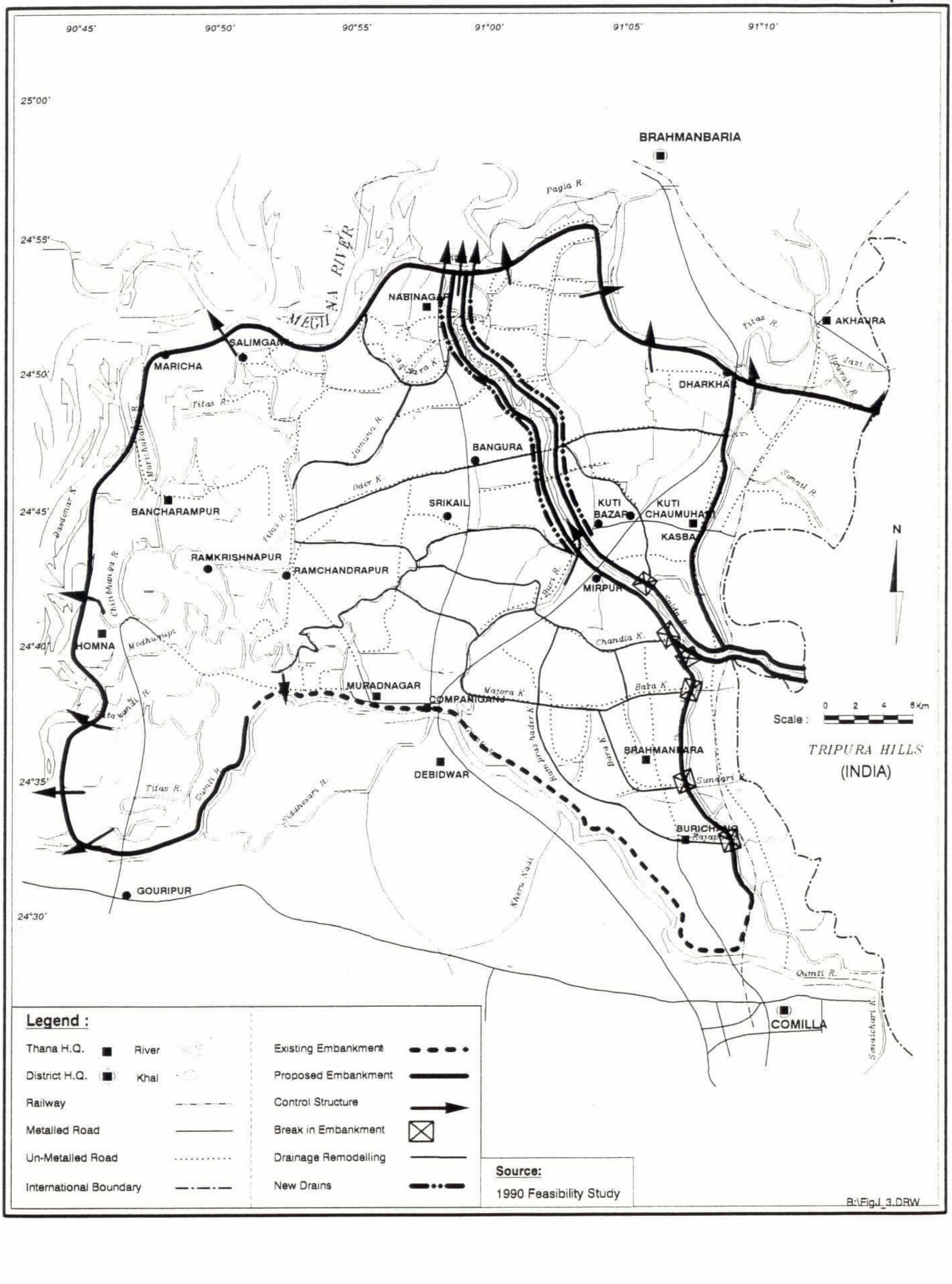
The peripheral embankment, from its junction with the Gumti river embankment at Paniatan in the south west to the Indian border in the north east, follows the alignment originally selected for the FCDI proposals. There is no reason to change this line, which was chosen on the basis of enclosing the maximum practicable area without making the embankments excessively high; the exclusion of the Hawrah river area from the polder was agreed with the BWDB, as there are severe problems of flooding on the Indian side of the border which would be exacerbated by empolderment - the area is also covered by a small schemes project.

As in the case of the FCDI scheme, the Salda and Buri channel is embanked from the high ground to the east of the railway line to the junction with the Pagla (Titas) river immediately to the north of Nabinagar town. Two further embankments, on the left (western) banks of Ghungur and Bijni rivers, complete the major earthworks proposed in this scheme. In case of the Ghungur embankment, the intention is to control the flood waters of the cross border rivers and thus reduce the flood peaks and water levels in the areas to the west. The Bijni embankment, which follows the road alignment from the Salda to the peripheral embankment, directs all the water crossing the border to the large regulator at the junction of the Bijni with the Titas.

There are a number of regulators in the peripheral embankment, many of which are designed as flushing sluices; that is, they will admit water for irrigation in the dry season, as well as draining the area in the post monsoon period. Especially large regulators are provided on the Chitibhanga River at Homna, to both polders and the Buri Nadi at Nabinagar, and on the Bijni River.

Figure J.3.2

FCD Proposal



There are three further structures; a navigation lock at Homna, to provide access for the existing river traffic, and two regulators/ flushing sluices linking the southern arm of the Buri to the embanked Salda/ Buri channel and in the Ghungur to the Salda.

A metalled road will be built from Homna via Nabinagar to Batmatha along the crest of the embankment. At Batmatha it will join the Comilla-Sylhet road. No other metalled roads are proposed, but it is anticipated that the embankments will be used as unmetalled tracks - and may eventually be improved, if traffic warrants it.

J.3.5 The Full Area FCDI Proposal

The FCDI alternative is illustrated in Figure J.3.3.

This proposal is for a comprehensive development of the area for both irrigation and drainage. The intention is to provide irrigation to all the irrigable land from either the surface water supplies, using LLP's, or from tubewells. Drainage pumping by the pumps installed for irrigation produces further benefits attributable to the project.

The main differences between this proposal and that for FCD are the installation of the four primary and five secondary pump stations, improved internal drainage, numerous controls on the channels to retain water levels in the dry season and additional roads, mainly to provide better access to the major structures.

The primary pump stations will be:

(a) Mohanpur, serving a low lying area of about 5,000 ha in the south west corner of the project.

(b) Homna, irrigating an area of about 53,500 ha in the west of the project and, with Nabinagar West, draining 103,000 ha.

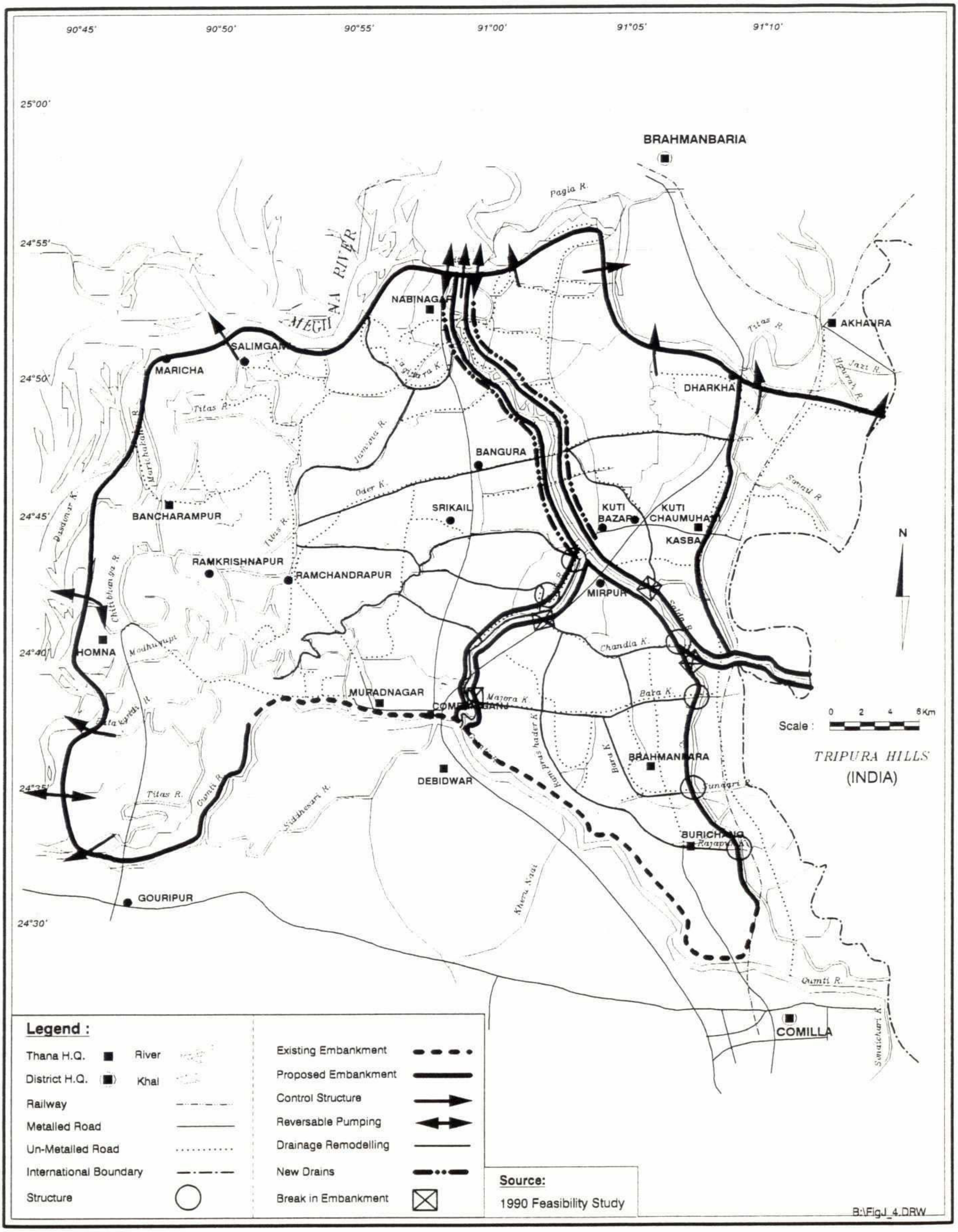
(c) Nabinagar West, providing irrigating water, with Nabinagar East, to the remainder of the project and, with Homna, draining the West and South areas totalling about 103,000 ha.

(d) Nabinagar East, irrigating with Nabinagar West and draining about 23,500 ha in the North West block of the project area.

Three of the five re-lift pump stations raise water pumped into the area by the Homna pump station from a nominal 2.9 m PWD to 3.8 m, PWD to irrigate higher lands. The two remaining stations raise water from the Salda to supply the Ghungur and the Bijni area with irrigation.

Figure J.3.3

FCDI Proposal



Source:
1990 Feasibility Study

Three options for the size of the pumping plant at the primary pump stations have been studied. In two of the options the pump capacity at the Bijni and Ghungur re-lift stations is also reduced. The options are listed below:

Pump Station	Option 1		Option 2		Option 3	
	Pump Size Cumec	No. of Pumps (Operating + Standby)	Pump Size Cumec	No. of Pumps (Operating + Standby)	Pump Size Cumec	No. of Pumps (Operating + Standby)
Main Pumping Stations						
Nabinagar East	6.25	3+1	6.25	2+1	6.25	3+1
Nabinagar West	6.25	5+1	6.25	4+1	6.25	4+1
Homna	6.25	8+1	6.25	8+1	6.25	6+1
Mohanpur	2.25	2+1	2.25	2+1	1.9	2+1
Total Capacity (cumec)	104.5	92.0	85.05			
Relief Pumping Stations						
Bijni	3	4+1	3	3+1	3	2+1
Ghungur	3	3+1	3	3+1	3	3+1

The results of a preliminary study with the Surface Water Simulation Modelling Programme showed that areas to the east of the Buri Nadi and south of the Salda were not well drained. Since it had also been decided to drain the cross border flows into the Ghungur through this area and down to the Homna pumping station, a considerable increase in the drainage capacity was needed. This has been provided by enlarging the existing main channels running westwards through the area.

In order to control level and supply of water during the dry season, it is necessary to place numerous checks and irrigation control structures in the internal channel network. Some of these, on the main drainage channels, are necessarily large, but the majority are small structures.

Additional metalled roads are to be provided, along the embankments where possible, to the re-lift pump stations. These will link to the existing road system in the area and provide improved access for the farmers as well.

For the purposes of comparing this option with alternative proposals, Option 2 (i.e. 92 cumec pumping capacity) has been selected.

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J.4 Sources of Agricultural Benefits

J.4.1 Introduction

The sources of agricultural benefits in FCD Projects are changed or improved flooding regimes which enable increased areas of shorter strawed aman crops to be grown in the monsoon season whereby farmers shift from deepwater aman to transplanted local varieties of aman to transplanted high yielding varieties of aman. On deeply flooded land where farmers have access to irrigation and grow a boro crop in the dry season it is unlikely that a reduction in monsoon flooding depths which would benefit the cultivation of deepwater aman will lead to substantially increased areas of the crop as farmers are constrained by the need to plant deepwater aman either before as soon as the boro crop is harvested and by deepwater aman's relatively modest profitability. In FCDI projects, similar benefits, flowing from reduced flooding depths, often enhanced by pumped drainage are supplemented by improved access to irrigation.

J.4.2 Changes in Cropping Patterns

The rationale behind the development of cropping patterns adopted in this study has already been discussed in Section J.2.6.

J.4.2.1 Zones A and B

Cropping patterns for Zones A and B were developed separately and then combined for the purposes of the economic analysis. In order to ensure that no dis-benefits were excluded cropping patterns were developed for the complete zone. Key inputs to the process were :

- that irrigation coverage, based on an expansion of the use of groundwater would reach 75% of NCA, irrespective of any project interventions.

- that increased areas of T aman within the embanked areas would be planted, although this would be to some extent, offset by decreased areas planted outside the protected areas.

The results of this process are presented in Table J.4.1.

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TABLE J.4.1

Summary of Cropping Pattern Changes : Zones A and B

(% of NCA)

	Year 1	Future w'out(1)	Future w'out(2)	Future with(1)	Future with(2)
B Aus, local	4.2%	2.6%	2.6%	2.6%	2.6%
B Aus, HYV	1.5%	1.5%	1.5%	1.5%	1.5%
T Aus, local	2.6%	1.1%	1.1%	1.1%	1.1%
T Aus, HYV irri	3.0%	2.7%	2.7%	3.4%	3.4%
T Aus, HYV n-ir	8.9%	8.1%	8.1%	9.2%	9.2%
Mixed aus/aman	1.7%	1.7%	1.7%	2.0%	2.0%
B Aman local dw	15.5%	9.5%	9.5%	6.3%	6.3%
T Aman local dw	7.0%	7.0%	7.0%	8.0%	8.0%
T Aman, local	20.9%	20.9%	20.9%	13.6%	13.6%
T Aman HYV irri	3.2%	3.2%	3.2%	4.4%	4.4%
T Aman HYV n-ir	17.8%	17.8%	17.8%	30.2%	30.2%
Boro, local	0.7%	0.7%	0.7%	0.7%	0.7%
Boro, HYV irrig	64.1%	74.3%	74.3%	74.3%	74.3%
Boro HYV p-irr.	0.0%	0.0%	0.0%	0.0%	0.0%
Wheat irrig.	1.7%	1.5%	1.5%	1.5%	1.5%
Wheat unirrig.	7.9%	6.4%	6.4%	6.4%	6.4%
Potato irrig.	2.3%	2.3%	2.3%	2.3%	2.3%
Potato unirrig.	2.1%	2.1%	2.1%	2.1%	2.1%
Jute	3.7%	3.7%	3.7%	3.7%	3.7%
Pulses: ave.	3.6%	2.7%	2.7%	2.7%	2.7%
Mustard	11.0%	9.2%	9.2%	10.3%	10.3%
Spices (chili)	0.8%	0.8%	0.8%	0.8%	0.8%
Veg. (brinjal)	1.9%	1.9%	1.9%	1.9%	1.9%
Total	186.2%	181.6%	181.6%	188.8%	188.8%

FWO (1), FW (1) : Year 10

FWO (2), FW (2) : Year 30

J.4.2.2 Zone C

Cropping patterns for Zone C have been developed for a number of different projections of what will happen in the future without project situation. These are all determined by assumptions regarding future exploitation of groundwater. In theory there are no long term constraints to the exploitation of groundwater in Zone C. In practice development may well be constrained as the technology required is either unproven (shallow force mode wells) or expensive (deep force mode wells). Analysis of Zone C proposals have therefore been undertaken for a number of different situations and cropping patterns.

Option 1. No further groundwater development

Option 2. Groundwater development proceeds rapidly irrespective of any project interventions reaching 75% coverage in 10 years.

Option 3. Groundwater development proceeds more slowly, taking 15 years to cover 75% of NCA. Cropping patterns for these options are presented in Table J.4.2

J.4.2.3 Zone D

No cropping patterns have been prepared as they are not required for the analysis of either khal excavation or the extension of the Gumti embankment.

J.4.2.4 FCD

Cropping patterns for the FCD option have been developed for Zones A B C and D on the same basis as for the other project interventions. Irrigation development over 75% of NCA in zones A, B and C and 60% in zone D is assumed for both the without and with project situations. The overall cropping pattern is presented in Table J.4.3.

J.4.2.5 FCDI

Cropping patterns for the FCDI option are more sensitive to without project irrigation development assumptions than FCD for obvious reasons. It was originally intended to investigate the sensitivity of such assumptions but the results of the preliminary analysis, using singular cropping patterns as for the FCD options were so discouraging that further work was abandoned. The cropping pattern used for the analysis is presented in Table J.4.4. but with higher T aman intensities.

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TABLE J.4.2 (i)

Summary of Cropping Pattern Changes : Zone C
(No further groundwater development)

(% of NCA)

	Year 1	Future w'out(1)	Future w'out(2)	Future with(1)	Future with(2)
B Aus, local	5.5%	5.5%	5.5%	5.5%	5.5%
B Aus, HYV	1.0%	1.0%	1.0%	1.0%	1.0%
T Aus, local	3.9%	3.9%	3.9%	4.0%	4.0%
T Aus, HYV irri	0.9%	0.9%	0.9%	1.2%	1.2%
T Aus, HYV n-ir	4.3%	4.3%	4.3%	6.0%	6.0%
Mixed aus/aman	11.0%	11.0%	11.0%	8.0%	8.0%
B Aman local dw	27.0%	27.0%	27.0%	10.3%	10.3%
T Aman local dw	0.8%	0.8%	0.8%	0.6%	0.6%
T Aman, local	13.8%	13.8%	13.8%	16.0%	16.0%
T Aman HYV irri	0.4%	0.4%	0.4%	1.3%	1.3%
T Aman HYV n-ir	6.6%	6.6%	6.6%	19.7%	19.7%
Boro, local	0.3%	0.3%	0.3%	0.3%	0.3%
Boro, HYV irrig	40.0%	40.0%	40.0%	60.7%	60.7%
Boro HYV p-irr.	0.0%	0.0%	0.0%	0.0%	0.0%
Wheat irrig.	1.0%	1.0%	1.0%	0.8%	0.8%
Wheat unirrig.	12.8%	12.8%	12.8%	11.2%	11.2%
Potato irrig.	0.1%	0.1%	0.1%	0.1%	0.1%
Potato unirrig.	1.2%	1.2%	1.2%	1.2%	1.2%
Jute	10.2%	10.2%	10.2%	10.2%	10.2%
Pulses: ave.	10.5%	10.5%	10.5%	9.0%	9.0%
Mustard	14.6%	14.6%	14.6%	12.0%	12.0%
Spices (chili)	0.9%	0.9%	0.9%	0.9%	0.9%
Veg. (brinjal)	1.5%	1.5%	1.5%	1.5%	1.5%
Total	168.3%	168.3%	168.3%	181.5%	181.5%

FWO (1), FW (1) : Year 10

FWO (2), FW (2) : Year 30

TABLE J.4.2 (ii)

Summary of Cropping Pattern Changes : Zone (FWO 10 year groundwater development)

(% of NCA)

	Year 1	Future w'out(1)	Future w'out(2)	Future with(1)	Future with(2)
B Aus, local	5.5%	2.5%	2.5%	2.5%	2.5%
B Aus, HYV	1.0%	0.0%	0.0%	0.0%	0.0%
T Aus, local	3.9%	1.4%	1.4%	1.4%	1.4%
T Aus, HYV irri	0.9%	0.5%	0.5%	1.2%	1.2%
Aus, HYV n-ir	4.3%	2.2%	2.2%	5.9%	5.9%
Mixed aus/aman	11.0%	4.0%	4.0%	3.2%	3.2%
B Aman local dw	27.0%	12.0%	12.0%	8.0%	8.0%
T Aman local dw	0.8%	0.8%	0.8%	0.6%	0.6%
T Aman, local	13.8%	13.8%	13.8%	16.0%	16.0%
T Aman HYV irri	0.4%	0.4%	0.4%	1.3%	1.3%
T Aman HYV n-ir	6.6%	6.6%	6.6%	19.7%	19.7%
Boro, local	0.3%	0.3%	0.3%	0.3%	0.3%
Boro, HYV irrig	40.0%	74.7%	74.7%	74.7%	74.7%
Boro HYV p-irr.	0.0%	0.0%	0.0%	0.0%	0.0%
Wheat irrig.	1.0%	0.6%	0.6%	0.6%	0.6%
Wheat unirrig.	12.8%	7.9%	7.9%	7.9%	7.9%
Potato irrig.	0.1%	0.1%	0.1%	0.1%	0.1%
Potato unirrig.	1.2%	1.2%	1.2%	1.2%	1.2%
Jute	10.2%	6.5%	6.5%	6.4%	6.4%
Pulses: ave.	10.5%	6.4%	6.4%	6.4%	6.4%
Mustard	14.6%	13.6%	13.6%	13.6%	13.6%
Spices (chili)	0.9%	0.9%	0.9%	0.9%	0.9%
Veg. (brinjal)	1.5%	1.5%	1.5%	1.5%	1.5%
Total	168.3%	157.9%	157.9%	173.4%	173.4%

FWO (1), FW (1) : Year 10

FW (2), FWO (2) : Year 30

TABLE J.4.2. (iii)

Summary of Cropping Pattern Changes : Zone C
(FWO : 15 year groundwater development)

(% of NCA)

	Year 1	Future w'out(1)	Future w'out(2)	Future with(1)	Future with(2)
B Aus, local	5.5%	4.4%	2.5%	2.5%	2.5%
B Aus, HYV	1.0%	0.6%	0.0%	0.0%	0.0%
T Aus, local	3.9%	3.0%	1.4%	1.4%	1.4%
T Aus, HYV irri	0.9%	0.7%	0.5%	1.2%	1.2%
T Aus, HYV n-ir	4.3%	3.5%	2.2%	5.9%	5.9%
Mixed aus/aman	11.0%	8.4%	4.0%	3.2%	3.2%
B Aman local dw	27.0%	21.5%	12.0%	8.0%	8.0%
T Aman local dw	0.8%	0.8%	0.8%	0.6%	0.6%
T Aman, local	13.8%	13.8%	13.8%	16.0%	16.0%
T Aman HYV irri	0.4%	0.4%	0.4%	1.3%	1.3%
T Aman HYV n-ir	6.6%	6.6%	6.6%	19.7%	19.7%
Boro, local	0.3%	0.3%	0.3%	0.3%	0.3%
Boro, HYV irrig	40.0%	52.8%	74.7%	74.7%	74.7%
Boro HYV p-irr.	0.0%	0.0%	0.0%	0.0%	0.0%
Wheat irrig.	1.0%	1.8%	0.6%	0.6%	0.6%
Wheat unirrig.	12.8%	11.0%	7.9%	7.9%	7.9%
Potato irrig.	0.1%	0.1%	0.1%	0.1%	0.1%
Potato unirrig.	1.2%	1.2%	1.2%	1.2%	1.2%
Jute	10.2%	8.8%	6.5%	6.4%	6.4%
Pulses: ave.	10.5%	9.0%	6.4%	6.4%	6.4%
Mustard	14.6%	14.2%	13.6%	13.6%	13.6%
Spices (chili)	0.9%	0.9%	0.9%	0.9%	0.9%
Veg. (brinjal)	1.5%	1.5%	1.5%	1.5%	1.5%
Total	168.3%	164.5%	157.9%	173.4%	173.4%

FW (1), FWO (1) : Year 10

FW (2), FWO (2) : Year 30

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TABLE J.4.3.

Summary of Cropping Pattern Changes
FCD : Full Area

(% of NCA)

	Year 1	Future w'out(1)	Future w'out(2)	Future with(1)	Future with(2)
B Aus, local	3.6%	2.0%	2.0%	2.0%	2.0%
B Aus, HYV	0.6%	0.6%	0.6%	0.6%	0.6%
T Aus, local	1.6%	0.9%	0.9%	0.9%	0.9%
T Aus, HYV irri	1.3%	1.2%	1.2%	1.8%	1.8%
T Aus, HYV n-ir	4.1%	3.9%	3.9%	5.4%	5.4%
Mixed aus/aman	5.0%	2.9%	2.9%	2.8%	2.8%
B Aman local dw	23.8%	15.4%	15.4%	15.0%	15.0%
T Aman local dw	3.3%	3.3%	3.3%	2.3%	2.3%
T Aman, local	12.6%	12.6%	12.6%	9.4%	9.4%
T Aman HYV irri	1.4%	1.4%	1.4%	2.2%	2.2%
T Aman HYV n-ir	9.0%	9.0%	9.0%	17.8%	17.8%
Boro, local	1.3%	1.3%	1.3%	1.3%	1.3%
Boro, HYV irrig	55.0%	69.1%	69.1%	69.1%	69.1%
Boro HYV p-irr.	0.0%	0.0%	0.0%	0.0%	0.0%
Wheat irrig.	1.2%	0.9%	0.9%	0.9%	0.9%
Wheat unirrig.	11.7%	8.3%	8.3%	8.3%	8.3%
Potato irrig.	1.0%	1.0%	1.0%	1.0%	1.0%
Potato unirrig.	2.3%	2.3%	2.3%	2.3%	2.3%
Jute	7.7%	6.6%	6.6%	6.2%	6.2%
Pulses: ave.	7.0%	5.2%	5.2%	5.2%	5.2%
Mustard	11.1%	10.2%	10.2%	11.8%	11.8%
Spices (chili)	2.7%	2.7%	2.7%	2.7%	2.7%
Veg. (brinjal)	3.4%	3.4%	3.4%	3.4%	3.4%
Total	170.7%	164.3%	164.3%	172.6%	172.6%

FW (1), FWO (1) : Year 10

FW (2), FWO (2) : Year 30

Q7C

TABLE J.4.4.

Summary of Cropping Pattern Changes
FCDI : Full Area

(% of NCA)

	Year 1	Future w'out(1)	Future w'out(2)	Future with(1)	Future with(2)
B Aus, local	3.6%	2.0%	2.0%	2.0%	2.0%
B Aus, HYV	0.9%	0.6%	0.6%	0.6%	0.6%
T Aus, local	2.2%	0.9%	0.9%	0.7%	0.7%
T Aus, HYV irri	1.7%	1.5%	1.5%	2.3%	2.3%
T Aus, HYV n-ir	4.5%	3.6%	3.6%	6.2%	6.2%
Mixed aus/aman	5.0%	2.9%	2.9%	2.3%	2.3%
B Aman local dw	25.2%	15.4%	15.4%	13.3%	13.3%
T Aman local dw	3.3%	3.3%	3.3%	4.0%	4.0%
T Aman, local	12.6%	12.6%	12.6%	9.1%	9.1%
T Aman HYV irri	1.4%	1.4%	1.4%	2.9%	2.9%
T Aman HYV n-ir	9.0%	9.0%	9.0%	25.8%	25.8%
Boro, local	1.3%	1.3%	1.3%	1.3%	1.3%
Boro, HYV irrig	51.9%	69.1%	69.1%	69.1%	69.1%
Boro HYV p-irr.	0.0%	0.0%	0.0%	0.0%	0.0%
Wheat irrig.	1.2%	0.9%	0.9%	0.9%	0.9%
Wheat unirrig.	11.7%	8.3%	8.3%	8.3%	8.3%
Potato irrig.	1.0%	1.0%	1.0%	1.0%	1.0%
Potato unirrig.	2.3%	2.3%	2.3%	2.3%	2.3%
Jute	7.7%	6.6%	6.6%	6.5%	6.5%
Pulses: ave.	7.0%	5.2%	5.2%	5.2%	5.2%
Mustard	11.1%	10.2%	10.2%	10.9%	10.9%
Spices (chili)	2.7%	2.7%	2.7%	2.7%	2.7%
Veg. (brinjal)	3.4%	3.4%	3.4%	3.4%	3.4%
Total	170.7%	164.3%	164.3%	181.0%	181.0%

FWO (1), FW (1) : Year 10

FWO (2), FW (2) : Year 30

J.4.3 Flood Control Benefits

J.4.3.1 Reduced Crop Damage

Annual crop damage estimates were discussed in Chapter J.2. These have been applied to the following percentages of NCA, which are calculated as the proportion of protected to unprotected areas.

Zone	A	:	73%
	B	:	19%
	C	:	25%
	D	:	na
FCD		:	100%
FCDI		:	100%

J.4.3.2 Reduced Infrastructure Damage

The estimates presented in Chapter J.2 are applied to the same areas as given in Section J.4.3.1. In the analysis the value of flood damage has been increased annually by 3% to allow for population and economic growth. This is at the lower end of the range suggested by the FPCO Guidelines, but the 1991 census indicates a reduced rate of population growth.

J.4.3.3 Fishery Losses

Fishery losses are estimated in Annex F, and are summarised in Table J.4.5.

TABLE J.4.5

Fish Losses in Tonnes per Year

	Present	FWO	FW	Loss
Zone A Polder	4582	5077	3755	1321
Zone B Polder	1070	1072	562	510
Zone C Polder	2340	2343	1009	1334
FCD	26782	27337	18113	9224
FCDI	26782	27337	18184	9153

In each of the cases above the construction of polders or embankments is assumed to remove all the high value migratory fish from the wild catch.

J.5 Costs of Development

Project costs for each option are presented below in Tables J.5.1, J.5.2 and J.5.3. Construction costs by year are also included.

TABLE J.5.1

Costs of Construction:Zones A,B and C

Zone A — Tk 000

Project Cost	1992 financial cost	price factor	con factor	1991 economic cost	%	con factor	O & M economic costs
Embankment	45480.0	1.05	0.66	28522	0.06	0.70	1815.05
Excavation	62440.0	1.05	0.66	39158	0.06	0.70	2491.90
	34400.0	1.05	0.66	21574	0.06	0.70	1372.86
Buildings		1.05		0	0.06	0.72	0.00
Regulators	53200.0	1.05	0.70	35386	0.03	0.72	1091.90
Vehicles	1000.0	1.05	0.68	646	0.04	0.87	93.97
Pump Stations civil		1.05		0	0.02	0.71	
Pump Stations M&E		1.05		0	0.03	0.70	
Land Acquisition	37500.0	1.05	0.53	18885			
	2750.0	1.05	0.87	2273			
Sub-total	236770.0			146445			6865.69
Contigencies	35515.5			21967			
Engineering	32674.3	1.05	0.87	27011			
Total	304959.8			195423			6865.69

Construction Schedule(economic prices)

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Tk 000	8913.70	8913.70	99377.16	78218.38	0.00	195423
Tk 000000	8.91	8.91	99.38	78.22	0.00	195

Zone B — Tk 000

Project Cost	1992 financial cost	price factor	con factor	1991 economic cost	%	con factor	O & M economic costs
Embankment	32059.00	1.05	0.66	20105	0.06	0.70	1279.44
Excavation	2534.00	1.05	0.66	1589	0.06	0.70	101.13
		1.05		0	0.06	0.70	0.00
Buildings		1.05		0	0.06	0.72	0.00
Regulators	12600.00	1.05	0.70	8381	0.03	0.72	258.61
Vehicles	1000.00	1.05	0.68	646	0.04	0.87	93.97
Pump Stations civil		1.05		0	0.02	0.71	
Pump Stations M&E		1.05		0	0.03	0.70	
Land Acquisition	12863.00	1.05	0.53	6478			
	987.00	1.05	0.87	816			
Sub-total	62043.00			38015.45			1733.14
Contigencies	9306.45			5702.32			
Engineering	8561.93	1.05	0.87	7078			
Total	79911.38			50795.76			1733.14

Construction Schedule(economic prices)

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Tk000	0.00	4671.48	34002.96	12121.32		50795.76
Tk000000	0.0	4.7	34.0	12.1		50.80

Zone C — Tk 000

Project Cost	1992 financial cost	price factor	con factor	1991 economic cost	%	con factor	O & M economic costs
Embankment	55443.0	1.05	0.66	34770.4	0.06	0.70	2212.66
Excavation	25619.0	1.05	0.66	16066.6	0.06	0.70	1022.42
		1.05	0.00	0.0	0.06	0.70	0.00
Buildings	5400.0	1.05	0.79	4053.6	0.06	0.72	221.66
Regulators	44300.0	1.05	0.70	29466.0	0.03	0.72	20.52
Vehicles	4000.0	1.05	0.68	2584.6	0.04	0.87	93.97
Pump Stations civil	97677.0	1.05	0.71	65897.6	0.02	0.71	1317.95
Pump Stations M&E	132910.0	1.05	0.64	80827.1	0.03	0.70	2652.14
Land Acquisition	16313.0	1.05	0.40	6200.3			
	3769.0	1.05	0.87	3115.8			
Power					11952.0	1.54	**18406.08**
Sub-total	385431.0			242982.0			**25947**
Contigencies	57814.7			36447.3			
Engineering	53189.5	1.05	0.87	44071.3			
Total	496435.1			323500.5			**25947.41**

Construction Schedule(economic prices)

Year 1	Year 2	Year 3	Year 4	Year 5	Total
14543.52	14543.52	104348.54	95032.48	95032.5	323500.54
14.5	14.5	104.3	95.0	95.0	

(82)

TABLE J.5.2

Costs of Construction:Zone D,Gumti Embankment and Irrigation Supply Improvement

Zone D(Gumti Embankment) Tk 000

Project Cost	1992 financial cost	price factor	con factor	1991 economic cost	%	con factor	O & M economic costs
Embankment	3685.00	1.05	0.66	2311	0.06	0.70	147.06
Excavation	0.00	1.05	0.66	0	0.06	0.70	0.00
		1.05		0			
Bridges		1.05	0.79	0	0.06	0.72	0.00
Regulators	4750.00	1.05	0.70	3159	0.03	0.72	97.49
Vehicles	500.00	1.05	0.68	323	0.04	0.87	46.98
Pump Stations civil		1.05	0.71	0	0.02	0.71	0.00
Pump Stations M&E		1.05	0.64	0	0.03	0.70	0.00
Land Acquisition	3131.25	1.05	0.40	1190			
		1.05	0.87	0			
Sub-total	12066.25			6983.66			291.5
Contigencies	1809.94			1047.55			
Engineering	1665.14		0.87	1448.67			
Total	15541.33			9479.88			

Construction Schedule(economic prices)

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Tk 000	478.06	1668.20	7333.62	0.00		9479.88

Zone D(Irrigation supply improvement) Tk 000

Project Cost	1992 financial cost	price factor	con factor	1991 economic cost	%	con factor	O & M economic costs
Embankment		1.05	0.66	0	0.06	0.70	0.00
Excavation	52806.00	1.05	0.66	33117	0.04	0.70	1404.95
		1.05		0			
Bridges		1.05	0.79	0	0.06	0.72	0.00
Regulators		1.05	0.70	0	0.03	0.72	0.00
Vehicles	500.00	1.05	0.68	323	0.04	0.87	46.98
Pump Stations civil		1.05	0.71	0	0.02	0.71	0.00
Pump Stations M&E		1.05	0.64	0	0.03	0.70	0.00
Land Acquisition		1.05	0.40	0			
		1.05	0.87	0			
Sub-total	53306.00			33439.72			1451.9
Contigencies	7995.90			5015.96			
Engineering	7356.23		0.87	6399.92			
Total	68658.13			44855.59			

Construction Schedule(economic prices)

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Tk 000	2111.97	2111.97	20315.82	20315.82		44855.59

TABLE J.5.3

Costs of Construction:FCDI and FCD

FCDI — Tk Million

Project Cost	1992 financial cost	price factor	con factor	1991 economic cost	%	con factor	O & M economic costs
Embankment	1160.00	1.05	0.66	727.5	0.06	0.70	46.29
Excavation	891.00	1.05	0.66	558.8	0.06	0.70	35.56
Buildings	171.00	1.05	0.79	128.4	0.06	0.70	6.82
Bridges,roads	341.00	1.05	0.79	256.0	0.06	0.72	14.00
Regulators	577.00	1.05	0.70	383.8	0.03	0.72	20.52
Vehicles	50.00	1.05	0.68	32.3	0.04	0.87	1.65
Pump Stations civil	651.00	1.05	0.71	439.2	0.02	0.71	8.78
Pump Stations M&E	620.00	1.05	0.64	377.0	0.03	0.70	12.37
Land Acquisition	1465.00	1.05	0.45	626.4			
	702.00	1.05	0.87	580.3			
Power					20.00	1.54	30.80
Sub-total	6628.0			4109.7			176.8
Contigencies	994.2			616.5			
Engineering	914.7	1.05	0.87	757.9			
Total	8536.9			5484.0			

Construction Schedule(economic prices)

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Tk Million	1096.80	1096.80	1096.80	1096.80	1096.80	5484.01

FCD — Tk Million

Project Cost	1992 financial cost	price factor	con factor	1991 economic cost	%	con factor	O & M economic costs
Embankment	1160.00	1.05	0.66	727.5	0.06	0.70	46.29
Excavation	746.00	1.05	0.66	467.8	0.06	0.70	29.77
Buildings	171.00	1.05	0.79	128.4	0.06	0.70	6.82
Bridges,roads	195.00	1.05	0.79	146.4	0.06	0.72	8.00
Regulators	547.00	1.05	0.70	363.8	0.03	0.72	20.52
Vehicles	50.00	1.05	0.68	32.3	0.04	0.87	1.65
Pump Stations civil	0.00	1.05	0.71	0.0	0.02	0.71	0.00
Pump Stations M&E	0.00	1.05	0.64	0.0	0.03	0.70	0.00
Land Acquisition	1314.00	1.05	0.45	561.9			
	629.00	1.05	0.87	520.0			
Power					0.00	1.54	0.00
Sub-total	4812.0			2948.1			113.1
Contigencies	721.8			442.2			
Engineering	664.1	1.05	0.87	550.2			
Total	6197.9			3940.5			

Construction Schedule(economic prices)

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Tk Million	788.10	788.10	788.10	788.10	788.10	3940.48

J.6 Results of the Economic Analysis

J.6.1 Zones A and B

This proposal is described in Section J.3.1. The results of the economic analysis for Zones A and B are presented in Tables J.6.1 to J.6.9, which cover the following:

- annual net income and cropped area by crop
- calculation of agricultural flood loss
- labour requirement and paddy production
- irrigation phasing and net crop income - future without
- irrigation phasing and net crop income - future with
- fisheries losses
- non agricultural flood damage
- project cash flows
- summary of benefits in financial prices
- summary of cropping pattern changes
- summary of result and sensitivity analysis

As can be seen in Tables J.6.6 and J.6.9 the project produces an IRR of 14.9%. The project returns are particularly sensitive to delays in either completion or the achievement of benefits. Given that a construction schedule of five year is proposed, it is not anticipated that these will occur.

Sensitivity to both fishery losses and reduced flood damage are similar. Inspection of the Cash flow (Table J.6.6) illustrates the relative importance of different costs and benefits. Incremental Crop income is the largest but is still only twice the fishery losses. In percentage terms the increase in crop income between the "with" and "without" situations is small, less than seven per cent. The importance of flood damage benefits, especially protection against flash floods is evident.

Implementation of the project should increase rice production by seven per cent. Employment is not increased significantly mainly because the increase in demand for agricultural labour is offset by the loss of employment in fisheries.

A multi criteria analysis which reviews the overall impact of the proposals for Zones A and B is presented in Annex H and in the Main report. Apart from the impact on capture fisheries the project is not expected to generate any serious environmental degradation. it may increase flooding depths in the Monsoon on the area to the east of the Zone A embankment by small amounts, although this will be counteracted to some extent by the improvement expected in the control of flash flooding through deepening and enlarging the River, Salda, and Buri.

TABLE J.6.1

Annual Total (Net) Income, and Cropped Area by Crop — economic prices

Economic prices — ZONES A & B

Crop	Net Income (Tk/ha)	Year 1 Area (ha)	Year 1 Total Income (Tk'000)	Future WO(1) Area (ha)	Future WO(1) Total Income (Tk'000)	Future WO(2) Area (ha)	Future WO(2) Total Income (Tk'000)	Future With(1) Area (ha)	Future With(1) Total Income (Tk'000)	Future With(2) Area (ha)	Future With(2) Total Income (Tk'000)
B Aus, local	3973	1967	7814	1215	4826	1215	4826	1215	4826	1215	4826
B Aus, HYV	5936	716	4249	718	4263	718	4263	718	4263	718	4263
T Aus, local	7358	1223	8996	536	3947	536	3947	536	3947	536	3947
T Aus, HYV irri	12711	1411	17937	1266	16098	1266	16098	1591	20227	1591	20227
T Aus, HYV n-ir	10219	4166	42569	3792	38746	3792	38746	4297	43907	4297	43907
Mixed aus/aman	6055	779	4715	779	4715	779	4715	950	5754	950	5754
B Aman local dw	5791	7278	42148	4479	25935	4479	25935	2935	16993	2935	16993
T Aman local dw	8404	3270	27476	3270	27476	3270	27476	3739	31419	3739	31419
T Aman, local	9850	9799	96524	9798	96515	9798	96515	6365	62701	6365	62701
T Aman HYV irri	14725	1505	22157	1505	22155	1505	22155	2073	30527	2073	30527
T Aman HYV n-ir	13545	8334	112883	8334	112875	8334	112875	14151	191671	14151	191671
Boro, local	12070	336	4058	336	4058	336	4058	336	4058	336	4058
Boro, HYV irrig	17168	30098	516708	34852	598333	34852	598333	34852	598333	34852	598333
Boro HYV p-irr.	-11389	0	0	0	0	0	0	0	0	0	0
Wheat irrig.	12095	815	9855	711	8602	711	8602	711	8602	711	8602
Wheat unirrig.	9143	3726	34064	2990	27333	2990	27333	2990	27333	2990	27333
Potato irrig.	28461	1070	30453	1070	30453	1070	30453	1070	30453	1070	30453
Potato unirrig.	11775	1000	11772	1000	11772	1000	11772	1000	11772	1000	11772
Jute	8985	1719	15448	1719	15448	1719	15448	1719	15448	1719	15448
Pulses: ave.	5622	1700	9559	1252	7039	1252	7039	1252	7039	1252	7039
Mustard	2269	5176	11745	4321	9805	4321	9805	4811	10917	4811	10917
Spices (chilli)	15847	382	6048	382	6048	382	6048	382	6048	382	6048
Veg. (brinjal)	13069	900	11768	900	11768	900	11768	900	11768	900	11768
Total		87369	1048945	85224	1088210	85224	1088210	88594	1148006	88594	1148006

Notes:
Total income is net of all on-farm costs except for irrigation which is analysed separately
Project Year 1: assumed 1994/95
Future Without (1): Future Without Project Conditions, Year 10
Future Without (2): Future Without Project Conditions, Year 30
Future With (1): Future With Project Conditions, Year 10
Future With (2): Future With Project Conditions, Year 30
% Increment (1): % difference FW (1) over FWO (1)
% Increment (2): % difference FW (2) over FWO (2)

Calculation of Agricultural Flood Loss — economic prices

Crop	percent loss	income/ha lost*	Year 1 area	Year 1 Tk'000	Year 1 tons	Future without (1) area	Future without (1) Tk'000	Future without (1) tons	Future without (2) area	Future without (2) Tk'000	Future without (2) tons
B Aus, local	2.46%	10443	23	239	46	14	147	28	14	147	28
B Aus, HYV	2.46%	12480	8	104	21	8	104	21	8	104	21
T Aus, local	2.46%	13651	14	194	36	6	85	16	6	85	16
T Aus, HYV irri	2.46%	20889	16	343	59	15	308	53	15	308	53
T Aus, HYV n-ir	2.46%	18298	48	886	155	44	807	141	44	807	141
Mixed aus/aman	2.28%	12829	8	108	19	8	108	19	8	108	19
B Aman local dw	2.28%	10713	78	839	148	48	516	91	48	516	91
T Aman local dw	2.28%	13909	35	489	84	35	489	84	35	489	84
T Aman, local	3.47%	16102	160	2583	417	160	2583	417	160	2583	417
T Aman HYV irri	3.47%	22623	25	557	95	25	557	95	25	557	95
T Aman HYV n-ir	3.47%	21344	136	2912	498	136	2912	498	136	2912	498
Boro, local	3.52%	16637	6	93	17	6	93	17	6	93	17
Boro, HYV irrig	3.52%	27046	500	13535	2702	579	15673	3129	579	15673	3129
Boro HYV p-irr.	3.00%	-2847	0	0	0	0	0	0	0	0	0
Jute	1.90%	16992	7	124	14	6	109	12	6	109	12
percent of area to which damage reduction applies	47.2%	total	1067	23007	4310	1092	24491	4621	1092	24491	4621

* lost income is gross crop income less 25% of costs

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TABLE J.6.2

Labour requirements and paddy production

		LABOUR REQUIREMENTS					PADDY PRODUCTION				
	Labour	Present	FWO (1)	FWO (2)	FW (1)	FW (2)	Present	FWO (1)	FWO (2)	FW (1)	FW (2)
		Labour	Labour	Labour	Labour	Labour					
	md/ha	md ('000s)	md ('000s)	md ('000s)	md ('000s)	md ('000s)	tonnes	tonnes	tonnes	tonnes	tonnes
B Aus, local	142	279	172	172	172	172	3934	2429	2429	2429	2429
B Aus, HYV	145	104	104	104	104	104	1789	1795	1795	1795	1795
T Aus, local	155	190	83	83	83	83	3056	1341	1341	1341	1341
T Aus, HYV irri	181	255	229	229	288	288	5080	4559	4559	5729	5729
T Aus, HYV n-ir	177	737	671	671	761	761	13330	12133	12133	13749	13749
Mixed aus/aman	165	129	129	129	157	157	1791	1791	1791	2186	2186
B Aman local dw	111	806	496	496	325	325	13708	8435	8435	5527	5527
T Aman local dw	134	438	438	438	501	501	7847	7847	7847	8973	8973
T Aman, local	146	1431	1431	1431	929	929	25477	25475	25475	16550	16550
T Aman HYV irri	171	257	257	257	353	353	5793	5793	5793	7982	7982
T Aman HYV n-ir	167	1388	1388	1388	2356	2356	30420	30418	30418	51652	51652
Boro, local	120	40	40	40	40	40	1009	1009	1009	1009	1009
Boro, HYV irrig	214	6441	7458	7458	7458	7458	162528	188203	188203	188203	188203
Boro HYV p-irr.	160	0	0	0	0	0	0	0	0	0	0
Wheat irrig.	127	103	90	90	90	90					
Wheat unirrig.	102	379	304	304	304	304					
Potato irrig.	194	208	208	208	208	208					
Potato unirrig.	175	175	175	175	175	175					
Jute	215	369	369	369	369	369					
Pulses: ave.	50	85	63	63	63	63					
Mustard	58	298	248	248	277	277					
Spices (chilli)	157	60	60	60	60	60					
Veg. (brinjal)	270	243	243	243	243	243					
Total		14413	14656	14656	15317	15317	275763	291227	291227	307124	307124

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TABLE J.6.3

Irrigation Phasing and Net Crop Income - Future Without

Year	Irrigated Area (ha) LLP	STW/SFM	DSSTW	DTW	Manual	Total	On-Farm Irrigation Cost (Tk'000)	Crop Income (1) (Tk'000)	Net Crop Income(2) (Tk'000)
1	6344	10217	188	11547	2325	30622	91070	1048945	957875
2	6344	10427	375	11670	2280	31097	92733	1053032	960300
3	6344	10637	563	11792	2235	31572	94396	1057120	962725
4	6344	10848	751	11915	2190	32048	96059	1061208	965150
5	6344	11058	938	12037	2146	32523	97722	1065296	967574
6	6344	11268	1126	12160	2101	32999	99385	1069384	969999
7	6344	11478	1314	12282	2056	33474	101048	1073472	972424
8	6344	11688	1501	12405	2011	33950	102711	1077560	974849
9	6344	11898	1689	12528	1966	34425	104374	1081647	977274
10 FWO 1	6344	12318	1877	12773	1877	35189	107020	1088210	981189
11	6344	12318	1877	12773	1877	35189	107020	1088210	981189
12	6344	12318	1877	12773	1877	35189	107020	1088210	981189
13	6344	12318	1877	12773	1877	35189	107020	1088210	981189
14	6344	12318	1877	12773	1877	35189	107020	1088210	981189
15	6344	12318	1877	12773	1877	35189	107020	1088210	981189
16	6344	12318	1877	12773	1877	35189	107020	1088210	981189
17	6344	12318	1877	12773	1877	35189	107020	1088210	981189
18	6344	12318	1877	12773	1877	35189	107020	1088210	981189
19	6344	12318	1877	12773	1877	35189	107020	1088210	981189
20	6344	12318	1877	12773	1877	35189	107020	1088210	981189
21	6344	12318	1877	12773	1877	35189	107020	1088210	981189
22	6344	12318	1877	12773	1877	35189	107020	1088210	981189
23	6344	12318	1877	12773	1877	35189	107020	1088210	981189
24	6344	12318	1877	12773	1877	35189	107020	1088210	981189
25	6344	12318	1877	12773	1877	35189	107020	1088210	981189
26	6344	12318	1877	12773	1877	35189	107020	1088210	981189
27	6344	12318	1877	12773	1877	35189	107020	1088210	981189
28	6344	12318	1877	12773	1877	35189	107020	1088210	981189
29	6344	12318	1877	12773	1877	35189	107020	1088210	981189
30 FW0 2	6344	12318	1877	12773	1877	35189	107020	1088210	981189

Note: (1) Net of costs other than on-farm irrigation
(2) Net of costs including on-farm irrigation

PV (12%), Tk Mn 7822

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TABLE J.6.4

Irrigation Phasing and Net Crop Income - Future With

Year	Irrigated Area (ha) LLP	STW/SFM	DSSTW	DTW	Manual	Total	On-Farm Irrigation Cost (Tk'000)	Crop Income (1) (Tk'000)	Net Crop Income (2) (Tk'000)
1	6344	10217	188	11547	2325	30622	91070	1048945	957875
2	6344	10315	375	11670	2280	30985	92384	1052684	960300
3	6344	10413	563	11792	2235	31348	93699	1056423	962725
4 complete	6793	10511	751	11915	2190	32160	95704	1060854	965150
5	6942	10609	938	12037	2146	32673	97249	1077255	980006
6	7091	10707	1126	12160	2101	33186	98794	1093303	994509
7	7241	10805	1314	12282	2056	33698	100339	1109350	1009011
8	7390	10903	1501	12405	2011	34211	101884	1125397	1023513
9	7540	11001	1689	12528	1966	34724	103429	1141444	1038016
10 FW 1	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
11	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
12	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
13	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
14	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
15	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
16	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
17	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
18	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
19	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
20	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
21	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
22	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
23	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
24	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
25	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
26	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
27	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
28	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
29	7689	10973	1877	12773	1877	35189	104912	1148006	1043094
30 FW 2	7689	10973	1877	12773	1877	35189	104912	1148006	1043094

Note: (1) Net of costs other than on-farm irrigation
(2) Net of costs including on-farm irrigation

PV (12%), TK Mn 8068

TABLE J.6.5

Fisheries losses

	Fish production tons FWO	tons FW	Financial Value per kg Tk. FWO	Tk. FW	Economic value net of catching Value per kg Tk. FWO	Tk. FW	Economic price net of catching Total value Tk'000 FWO	Tk'000 FW	Tk'000 FWO-FW	financial prices Net of catching Total value Tk'000 FWO	Tk'000 FW
year 1	3732	3732	24.50	24.50	10.92	10.92	40735	40735	0	41674	41674
2	3715	3715	24.50	24.50	10.92	10.92	40549	40549	0	41484	41484
3	3698	3698	24.50	24.50	10.92	10.92	40364	40364	0	41294	41294
4	3681	3681	24.50	24.50	10.92	10.92	40178	40178	0	41105	41105
5	3664	1816	24.50	24.50	10.92	5.67	39993	10293	29699	40915	20279
6	3647	1816	24.50	20.86	10.92	5.67	39807	10293	29514	40725	8826
7	3647	1816	24.50	20.86	10.92	5.67	39807	10293	29514	40725	8826
8	3647	1816	24.50	20.86	10.92	5.67	39807	10293	29514	40725	8826
9	3647	1816	24.50	20.86	10.92	5.67	39807	10293	29514	40725	8826
10	3647	1816	24.50	20.86	10.92	5.67	39807	10293	29514	40725	8826

	fin.	econ.
gear cost per day	10.00	8.70
labour cost per day	30.00	22.50

Fish labour use	present	FWO 1	FWO 2	FW 1	FW 2	
kg per day	3.0	3.0	3.0	2.5	2.5	
'000 days	1244	1216	1216	726	726	
TK per day	54	54	54	32	32	(fishermans total income per day less gear cost in financial prices)
	39	39	39	32	32	(excludes leaseholders' share ??)

Non-agricultural flood damage

value of reduction per ha	179 Tk/ha
@ economic prices	156 Tk/ha
damage reduction applies to	47% of NCA
Total damage reduction	3448 Tk'000

TABLE J.6.6

Project Cash Flows (1991 Economic Prices)

(Million Taka)

Year	Net Crop Income FWO	Net Crop Income FW	Benefits Incremental Crop Income	Flood damage non-agr.	Flood damage crop	Total Benefits	Costs Capture Fisheries Losses	Capital Costs	O&M Costs	Total Costs	Net Incremental Benefits
1	958	958	0	0.0	0.0	0.0	0.0	8.9	0.0	8.9	-8.9
2	960	960	0	0.0	0.0	0.0	0.0	8.9	0.0	8.9	-8.9
3	963	963	0	0.0	0.0	0.0	0.0	104.1	0.0	104.1	-104.1
4	965	965	0	0.0	0.0	0.0	0.0	112.2	0.0	112.2	-112.2
5	968	980	12	3.9	24.5	40.8	29.5	0.0	7.5	37.0	3.8
6	970	995	25	4.0	24.5	53.0	29.5	0.0	7.5	37.0	16.0
7	972	1009	37	4.0	24.5	65.1	29.5	0.0	7.5	37.0	28.0
8	975	1024	49	4.1	24.5	77.3	29.5	0.0	7.5	37.0	40.2
9	977	1038	61	4.2	24.5	89.5	29.5	0.0	7.5	37.0	52.5
10	981	1043	62	4.4	24.5	90.8	29.5	0.0	7.5	37.0	53.8
11	981	1043	62	4.5	24.5	90.9	29.5		7.5	37.0	53.9
12	981	1043	62	4.6	24.5	91.0	29.5		7.5	37.0	54.0
13	981	1043	62	4.8	24.5	91.2	29.5		7.5	37.0	54.2
14	981	1043	62	4.9	24.5	91.3	29.5		7.5	37.0	54.3
15	981	1043	62	5.1	24.5	91.5	29.5		7.5	37.0	54.4
16	981	1043	62	5.2	24.5	91.6	29.5		7.5	37.0	54.6
17	981	1043	62	5.4	24.5	91.8	29.5		7.5	37.0	54.8
18	981	1043	62	5.5	24.5	91.9	29.5		7.5	37.0	54.9
19	981	1043	62	5.7	24.5	92.1	29.5		7.5	37.0	55.1
20	981	1043	62	5.9	24.5	92.3	29.5		7.5	37.0	55.3
21	981	1043	62	6.0	24.5	92.4	29.5		7.5	37.0	55.4
22	981	1043	62	6.2	24.5	92.6	29.5		7.5	37.0	55.6
23	981	1043	62	6.4	24.5	92.8	29.5		7.5	37.0	55.8
24	981	1043	62	6.6	24.5	93.0	29.5		7.5	37.0	56.0
25	981	1043	62	6.8	24.5	93.2	29.5		7.5	37.0	56.2
26	981	1043	62	7.0	24.5	93.4	29.5		7.5	37.0	56.4
27	981	1043	62	7.2	24.5	93.6	29.5		7.5	37.0	56.6
28	981	1043	62	7.4	24.5	93.8	29.5		7.5	37.0	56.8
29	981	1043	62	7.7	24.5	94.1	29.5		7.5	37.0	57.0
30	981	1043	62	7.9	24.5	94.3	29.5		7.5	37.0	57.3
Present Value @12%		8068	246	23.7	122.8	393.0	148.1	160.5	37.6	346.2	46.8
										EIRR (%)	14.86

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TABLE J.6.7

Summary of Benefits

	Unit	Project year 1	Future Without (1)	Future Without (2)	Future With (1)	Future With (2)	% Increment (1)	% Increment (2)
Net Cultivated Area	'000 hectares	46.9	46.9	46.9	46.9	46.9	0	0
Irrigated Area	'000 hectares	30.5	35.2	35.2	35.2	35.2	0	0
Labour Requirement (ag & fish)	million man days	15.7	15.9	15.9	16.0	16.0	1	1
Paddy Production	'000 tonnes	276	291	291	307	307	5	5
Cropping Intensity (excl. orchard)	% NCA	186%	182%	182%	189%	189%	4	4
Irrigated area	% NCA	65%	75%	75%	75%	75%	0	0
Net Crop Income	million Taka	933	969	969	1,029	1,029	6	6
Net fishery income	million Taka	42	41	41	9	9		
Crop flood loss reduction	million Taka				28	28		
Non-agric. flood loss reduction	million Taka				5	10		

Notes:
Project Year 1: assumed 1994/95
Future Without (1): Future Without Project Conditions, 5 years after project would have been completed
Future Without (2): Future Without Project Conditions, Year 30
Future With (1): Future With Project Conditions, 5 years after project completion
Future With (2): Future With Project Conditions, Year 30
% Increment (1): % difference FW (1) over FWO (1)
% Increment (2): % difference FW (2) over FWO (2)
Flood losses refer to average annual losses that will be eliminated by the project.
Values in 1991 financial prices

TABLE J.6.8

Summary of Cropping Pattern Changes

(% of NCA)

	Year 1	Future w'out(1)	Future w'out(2)	Future with(1)	Future with(2)
B Aus, local	4.2%	2.6%	2.6%	2.6%	2.6%
B Aus, HYV	1.5%	1.5%	1.5%	1.5%	1.5%
T Aus, local	2.6%	1.1%	1.1%	1.1%	1.1%
T Aus, HYV irri	3.0%	2.7%	2.7%	3.4%	3.4%
T Aus, HYV n-ir	8.9%	8.1%	8.1%	9.2%	9.2%
Mixed aus/aman	1.7%	1.7%	1.7%	2.0%	2.0%
B Aman local dw	15.5%	9.5%	9.5%	6.3%	6.3%
T Aman local dw	7.0%	7.0%	7.0%	8.0%	8.0%
T Aman, local	20.9%	20.9%	20.9%	13.6%	13.6%
T Aman HYV irri	3.2%	3.2%	3.2%	4.4%	4.4%
T Aman HYV n-ir	17.8%	17.8%	17.8%	30.2%	30.2%
Boro, local	0.7%	0.7%	0.7%	0.7%	0.7%
Boro, HYV irrig	64.1%	74.3%	74.3%	74.3%	74.3%
Boro HYV p-irr.	0.0%	0.0%	0.0%	0.0%	0.0%
Wheat irrig.	1.7%	1.5%	1.5%	1.5%	1.5%
Wheat unirrig.	7.9%	6.4%	6.4%	6.4%	6.4%
Potato irrig.	2.3%	2.3%	2.3%	2.3%	2.3%
Potato unirrig.	2.1%	2.1%	2.1%	2.1%	2.1%
Jute	3.7%	3.7%	3.7%	3.7%	3.7%
Pulses: ave.	3.6%	2.7%	2.7%	2.7%	2.7%
Mustard	11.0%	9.2%	9.2%	10.3%	10.3%
Spices (chilli)	0.8%	0.8%	0.8%	0.8%	0.8%
Veg. (brinjal)	1.9%	1.9%	1.9%	1.9%	1.9%
total	186.2%	181.6%	181.6%	188.8%	188.8%

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TABLE J.6.9

Summary of Results and Sensitivity Analyses

ZONES A & B

Capital cost	234.1 Tk.m.	construction period	4 years
Annual O&M cost	7.5 Tk.m.	(economic prices)	

Net Present Value @12%	46.8 Taka million (economic prices)
Economic Internal Rate of Return	14.9 %

Sensitivity Analyses

	Economic IRR (%)							
	Base	Change in Variable						Switching
Variable	Case	+10%	+25%	+50%	-10%	-25%	-50%	Value (%)
Capital Costs	14.9	13.8	12.3	10.5	16.1	18.5	24.4	29.15
O&M Costs	14.9	14.6	14.3	13.7	15.1	15.4	16.0	124.27
Fisheries Losses	14.9	14.0	12.6	10.3	15.7	17.0	19.2	31.58
Reduced flood losses	14.9	15.7	17.0	19.1	14.0	12.6	10.3	31.91
Total Benefits	14.9	17.1	20.2	24.9	12.5	8.4	-1.7	11.90
Incremental Net Crop Income	14.9	16.2	18.2	21.1	13.4	11.0	6.2	18.98
Delay in full benefits								
2 years	11.6							
4 years	10.1							
Delays in completion								
2 years	12.1							
4 years	10.8							

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y2

J.6.2 Zone C

This proposal is described in section J.3.2. The difficulty in analysing the proposed interventions in Zone C concern the rate and extent to which groundwater can be expected to be exploited in the "future without" project situation. This is because shallow tubewells are hampered by the presence of underground gas reserves which break suction in the pump when the gas passes through the system. Alternative force mode technology for either shallow or deep wells should overcome the problem but application of such technologies have been constrained by their cost and novelty (in the case of the shallow force mode tubewell). At economic prices both shallow and deep force mode wells are cheaper than the alternative of pumping water from the River Meghna into khals and out of khals onto the land with low lift pumps. A comparison of costs, based on the proposed pumping stations for Zone C, which are designed for an irrigation duty of 9800 ha has been made with both shallow and deep force mode tubewells, and the present value of providing one hectare of irrigation over 30 years at 12% calculated

Pump station and LLPs	PV (12%) per ha	=	Tk. 30 180
Shallow force Mode tubewell	PV (12%) per ha	=	Tk. 15 000
Deep tubewell	PV (12%) per ha	=	Tk. 17 800

(Present values assume the pump station takes four years to build and that investment in secondary pumping occurs in year 5. LLPs are 20 l/s, irrigating 10 ha with an operational life of 5 years. SFMTWs are 15 l/s, command 7.5 ha with an operational life of 10 years. DTWs are 30 l/s, irrigate 15 ha with an operational life of 10 years).

Thus it may be concluded that, if only irrigation is considered, exploiting groundwater will be cheaper, in economic prices at least. In financial prices the outcome is far less clearcut because:

1) electricity for irrigation is subsidised whereas gas oil is taxed

2) both shallow force mode and deep tubewells are expensive and it is likely that farmers would be reluctant to invest such large sums even if credit were easier to obtain than it is at present.

As a consequence it is by no means certain that investment in groundwater will occur without an official intervention to encourage its development (as for example the National Minor Irrigation Development Project). For these reasons three alternative analyses of Zone C proposals have been undertaken which are all based on different "without project" developments. Thus in each case, the "future with" is the construction of, the northern polder, with irrigation supplies sufficient for 9800 ha supplied by surface water and pumped drainage of the polder in the wet season, while the "future without" comprises:

1) No further development of ground water

2) a rapid development of groundwater such that 75% of NCA is irrigated by year 10 (with the balance of irrigation required in the "with project" also supplied by groundwater

3) a slow development of groundwater such that 53% of NCA is irrigated by year 10 (40% is irrigated at present) and 75% by year 15.

The results of these analyses are presented in Tables J.6.10, J.6.11 and J.6.12. With no "future without" groundwater development the proposal produces an IRR of 18.3%, benefiting from both increased irrigation areas and substantial drainage benefits within the polder (where for land increases from 7 to 73% NCA. With "future without" groundwater development the project bases its irrigation benefits and the IRR falls to less than 12%. As a result the scheme cannot be recommended for implementation until the practical applicability of shallow force mode tubewells is established or disproved. In the event of the latter, the scheme would look attractive although it must be remembered that there are substantial fisheries losses and environmental costs associated with its development.

J.6.3 Zone D

The two evaluated proposals for Zone D are:

1) the re-excavation of Khals to improve irrigation supply

2) the extension of the River Gumti embankment to provide protection to areas currently open to flash flooding.

Re-excavation of Khals

The re-excavation of Khals should increase the area able to irrigate with low lift pumps by approximately 10 000 ha.

The analysis of this option has been based on a cost comparison between excavation and irrigation using LLPs and the alternative costs of development with shallow tubewells (STW). There is little doubt that farmers will invest in LLPs given to opportunity to do so but in order to test the sensitivity to under-utilisation of water, the area of new irrigation required 12% was also calculated.

The cash flow for this calculation is presented in Table J.6.13 where it can be seen that with an increase of 10 000 ha the IRR = 28%. An IRR of 12% is obtained with an increase in irrigated area of 5200 ha, or just over half of what is expected.

Assumptions made for this analysis were:

1) LLPs and STWs are replaced every 5 years
2) LLPs command an area of 10 hectares, with a discharge of 20 l/s.
3) STWs command an area of 4.5 hectares with a discharge of 8 l/s.

Costs for LLPs and STWs out presented in Appendix J.1.

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TABLE J.6.10

Zone C(no further groundwater development)
Summary of Results and Sensitivity Analyses

Capital cost	323.3 Tk.m.	construction period	5 years
Annual O&M cost	25.9 Tk.m.	(economic prices)	

Net Present Value @12%	157.8 Taka million (economic prices)
Economic Internal Rate of Return	18.34 %

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable +10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
Capital Costs	18.3	17.2	15.6	13.6	19.7	22.2	28.4	74.09
O&M Costs	18.3	17.9	17.2	16.1	18.8	19.4	20.5	136.69
Fisheries Losses	18.3	18.1	17.7	17.0	18.6	19.0	19.7	218.32
Reduced flood losses	18.3	18.4	18.5	18.7	18.3	18.2	18.0	572.22
Total Benefits	18.3	20.2	22.9	26.8	16.3	12.8	5.2	28.25
Incremental Net Crop Income	18.3	20.2	22.7	26.5	16.4	13.1	5.9	29.33
Delay in full benefits								
2 years	15.0							
4 years	13.5							
Delays in completion								
2 years	14.9							
4 years	13.3							

06/02/93 GUMMOD.WK1

TABLE J.6.11

Zone C(10 year FWO groundwater development)
Summary of Results and Sensitivity Analyses

Capital cost	323.3 Tk.m.	construction period	5 years
Annual O&M cost	25.9 Tk.m.	(economic prices)	

Net Present Value @12%	-64.0 Taka million (economic prices)
Economic Internal Rate of Return	9.15 %

Sensitivity Analyses		Economic IRR (%)						
	Base	Change in Variable						Switching
Variable	Case	+10%	+25%	+50%	-10%	-25%	-50%	Value (%)
Capital Costs	9.1	8.4	7.4	6.1	10.0	11.4	14.8	30.05
O&M Costs	9.1	8.6	7.8	6.3	9.7	10.5	11.7	55.44
Fisheries Losses	9.1	8.8	8.3	7.4	9.5	10.0	10.8	88.55
Reduced flood losses	9.1	9.2	9.3	9.5	9.1	8.9	8.7	372.24
Total Benefits	9.1	10.7	12.8	15.8	7.4	4.2	-5.2	19.01
Incremental Net Crop Income	9.1	10.6	12.6	15.5	7.5	4.5	-3.7	20.12
Delay in full benefits								
2 years	8.6							
4 years	7.5							
Delays in completion								
2 years	7.7							
4 years	6.9							

TABLE J.6.12

Zone C(15 year groundwater development)
Summary of Results and Sensitivity Analyses

Capital cost	327.1 Tk.m.	construction period	5 years
Annual O&M cost	25.9 Tk.m.	(economic prices)	

Net Present Value @12%	-17.7 Taka million (economic prices)
Economic Internal Rate of Return	11.16 %

Sensitivity Analyses

Variable	Base Case	Economic IRR (%) Change in Variable +10%	+25%	+50%	-10%	-25%	-50%	Switching Value (%)
Capital Costs	11.2	10.2	9.1	7.5	12.2	14.1	18.7	8.20
O&M Costs	11.2	10.6	9.7	8.2	11.7	12.5	13.8	15.31
Fisheries Losses	11.2	10.8	10.3	9.4	11.5	12.0	12.9	24.45
Reduced flood losses	11.2	11.2	11.4	11.6	11.1	10.9	10.7	97.54
Total Benefits	11.2	12.9	15.4	18.9	9.2	5.7	-4.2	4.58
Incremental Net Crop Income	11.2	12.9	15.2	18.6	9.3	6.0	-2.7	4.81
Delay in full benefits								
2 years	9.1							
4 years	8.1							
Delays in completion								
2 years	9.3							
4 years	8.3							

06/02/93 GUMMOD.WK1

TABLE J.6.13
Irrigation Supply Improvement Economic Analysis

Year	Capital Cost	O&M Cost	LLP Capital Cost	LLP O&M Cost	STW Capital Cost	STW O&M Cost	Cash Flow
1	-2111.97						-2111.97
2	-2111.97						-2111.97
3	-20315.82						-20315.82
4	-20315.82						-20315.82
5		-1451.93	-24430.00	-8661.00	54162.22	16066.67	35685.96
6		-1451.93		-8661.00		16066.67	5953.73
7		-1451.93		-8661.00		16066.67	5953.73
8		-1451.93		-8661.00		16066.67	5953.73
9		-1451.93		-8661.00		16066.67	5953.73
10		-1451.93	-24430.00	-8661.00	54162.22	16066.67	35685.96
11		-1451.93		-8661.00		16066.67	5953.73
12		-1451.93		-8661.00		16066.67	5953.73
13		-1451.93		-8661.00		16066.67	5953.73
14		-1451.93		-8661.00		16066.67	5953.73
15		-1451.93	-24430.00	-8661.00	54162.22	16066.67	35685.96
16		-1451.93		-8661.00		16066.67	5953.73
17		-1451.93		-8661.00		16066.67	5953.73
18		-1451.93		-8661.00		16066.67	5953.73
19		-1451.93		-8661.00		16066.67	5953.73
20		-1451.93	-24430.00	-8661.00	54162.22	16066.67	35685.96
21		-1451.93		-8661.00		16066.67	5953.73
22		-1451.93		-8661.00		16066.67	5953.73
23		-1451.93		-8661.00		16066.67	5953.73
24		-1451.93		-8661.00		16066.67	5953.73
25		-1451.93	-24430.00	-8661.00	54162.22	16066.67	35685.96
26		-1451.93		-8661.00		16066.67	5953.73
27		-1451.93		-8661.00		16066.67	5953.73
28		-1451.93		-8661.00		16066.67	5953.73
29		-1451.93		-8661.00		16066.67	5953.73
30		-1451.93	-24430.00	-8661.00	54162.22	16066.67	35685.96
						NPV at 12%	36633.43
						IRR	27.87%

Extension of the River Gumti Embankment

The proposal is to construct a submersible embankment along the right bank of the Gumti in order to prevent flash flooding between January and June. The difficulty in analysing the proposal stems from a lack of knowledge in predicting the frequency and extent of flash floods, mainly arising from the fact that the previous extension was only completed within the last two years, so current conditions all not well defined.

In addition it is not known to what extent the current proposal will simply move the location of flooding in exactly the some way as the previous extension has done. They are good reasons for supposing that the proximity of the end of the proposed embankment to the River Meghna will alleviate flash flooding very considerably as the low flows in the Meghna at this time should encourage the water to flow into the river rather than back up and cause flooding. The Khal re-excavation programme should also assist in reducing flooding by greatly increasing the water holding capacity of the khals. An analysis was undertaken to determine the minimum annual are of boro which would need to be saved to make the scheme worthwhile. As the scheme is so cheap, this minimum area is only 65 hectares. Given that unofficial estimates of damage in 1993 exceed 1000 hectares it seems most unlikely that the proposal will not be worthwhile. Analysis of the areas flooded prior to the extension completed in 1991 suggest that about 300 hectares are damaged every three years. Inserting these figures (i.e. 100 ha per year) into the cash flow produces an IRR of 24%. The Cash flow is presented in Table J.6.14.

J.6.4 Full Area FCD and FCDI Proposals

A description of these proposals is given in sections J.3.4 and J.3.5.

Full Area FCD

This proposal has been analysed on the basis of model projections for areas of crops which can be safely grown. Cropping patterns were derived for Zones A, B, C and D and are amalgamated for inclusion in the economic model. Groundwater development and irrigation coverage are assumed to be the same as for the other options i.e. 75% in Zones A, B and C and 60% in Zone D.

The economic analysis produced a negative rate of return. It remained negative when fishery losses were reduced to zero, mainly because the agricultural incremental benefits are extremely low. These are caused by severe internal drainage problems which limit improvements in the flood regime. The expected change in flood phases is given below:

	Highland(F0)	Medium land(F1)	Low land (F2+)
Zone A			
Present	38%	43%	19%
FCD	54%	40%	6%

TABLE J.6.14
Gumti Submersible Embankment Economic Analysis

Year	Capital Cost	O&M Cost	Benefit	Cash Flow
1	-478.06			-478.06
2	-1668.20			-1668.20
3	-7333.62			-7333.62
4		-291.54	2704.60	2413.06
5		-291.54	2704.60	2413.06
6		-291.54	2704.60	2413.06
7		-291.54	2704.60	2413.06
8		-291.54	2704.60	2413.06
9		-291.54	2704.60	2413.06
10		-291.54	2704.60	2413.06
11		-291.54	2704.60	2413.06
12		-291.54	2704.60	2413.06
13		-291.54	2704.60	2413.06
14		-291.54	2704.60	2413.06
15		-291.54	2704.60	2413.06
16		-291.54	2704.60	2413.06
17		-291.54	2704.60	2413.06
18		-291.54	2704.60	2413.06
19		-291.54	2704.60	2413.06
20		-291.54	2704.60	2413.06
21		-291.54	2704.60	2413.06
22		-291.54	2704.60	2413.06
23		-291.54	2704.60	2413.06
24		-291.54	2704.60	2413.06
25		-291.54	2704.60	2413.06
26		-291.54	2704.60	2413.06
27		-291.54	2704.60	2413.06
28		-291.54	2704.60	2413.06
29		-291.54	2704.60	2413.06
30		-291.54	2704.60	2413.06
			NPV at 12%	6665.24
			IRR	23.75%

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Zone B			
Present	20%	24%	56%
FCD	34%	23%	33%
Zone C			
Present	5%	21%	74%
FCD	12%	27%	61%
Zone D			
Present	3%	10%	87%
FCD	4	14%	82%
Total			
Present	14%	23%	63%
FCD	23%	27%	51%

At economic prices the project costs Tk 33 000 per hectare, which is simply too much for the relatively modest improvements achieved.

FCDI

This option is analysed on the same basis as the FCD proposal with the difference that a far higher proportion of irrigation is supplied using LLPs (47%) and higher cropping intensities are achieved in the wet season through improved drainage.

The project produces a slightly better IRR than the FCD proposal although it is still negative.

Flood regime changes are given below:

	Highland(F0)	Medium land(F1)	Low land (F2+)
Present	14%	23%	63%
FCDI	33%	26%	42%
1990 Study	0 - 30 CM	30 - 60 CM	60 CM+
Present	21%	9%	70%
FCDI (104.5 cumecs)	89%	4%	7%

The discrepancy between the results presented here and the 1990 study are explained in part by the differences in post project flooding regimes. Other important factors in explaining the differences are the yield increases assumed in the "future with" project over the future without project in the 1990 study and the far lower irrigation coverage assumed. In addition the 1990 study incorporated flood losses of 5% for wet season crops in the "without project" analysis whereas the current study uses rather lower figures. These have been offset however by the inclusion in this analysis of non agricultural damage and flash flood damage to the boro crop. At economic prices, the project costs Tk 45 800 per cultivated hectare to construct, and Tk 1400 per hectare per year to operate. With this level of costs, benefits would have to be doubled to make the project worthwhile, which is roughly what would happen of the project had managed to convert ready 90% of NCA to F0 as was envisaged by the 1990 study.

J.6.5 Financial Analyses

Financial Analysis of farm models has been restricted to Zones A and B, as these are the only proposals recommended for immediate implementation.

Given the relatively small agricultural changes anticipated, many farmers are not expected to change their farming systems greatly. Many of those pumps inside the proposed embankments are also unlikely to experience significant changes in flooding regimes although they will of course benefit from protection from floods. The major impact of the project will fall on those farmers whose land classification will be changed moving from medium land (F1) to highland (F0) or from low land (F2) to medium land (F1).

Farm models reflecting these changes are presented in Tables J.6.15 and J.6.16 for Zones A and B. They are presented in Tk per hectare for farmers on HL (highland), ML (Medium land) and LL (Low land), in Tk per average farm size for sharecroppers (as sharecropping is an activity restricted to small and medium farm sizes, only these sizes are included).

Given the relatively small changes in flooding regimes which the project is expected to precipitable, most farmers will only benefit from flood protection. Farmers in areas where flooding regimes will be improved should benefit from opportunities to cultivate higher value varieties of T aman in the wet season. Given that high yielding varieties of T aman are already widely cultivated on high lands, it seems likely that farmers will react positively to improved flooding regimes. As a very high proportion of farmers are owner occupiers (80%), disincentives arising from sharecropping arrangements which substantially increase the risks in growing high input crops are of little importance. Following detailed design it will be possible to identify much more precisely which areas benefit directly and a programme to encourage farmers to switch to HYV or LT aman could easily be devised by the extension service within its current budget. Even though the agricultural incremental benefits are not substantial, it is obviously still very important that they are obtained if the project is to be worthwhile. The most useful factor in favour of the project is that changed flooding regimes often allow farmers to adopt what is probably the most preferred cropping pattern, boro followed by T aman. This is popular because it allows farmers plenty of time between the crops to organise and prepare for the next one, and a reasonable window in which to plant and harvest the crop.

TABLE J.6.15

ZONE A Farm Models

Returns per Ha at Financial Prices assuming no change in land type

	Marginal HL	Small HL	Medium HL	Large HL	Marginal ML	Small ML	Medium ML	Large ML	Marginal LL	Small LL	Medium LL	Large LL
Present	45313.77	39606.80	35547.50	36456.45	33700.99	29076.63	25823.40	26457.19	26153.19	22438.70	19771.96	21157.22
Future Without	46456.30	40302.38	35963.16	37021.34	34784.50	29787.61	26311.27	26979.01	27130.83	23058.07	20184.51	21488.77
Future With	49186.51	42930.65	38526.47	39759.71	35291.74	30450.06	27080.61	27839.09	29270.53	25011.37	22033.53	23263.62
FW less FWO	2730.211	2628.269	2563.308	2738.365	507.2383	662.4437	769.3394	860.0860	2139.699	1953.300	1849.023	1774.855

Returns per Ha at Financial Prices assuming changes in land type

	ML to HL	ML to HL	ML to HL	ML to HL	LL to ML	LL to ML	LL to ML	LL to ML
Present	33700.99	29076.63	25823.40	26457.19	26153.19	22438.70	19771.96	21157.22
Future Without	34784.50	29787.61	26311.27	26979.01	27130.83	23058.07	20184.51	21488.77
Future With	49186.51	42930.65	38526.47	39759.71	35291.74	30450.06	27080.61	27839.09
FW less FWO	14402.01	13143.04	12215.19	12780.70	8160.903	7391.985	6896.102	6350.327

Returns per average farm size at Financial Prices assuming changes in land type

Farm size	0.15	0.6	1.5	3.9	0.15	0.6	1.5	3.9
Present	5055.149	17445.98	38735.10	103183.0	3922.978	13463.22	29657.94	82513.17
Future Without	5217.675	17872.56	39466.91	105218.1	4069.625	13834.84	30276.77	83806.20
Future With	7377.977	25758.39	57789.70	155062.8	5293.761	18270.03	40620.92	108572.4
FW less FWO	2160.301	7885.825	18322.79	49844.73	1224.135	4435.191	10344.15	24766.27

Sharecropper Returns per ha at Financial Prices no assuming changes in land type

	Small HL	Medium HL	Small ML	Medium ML	Small LL	Medium LL
Present	22302.21	18242.90	15755.63	12502.40	11860.61	8987.051
Future Without	22486.56	18147.34	15927.50	12451.17	11860.61	8987.051
Future With	25788.95	21384.76	17774.88	14405.44	14314.18	11336.34
FW less FWO	3302.380	3237.420	1847.374	1954.270	2453.575	2349.297

Sharecropper Returns per average farm size at Financial Prices no assuming changes in land type

	ML to HL 0.6	ML to HL 1.5	LL to ML 0.6	LL to ML 1.5
Present	**15755.63**	12502.40	11860.61	8987.051
Future Without	**15927.50**	12451.17	11860.61	8987.051
Future With	**25788.95**	21384.76	17774.88	14405.44
FW less FWO	**9861.442**	8933.593	5914.272	5418.389

TABLE J.6.16

ZONE B Farm Models

Returns per Ha at Financial Prices assuming no change in land type

	Marginal HL	Small HL	Medium HL	Large HL	Marginal ML	Small ML	Medium ML	Large ML	Marginal LL	Small LL	Medium LL	Large LL
Present	34234.61	30170.59	27252.10	28110.50	30807.90	26901.58	24116.06	24796.74	25119.06	21554.19	19000.60	20399.08
Future Without	34903.62	30644.72	27624.00	28386.73	31650.64	27464.92	24519.33	25134.21	25512.48	21752.45	19095.66	20445.61
Future With	41022.01	35931.89	32318.49	33666.50	32088.88	27921.70	24991.57	25643.15	26491.78	22637.01	19926.66	21225.82
FW less FWO	6118.389	5287.168	4694.488	5279.769	438.2318	456.7767	472.2415	508.9314	979.2986	884.5547	831.0079	780.2092

Returns per Ha at Financial Prices assuming changes in land type

	ML to HL	ML to HL	ML to HL	ML to HL	LL to ML	LL to ML	LL to ML	LL to ML
Present	30807.90	26901.58	24116.06	24796.74	25119.06	21554.19	19000.60	20399.08
Future Without	31650.64	27464.92	24519.33	25134.21	25512.48	21752.45	19095.66	20445.61
Future With	41022.01	35931.89	32318.49	33666.50	32088.88	27921.70	24991.57	25643.15
FW less FWO	9371.366	8466.972	7799.158	8532.282	6576.391	6169.245	5895.916	5197.540

Returns per average farm size at Financial Prices assuming changes in land type

	0.13	0.5	1.6	3.6	0.13	0.5	1.6	3.6
Present	4005.028	13450.79	38585.70	89268.27	3265.477	10777.09	30400.96	73436.69
Future Without	4114.584	13732.46	39230.93	90483.19	3316.623	10876.22	30553.05	73604.20
Future With	5332.862	17965.94	51709.58	121199.4	4171.554	13960.85	39986.52	92315.34
FW less FWO	1218.277	4233.486	12478.65	30716.21	854.9309	3084.622	9433.465	18711.14

Sharecropper Returns per ha at Financial Prices assuming no changes in land type

	Small HL	Medium HL	Small ML	Medium ML	Small LL	Medium LL
Present	17308.61	14390.12	15187.52	12402.00	11825.53	9168.741
Future Without	17479.88	14459.15	15411.47	12465.88	11825.53	9168.741
Future With	21219.46	17606.06	16339.46	13409.33	12894.30	10183.96
FW less FWO	3739.589	3146.909	927.9894	943.4542	1068.768	1015.221

Sharecropper Returns per average farm size at Financial Prices assuming changes in land type

	ML to HL 0.5	ML to HL 1.6	LL to ML 0.5	LL to ML 1.6
Present	7593.763	19843.20	5912.769	14669.98
Future Without	7705.737	19945.41	5912.769	14669.98
Future With	10609.73	28169.70	8169.732	21454.94
FW less FWO	2903.997	8224.288	2256.963	6784.955

APPENDIX J.I

ECONOMICS OF MINOR IRRIGATION

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APPENDIX J.I

ECONOMICS OF MINOR IRRIGATION

Costs used in project economic appriasal

1. Specification:

The attached tables show the cost of different modes of minor irrigation. Capital and operating costs have been calculated for a range of different technologies as shown in Table **. These include:

a. LLP 1 - 0.7/1.0 cu.sec pump irrigating 10 ha, using the same 8hp engine as a STW.

b. LLP 2 - 2 cusec pump irrigating 20 ha.

c. STW - a conventional STW using a Japanese engine. Although many STWs have cheaper Chinese engines, these are slightly less fuel efficient and have a shorter life (crankshfts usually break after 2 or 3 years, so their overall cost has been calculated to be slightly higher than the Japanese engine.

d. DSSTW - as for the STW but in an unlined pit 1.5 m deep.

f. SFMTW 1 - force mode shallow well for areas where there is gas. Although it uses the same engine, it has higher output that the STW as it would not run into suction problems at the end of the season.

g. SFMTW 2 - for areas where there is also a salinity problem as well as gas - this well skims of fresh water from a shallow fresh upper aquifer.

h. SFMTW 3 - a larger version of SFMTW 1

i. DFMTW 1 - a 1 cu sec version of a DTW for deeper aquifers.

j. DFMTW 2 - a 2 cusec DTW similar to existing wells but with materials and costs adjusted to make it more appropriate for private sector investment.

k. DFMTW 3 - a special well for the conditions of the saline area of Noahkali.

2. Capital costs

a. The screen cost of SFMTW 2 is high as its a large diameter screen into which the pump in placed.

b. Capital costs annualized over the life of the well/pump at an interest rate of 12% per year.

c. The pump survey showed that less than 10% of engines are used for other purposes in the off-season so no allowance has been made for this extra income.

d. The cost of water channel construction (unlined earth) has been calculated for different well options. The length of channel per ha irrigated and the average cross section rises as the command area increases, as more and bigger channels would be needed. The cost is purely that of labour for earth moving.

3. Operating Costs

a. Hours of pump operation are all well within normal limits. The relative short hours of LLP 2 and DTW 2 indicate that command areas for 2 cusec pumps are more likely to be limited by management/distribution issues than by pump capacity.

b. Pump and engine efficiency is based on the DTW II Project Technology Report. The efficiency of centrifugal pumps in STW is lower than the same pump in LLP or FM pumps as they reach suction limits when water levels fall.

c. The static water table varies between modes to reflect the varying conditions that they would be used under.

d. Draw down is based on well output and well yield - the 2 cusec DTW 3 is 12 lt/sec/m, the 1 cusec DTW is 10.29 (as screen diameter is smaller) -this is also used for the FMSTWs - and STW/DSSTWs, with crude and cheap screen only get 6 l/s/m.

e. Total pumping head is SWL + draw-down +2% friction loss + 1 metre above the surface.

f. Fuel consumption is calculated as cu.m. water ÷ 275 ÷ pump efficiency × 0.25. It gives similar fuel consumption rates to the DTW II report for DTW, but rather less for STW.

g. Fuel cost is Tk14/lt plus 10% for oil. Costs have not been calculated for electric pumps as, although the financial cost is lower, the economic cost is similar to that of diesel as the high cost of rural power disrtribution needs to be taken into account.

h. Spares cost as a percentage of engine and pump cost per 1000 hours of operation. 10% is added for mechanics charges.

i. The cost of the pump operator is the hourly wage rate times the annual hours of operation. However as operators do other work such as water distribution, only a third of a man is need for the LLP, STW and SFMTW, and half a man for the DTW.

j. Water guard and channel maintenance as based on the cost of one man per day of the season per 30 ha irrigated.

k. Miscellaneous costs include annual re-excavation of DSSTW pits.

3. Total cost per ha indicates that:

- LLP is significantly cheaper, at a cost of under Tk2,500 per ha per year.
- DTW and DSSTW are more expensive, at over Tk5,500 per year. The special DTW 3 for the special saline conditions of Noahkali is particularly expensive, suggesting that development of alternative surface water supplies is a more feasible option.
- There is little difference between STW and SFMTW. For small command areas STW remain the cheapest option, and will continue to be prefered due to their lower capital costs. Howver SFMTWs do provide a low cost option,even at slightly greater depths to water than STW and DSSTW: - but this is a new and largely untried concept in Bangladesh.

4. Costs have also been calculated at economic prices using conversion factors determined by FPCO. Irrigation costs are substantially lower than at financial prices, but the relative ranking of the different modes and technologies remain broadly similar.

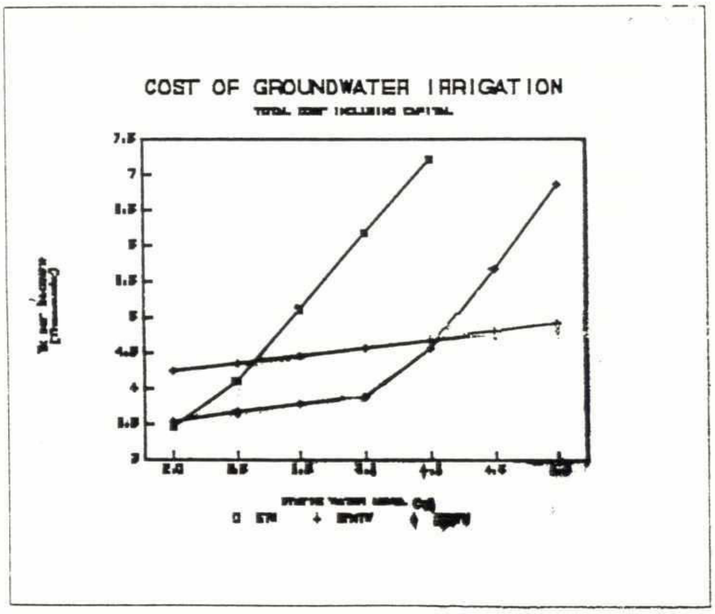
5. The cost of traditional irrigation has been calculated as the cost of two men operating a swing basket for a 90 day period during the boro season. This amounts to Tk7,200 per ha in financial prices or Tk5,400 at economic prices. This is substantially more than alternative sources such as LLP and STW. In fact what the farmer is paying for with his own labour is a saving on hiring a mechanical pump. Therefore the labour cost has been reduced by 50% which puts it between an LLP and STW. In practice actual labour use may be less than 180 days per ha as farmers apply less than optimal amount of water. There is evidence from Gumti (but not Naohkali) that traditionally irrigated boro does yields less (and also gets lower levels of fertiliser).

6. Crop budgets at financial prices include irrigation costs based on fees charged in pumps surveyed in the Gumti II irrigation pump survey. An overall fee for irrigating boro has been calculated using the average for different modes wieghted by the proportion of modes found in the region. The cost for other crops has been calculated according to the proportion that their fees are to the boro fee. It is assumed that local boro only needs half the irrigation of hyv boro as it is grown in naturally wet places. In both Noahkali and Gumti a flat rate irrigation fee is the normal method of charging for water, rather than a share of the crop.

Appraisal of Shallow Force Mode Tubewells

In some parts of the region farmers complain that groundwater supplies are limited and STW run dry towards the end of the season. Although recharge may be sufficient to support a larger area of irrigation, the aquifer may lack suffient storage in its uppermost layer which is easily accessible to STWs. As the water table falls the STWs' suction pump reaches its limit and the operator has to reduce the rate of pumping by slowing the engine. This in turn makes the pump less efficient in terms of energy needed to raise water and the reduced supply also limits the command area.

Table 2 and Figure 1 compare the cost of three technologies, STW, DSSTW and SFMTW, with the depth to water table varying from 2 to 5 metres. The STW, with its low capital cost, produces water most cheaply when the water is within 2 m of the surface, but as soon as the water table starts to fall, it is worth deep setting the STW to maintain pump efficiency. It is prehaps surprising that more STW are not deep set - which only tends to happen as the water table falls out of reach of the suction limit. The SFMTW has a higher capital cost, but its efficiency is not effected by the depth to the water table. At over 2.5 metres the SFMTW becomes a cheaper water source than the STW, but the DSSTW maintains its efficiency up to 4.5 m - and if the pit were deeper than 1.5m its advantage would be continued further.



This analysis indicates that both DSSTW and SFMTW can provide an enonomic alternative to STW in situations where the water table has fallen sufficiently to reduce the efficiency of STW operation.

COST OF MINOR IRRIGATION

WATER CHANNELS										
Type of well	LLP1	LLP2	STW	DSSTW	SFMTW1	SFMTW2	SFMTW3	DFMTW1	DFMTW2	DFMTW3
Command area	10.0	20.0	4.5	4.5	7.5	7.5	11.0	15.0	22.0	15.0
Chahnnel length/ha	80	80	60	60	60	60	80	90	90	90
Ave. cross section	0.9	0.9	0.6	0.6	0.6	0.6	0.9	0.9	0.9	0.9
Cu.m. soil per ha	72	72	36	36	36	36	72	81	81	81
Cu.m. dug per day	3	3	3	3	3	3	3	3	3	3
Cost/person – day	40	40	40	40	40	40	40	40	40	40
Cost per ha	960	960	480	480	480	480	960	1080	1080	1080
Cost per well	9600	19200	2160	2160	3600	3600	10560	16200	23760	16300

SCECIFICATION	LLP1	LLP2	STW	DSSTW	SFMTW1	SFMTW2	SFMTW3	DFMTW1	DFMTW2	DFMTW3
Discharge l/sec	20	56	8	8	15	15	23	30	60	30
Command area	10.0	20.0	4.5	4.5	7.5	7.5	11.0	15.0	22.0	15.0
Pump chamber – m	0	0	0	0	18	12	18	21	24	27
Screen length – m	0	0	12	12	12	12	18	18	24	18
Blank casing – m	3	3	18	18	0	0	0	21	22	105
Well depth – m	0	0	30	30	30	24	36	60	70	150

CAPITAL COST (financial prices)

Prices:											
Pump chamber	per metre	0	0	0	0	330	330	340	1250	1608	1250
Well screen	per metre	0	0	180	180	240	1280	656	656	656	656
Blank casing	per metre	150	150	150	150	330	330	340	623	623	623
Installation	per metre	0	0	60	60	300	300	400	500	780	900
Costs:											
Pump chamber		0	0	0	0	5940	3960	6120	26250	38592	33750
Well screen		0	0	2160	2160	2880	15360	11808	11808	15744	11808
Blank casing		450	450	2700	2700	0	0	0	13083	13706	65415
Other costs		500	500	1700	1700	10000	10000	12000	15000	25000	15000
Total well components		950	950	6560	6560	18820	29320	29928	66141	93042	125973
Engine and pump		26500	66250	26500	26500	51500	51500	63000	74500	200000	74500
Installaiton & pit		0	0	2160	3160	10800	9000	16800	33000	59280	140400
Water channels		9600	19200	2160	2160	3600	3600	10560	16200	23760	16200
Total capital		37050	86400	37380	38380	84720	93420	120288	189841	376082	357073
Assumed life	years	5	5	5	5	10	10	10	10	10	10
Capital cost (incl. channel)		37050	86400	37380	38380	84720	93420	120288	189841	376082	357073
Cost per year – int. :	16%	11315	26387	11416	11722	17529	19329	24888	39278	77812	73879
Total/ha/year		1132	1319	2537	2605	2337	2577	2263	2619	3537	4825

		LLP1	LLP2	STW	DSSTW	SFMTW1	SFMTW2	SFMTW3	DFMTW1	DFMTW2	DFMTW3
OPERATING COSTS (financial prices)											
Re nents											
W mm/season		740	740	740	740	740	740	740	740	740	740
Peak mm/day		9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
Length of season		140	140	140	140	140	140	140	140	140	140
Hours of operation											
Per day: peak		13.54	9.67	15.23	15.23	13.54	13.54	12.95	13.54	9.93	13.54
	Average	7.34	5.24	8.25	8.25	7.34	7.34	7.02	7.34	5.38	7.34
Total per		1027	734	1155	1155	1027	1027	982	1027	753	1027
Pump efficiency		50%	50%	38%	38%	50%	50%	50%	50%	55%	50%
Static wa vel	meters	3.0	3.0	3.0	4.5	5.5	5.5	5.5	9.0	9.0	9.0
Drawdown – m	meters	0.0	0.0	1.3	1.3	2.5	1.3	2.2	2.9	5.0	2.9
Total pump head	meters	4.1	4.1	5.4	7.0	9.2	7.9	8.9	13.2	15.3	13.2
Fuel consumption	Litre/hr.	0.53	1.49	0.37	0.48	0.90	0.77	1.34	2.58	5.46	2.58
	Litre/yr.	546	1092	431	553	924	795	1315	2653	4109	2653
	Litre/ha.	55	55	39	50	50	43	48	72	76	72
Operation Costs											
Fuel and oil		8407	16813	6645	8521	14225	12245	20250	40858	63278	40858
Spares costs as % of pump/engine											
Cost per 1000 hours per yr.		4%	4%	4%	4%	4%	4%	4%	4%	3%	4%
Taka per year		1089	1944	1225	1225	2116	2116	2476	3061	4519	3061
Mechanic charges		109	194	122	122	212	212	248	306	452	306
Labour cost	Operator	1712	1223	1926	1926	1712	2568	2456	2568	1883	2568
Water guard/channel maint.		1400	2800	630	630	1050	1050	1540	2100	3080	2100
Miscellaneous costs & pit		300	450	300	1300	600	600	700	750	1000	750
Total Cost	per year	13016	23425	10848	13724	19914	18790	27670	49643	74212	49643
(Operating)	per ha	1302	1171	2411	3050	2655	2505	2515	3310	3373	3310
T ALL COST PER HA		2433	2491	4948	5655	4992	5083	4778	5928	6910	8235
per ha/mm		3.29	3.37	6.69	7.65	6.75	6.87	6.46	8.02	9.34	11.14

IC PRICES

	C.F.	LLP1	LLP2	STW	DSSTW	SFMTW1	SFMTW2	SFMTW3	DFMTW1	DFMTW2	DFMTW3
Capital costs:											
Pump chamber	0.61	0	0	0	0	3623	2416	3733	16013	23541	20588
Well screen	0.61	0	0	1318	1318	1757	9370	7203	7203	9604	7203
Blank casing	0.61	275	275	1647	1647	0	0	0	7981	8361	39903
Other costs	0.87	435	435	1479	1479	8700	8700	10440	13050	21750	13050
Total well components		710	710	4444	4444	14080	20485	21376	44246	63256	80744
Engine and pump	0.62	16430	41075	16430	16430	31930	31930	39060	46190	124000	46190
Installation and pit	0.87	0	0	1879	2749	9396	7830	14616	28710	51574	122148
Water channels	0.75	7200	14400	1620	1620	2700	2700	7920	12150	17820	12150
Total capital cost		24340	56185	24373	25243	58106	62945	82972	131296	256649	261232
Cost per year – int. =	12%	6752	15586	6761	7003	10284	11140	14685	23237	45423	46234
Total/ha/yr.		675	779	1503	1556	1371	1485	1335	1549	2065	3082
Operating Costs	c.f.										
l oil	0.63	5296	10592	4186	5368	8962	7714	12758	25741	39865	25741
	0.62	675	1205	759	759	1312	1312	1535	1898	2802	1898
Mechanic	0.87	95	169	107	107	184	184	215	266	303	266
Operator	0.75	1284	917	1444	1444	1284	1926	1842	1926	1412	1926
Water Guard	0.75	1050	2100	473	473	788	788	1155	1575	2310	1575
Miecellaneous	0.87	261	392	261	1131	522	522	609	653	870	653
Total		8661	15375	7230	9282	13051	12446	18114	32058	47652	32058
Total per ha		866	769	1607	2063	1740	1659	1647	2137	2166	2137
TOTAL ALL COST PER HA		1541	1548	3109	3619	3111	3145	2982	3686	4231	5219

COMPARISON OF COST OF SUCTION AND FORCE MODE PUMPS AT DIFFERENT DEPTHS TO WATER TABLE

	STW	STW	STW	STW	STW	SFMTW 1	SFMTW 1	SFMTW 1	SFMTW 1	SFMTW 1	SFMTW 1	SFMTW 1	DSSTW	DSSTW	DSSTW	DSSTW	DSSTW	DSSTW	DSSTW
SPECIFICATION																			
Depth to water table(m)	2.0	2.5	3.0	3.5	4.0	2.0	2.5	3.0	3.5	4.0	4.5	5.0	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Discharge l/sec	12	10	8	6	5	12	12	12	12	12	12	12	12	12	12	12	10	8	6
Command area	7.5	6.0	4.5	3.8	3.2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	6.0	4.5	3.8
													0	0	0	0	0	0	0
Pump chamber – m	0	0	0	0	0	18	18	18	18	18	18	18	12	12	12	12	12	12	12
screen length – m	12	12	12	12	12	12	12	12	12	12	12	12	18	18	18	18	18	18	18
Blank casing – m	18	18	18	18	18	0	0	0	0	0	0	0	30	30	30	30	30	30	30
Well depth – m	30	30	30	30	30	30	30	30	30	30	30	30							
CAPITAL COSTS (financial prices)																			
Prices:																			
Pump chamber/m	0	0	0	0	0	330	330	330	330	330	330	330	0	0	0	0	0	0	0
Well screen/m	240	240	240	240	240	240	240	240	240	240	240	240	180	180	180	180	180	180	180
Blank casing/m	230	230	230	230	230	330	330	330	330	330	330	330	150	150	150	150	150	150	150
Installation/m	100	100	100	100	100	300	300	300	300	300	300	300	60	60	60	60	60	60	60
Costs:																			
Pump chamber	0	0	0	0	0	5940	5940	5940	5940	5940	5940	5940	0	0	0	0	0	0	0
Well screen	2880	2880	2880	2880	2880	2880	2880	2880	2880	2880	2880	2880	2160	2160	2160	2160	2160	2160	2160
Blank casing	4140	4140	4140	4140	4140	0	0	0	0	0	0	0	2700	2700	2700	2700	2700	2700	2700
Other costs	1700	1700	1700	1700	1700	10000	10000	10000	10000	10000	10000	10000	1700	1700	1700	1700	1700	1700	1700
Total well components	8720	8720	8720	8720	8720	18820	18820	18820	18820	18820	18820	18820	6560	6560	6560	6560	6560	6560	6560
Engine and pump	26500	26500	26500	26500	26500	51500	51500	51500	51500	51500	51500	51500	26500	26500	26500	26500	26500	26500	26500
Installation & pit	3600	3600	3600	3600	3600	10800	10800	10800	10800	10800	10800	10800	3160	3160	3160	3160	3160	3160	3160
Water channels	2160	2160	2160	2160	2160	3600	3600	3600	3600	3600	3600	3600	2160	2160	2160	2160	2160	2160	2160
Total capital	40980	40980	40980	40980	40980	84720	84720	84720	84720	84720	84720	84720	38380	38380	38380	38380	38380	38380	38380
Assumed life	5	5	5	5	5	10	10	10	10	10	10	10	5	5	5	5	5	5	5
Capital cost	38820	38820	38820	38820	38820	81120	81120	81120	81120	81120	81120	81120	38380	38380	38380	38380	38380	38380	38380
Cost per year	11856	11856	11856	11856	11856	16784	16784	16784	16784	16784	16784	16784	11722	11722	11722	11722	11722	11722	11722
	1581	1976	2635	3120	3705	2238	2238	2238	2238	2238	2238	2238	1563	1563	1563	1563	1954	2605	3085

OPERATING COSTS (financial prices)		STW	STW	STW	STW	STW	SFMTW I	SFMTW I	SFMTW I	SFMTW I	SFMTW I	SFMTW I	SFMTW I	DSSTW	DSSTW	DSSTW	DSSTW	DSSTW	DSSTW	DSSTW
Requirements																				
Water: mm/season		740	740	740	740	740	740	740	740	740	740	740	740	740	740	740	740	740	740	740
Peak: mm/day		9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
Length of season		140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
Hours of operation																				
Per day: peak		16.93	16.25	15.23	17.15	17.33	16.93	16.93	16.93	16.93	16.93	16.93	16.93	16.93	16.93	16.93	16.93	16.25	15.23	17.15
		9.17	8.80	8.25	9.29	9.39	9.17	9.17	9.17	9.17	9.17	9.17	9.17	9.17	9.17	9.17	9.17	8.80	8.25	9.29
Total per year		1284	1233	1155	1301	1315	1284	1284	1284	1284	1284	1284	1284	1284	1284	1284	1284	1233	1155	1301
Pump/engine efficiency		45%	42%	38%	32%	30%	50%	50%	50%	50%	50%	50%	50%	45%	45%	45%	45%	42%	38%	32%
Static water level		2.0	2.5	3.0	3.5	4.0	2.0	2.5	3.0	3.5	4.0	4.5	5.0	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Drawdown – m		2.0	1.7	1.3	1.0	0.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.7	1.3	1.0
Total pump head		5.1	5.3	5.4	5.6	5.9	5.1	5.6	6.1	6.6	7.1	7.6	8.1	5.1	5.6	6.1	6.6	6.8	7.0	7.1
Fuel consurmption: lt/hr		0.44	0.41	0.37	0.34	0.32	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.44	0.49	0.53	0.58	0.53	0.48	0.44
	lt/year	569	504	431	446	425	512	564	615	667	718	769	821	569	626	683	741	651	553	568
	lt/ha	31	34	39	48	54	28	3.0	33	36	39	42	44	31	34	37	40	44	50	61
Operating costs																				
fuel and oil		8766	7765	6645	6872	6549	7889	8681	9473	10265	11057	11849	12641	8766	9646	10526	11406	10028	8521	8753
Spares cost as % of pump/engine		4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Cost per 1000 hours	Taka per year	1361	1306	1225	1379	1394	2645	2645	2645	2645	2645	2645	2645	1361	1361	1361	1361	1306	1225	1379
Mechanics charges		136	131	122	138	139	264	264	264	264	264	264	264	136	136	136	136	131	122	138
Labour cost		2140	2054	1926	2168	2191	2140	2140	2140	2140	2140	2140	2140	2140	2140	2140	2140	2054	1926	2168
Water guard/channel maint.		1400	1120	840	709	597	1400	1400	1400	1400	1400	1400	1400	1050	1050	1050	1050	840	630	532
Micscelleneous cost & pit		300	300	300	300	300	600	600	600	600	600	600	600	1300	1300	1300	1300	1300	1300	1300
Total cost per yr.		14102	12676	11058	11567	11170	14938	15730	16522	17314	18106	18898	19690	14752	15632	16512	17392	15659	13724	14271
(Operating) per ha		1880	2113	2457	3044	3491	1992	2097	2203	2309	2414	2520	2625	1967	2084	2202	2319	2610	3050	3755
TOTAL ALL COSTS PER HA		3461	4089	5092	6164	7196	4230	4335	4441	4546	4652	4758	4863	3530	3647	3765	3882	4563	5655	6840
Total cost per ha/mm		4.68	5.53	6.89	8.34	9.73	5.72	5.86	6.01	6.15	6.29	6.43	6.58	4.77	4.93	5.09	5.25	6.17	7.65	9.25