Once thana-level damage data were derived, these were applied to project areas pro-rata to the proportion of a particular thana falling within the project area.

One point of interest from Table 4.15. is the relatively small difference between damage avoided from protection upto a 1:20 year return period, and damage avoided from lesser degrees of protection (1:10, 1:5 year). These results have to be treated cautiously because of the low levels of confidence attached to the damage - frequency curves, but they do have a logic to them: clearly the damage caused by a 1:20 year flood is considerably greater than that caused by 1:5 year floods, but the infrequency of the major events means that major damages in one year do not translate into major changes in the value of expected annual damage. The results also suggest that crop damage in years of moderate flooding may also be quite widespread if less dramatic than in high flood years. If these results are broadly correct, they do raise the question of the desirable level of protection to aim for, from economic and other viewpoints. In this study, however, the already laid-down standards for levels of protection along internal and major rivers have generally been applied.

The damage figure calculated from the damage frequency curve is in financial prices: it was adjusted to economic prices simply by using the conversion factor for paddy (0.88), since paddy is easily the most affected crop. It was then assumed that, in areas where full flood protection is planned, 80% of all crop damage could be avoided as a result of flood control. Some crop damage would still occur due to localised drainage congestion. The parameter was reduced to 50% in the case of the Lower Atrai "flow" areas. The implication of this figure is that the "green river" option should reduce damage compared with the present condition, which is full FCD with breaches, but some damage can still be expected since only partial protection is being given.

In a small number of projects (for example Chalan Beel Polder D) these rules were changed to take account of a specific local issue (e.g. in Polder D the likelihood of continued public cuts.). For Polder D it was therefore assumed that damage reductions would be only 50% in both flow and fully protected areas.

4.4 Estimation of Fisheries and Environmental Impacts

4.4.1 General

As discussed earlier, the main ecological/environmental impact of flood control, at least in the short-medium term, is likely to be impacts on the floodplain fisheries. The data exist to value these changes and include them in the main economic analysis. With other impacts data are scarce and/or difficult to value.

The approach adopted here is therefore to include fisheries impacts in the basic economic analysis while, in general, other environmental impacts have been ranked in the Initial Environmental Evaluation (IEE) and then included along with the economic analysis in the multi-criteria analysis.

4.4.2 Estimation of Fisheries Impacts

Production

Reliable secondary data on the fisheries sector is rather limited, therefore much of the information used here has been collected by FAP 2.

A basic distinction has been drawn between capture and culture fisheries: capture fisheries includes beel, river, floodplain and borrowpit fisheries, while culture fisheries comprises ponds in different states of development. Each habitat-type has different catch rates and different areas: further, productivity rates can be expected to change between future-without and future-with conditions. In this respect the treatment of yield rates between future-without and future-with differs from the analysis of crop changes, but for good reasons: any difference in yield rates for crops would depend on farmers feeling confident that increased investment was justified, something which can be hoped for but cannot be predicted with confidence. In contrast, fisheries yields would change, in the case of capture fisheries, as a direct biological response (mostly negative), and in the case of culture fisheries, as a direct result of reduced overtopping of ponds.

The different catch rates are shown in Table 4.17.

The area of floodplain was derived from the output of the hydro-dynamic model and from drainage analysis. The area of F1 - F4 land flooded to more than 0.3 ms for a period of at least 3 months was taken as the potential floodplain area for capture fisheries. This tended to give higher estimates of floodplain fisheries than in previous analyses but it is felt to give estimates which are of the right order of magnitude.

The areas of perennial beels, rivers and canals were determined from SPARRSO satellite imagery, although the imagery was developed in the early 1980s. Areas of ponds were collected from Thana Fisheries Officers as well as SPARRSO data.

Prices and Production Costs

Financial prices were determined on the basis of field surveys. They represent an average of the prices actually received by the fisherman/pond owner, rather than of retail prices.

Costs of labour and materials were also obtained from field surveys supplemented by secondary sources. These data are shown in the notes to Table 4.17.

The issue of economic valuation of fish prices is discussed in more detail in the next section. To summarise here, it was felt that the decline in capture fisheries that has taken place over recent years partly as a result of FCD, and which is likely to continue, allied to the high cost of producing cultured fish at anything like the rates needed to replace capture fisheries output, warranted a higher economic price than the current market price to reflect likely scarcity in future. A scarcity premium of 25% was added to the market price of both capture and culture fisheries to give the economic price used for analysis.

The adjustments to analysis of the economic value of fish output, both in terms of revised assessments of the floodplain areas available to fish resources, and in terms of prices, resulted in higher assessments of the value of fish output than in previous analyses (including those done at interim report stage for this study). This is regarded as a positive development in the analysis of water resource projects, where many previous appraisals have almost totally disregarded the existing and potential fish resources, the communities involved in full-time fishing, and the value of capture fisheries as a (relatively) open-access resource providing nutrition and income benefits to poor households.

Table 4.17 Fish Catch Rates

A. PRESENT CONDITION	AREAS (ha.)	YIELD (kg/ha)	PRODUC -TION (m.t.)	ECONOMIC PRICE (Tk/kg)	GROSS BENEFIT (Tk mn)	UNIT COSTS (Tk/kg)	TOTAL COSTS (Tk mn)	NET BENEFIT (Tk mn)
BEELS		400	0	43.75	0	7.8	0	0
RIVERS		40	0	43.75	0	7.8	0	0
FLOOD-PLAIN		70	0	43.75	0	7.8	0	0
PONDS (CULTURED/ CULTURABLE)		850	0	62.5	0	11.4	0	0
PONDS (DERELICT)		180	0	43.75	0	6.2	0	0
BORROW PITS		180	0	43.75	0	7.8	0	0
TOTALS	0		0		0		0	0
B. FUTURE WITHOUT	AREAS (ha.)	YIELD (kg/ha)		ECONOMIC PRICE (Tk/kg)		UNIT COSTS (Tk/kg)		
BEELS		400	0	43.75	0	7.8	0	0
RIVERS		40	0	43.75	0	7.8	0	0
FLOOD-PLAIN		70	0	43.75	0	7.8	0	0
PONDS (CULTURED/ CULTURABLE)		850	0	62.5	0	11.4	0	0
PONDS (DERELICT)		180	0	43.75	0	6.2	0	0
BORROW PITS		180	0	43.75	0	7.8	0	0
TOTALS	0		0		0		0	0
C. FUTURE WITH (FULL FCD)	AREAS (ha.)	YIELD (kg/ha)		ECONOMIC PRICE (Tk/kg)		UNIT COSTS (Tk/kg)		
BEELS		250	0	43.75	0	7.8	0	0
RIVERS		20	0	43.75	0	7.8	0	0
FLOOD-PLAIN		50	0	43.75	0	7.8	0	0
PONDS (CULTURED/ CULTURABLE)		1000	0	62.5	0	13.2	0	0
PONDS (DERELICT)		50	0	43.75	0	6.2	0	0
BORROW PITS		250	0	43.75	0	7.8	0	0
TOTALS	0		0		0		0	0

D. FUTURE WITH (PARTIAL PROTECTION)	AREAS (ha.)	YIELD (kg/ha)		ECONOMIC PRICE (Tk/kg)		UNIT COSTS (Tk/kg)		
BEELS		400	0	43.75	0	7.8	0	0
RIVERS		40	0	43.75	0	7.8	0	0
FLOOD-PLAIN		70	0	43.75	0	7.8	0	0
PONDS (CULTURED/ CULTURABLE)		850	0	62.5	0	11.4	0	0
PONDS (DERELICT)		50	0	43.75	0	6.2	0	0
BORROW PITS		250	0	43.75	0	7.8	0	0
TOTALS	0		0		0		0	0

Price assumptions:
Economic price of output = market price x 1.25

Market price of capture fisheries = Tk35/kg.

Market price of culture fisheries = Tk50/kg

Unit production costs of capture fisheries = Tk10/kg.

Assume 75% labour costs, 25% other costs, conversion factor = 0.78.

Unit production costs of capture fisheries (economic prices) = Tk7.8/kg.

Unit production costs of culture fisheries = Tk13/kg for yields < 1 m.t./ha, Tk15/kg for yields 1 m.t./ha +.

Conversion factor = 0.88 (weighted av. of labour + non-labour inputs).

Unit production costs of culture fisheries (economic prices) = Tk11.4/kg for yields < 1 m.t./ha, Tk 13.2/kg for yields 1 m.t./ha +.

Unit production costs of derelict ponds = Tk8/kg.

Assume 75% labour costs, 25% other costs, conversion factor = 0.78.

Unit production costs of derelict ponds (economic prices) = Tk6.2/kg.

4.4.3 Environmental Impacts

Other environmental impacts have generally not been valued in monetary terms. While it has been intended to value as many impacts as possible in the cost-benefit analysis, the nature of the data available made it difficult to do so. In addition, it was felt that potentially important components such as navigation and health should be the subject of more in-depth studies in the next stage, which would be able to look at issues on a sub-regional basis, rather than any piecemeal analysis being done at this stage which might well understate the importance of these components.

Similar reasoning applied to the evaluation of the wetlands, particularly Chalan Beel. The information collected at this stage now needs to be integrated with other work, e.g. by FAP 16 and FAP 17, and carried to a more detailed level of analysis. The work conducted in this study provides an important baseline for future work. Nonetheless, the economic analysis of the Lower Atrai as a system allowing extensive flows through it is itself some indication of the practical value of the wetlands system in that area, particularly its role for flood attenuation and storage. This role was disrupted by the development of full FCD in the Lower Atrai basin, and the plans prepared by this study effectively aim to revitalise the flood attenuation function of the wetland system.

A further small survey was conducted in the Lower Atrai to attempt to determine the economic value of natural products from the Chalan Beel wetlands system. The study focussed on landless households and estimated a household's average net income purely from use of natural resources to be over Tk2,000 (in terms of money earned or saved). It is felt that this is only a small portion of the benefits which could be attributed to the wetland system.

A sensitivity analysis of reductions in natural soil fertility due to embanking was conducted in one area (Polder C). This had no impact on the rate of return, but may be important in the longer-term: again, data on long-term processes were not available to expand the scope of the economic analysis.

4.4.4 External and Downstream Impacts

Many previous plans for flood control projects have neglected external and downstream impacts: this neglect has in some cases contributed to subsequent failure of a project, as those adversely affected outside the scheme are forced to cut the embankment to reduce damaging water levels: much of the Lower Atrai suffers from this essential neglect of integrated planning.

A major justification for the FAP regional approach is precisely the need for integrated analysis of flood control measures. The planning work of FAP 2 has been explicitly aware of the need for avoiding adverse external impacts where possible. One example of this has been the adoption of a planning principle by which any development should, if possible, not add to discharges downstream. Another example has been the planning for the Lower Atrai on a basin-wide level, aided by a hydrodynamic model which can be used to analyse the impact on water levels throughout the basin of any proposed structural development.

In terms of implications for the economic analysis, the planning approach adopted has either specifically excluded some downstream effects or internalised them, i.e. they are part of the analysis because of the way the planning area has been defined. For example, the analysis of the Lower Atrai basin includes impacts in Bogra Polder 4, an area for which no development is planned but where water level changes as a result of upstream developments do have an impact. In analysis of the Upper Karatoya/Bangali Floodway, the impact in terms of reduced damage downstream has been included.

In terms of external impacts, the likelihood of continued public cuts in areas such as Chalan Beel Polder D has been taken into account by scaling down the expected damage reductions that will occur with development. The analysis in Polder D reflects the utility of the hydro-dynamic model in also capturing the impact of developments external to the project being considered, as well as the external impact of projects being proposed (in this case, the imminent completion of the Barnai project will raise water levels to the west of Polder D and increase the likelihood of public cutting under present conditions).

In summary, to a large degree external and downstream impacts have been included in the analysis, and the minimisation of negative effects has been made an explicit goal of planning.

4.5 Estimation of Non-Crop Damage Reduction Benefits

The significant damage to infrastructure, private and public property due to major floods was amply demonstrated in 1987 and 1988. Avoidance of such damage is therefore potentially an important benefit of flood control.

Quantification of such damage is difficult, but an attempt has been made to derive figures which should be of the correct order of magnitude. Detailed data on non-crop damage exist principally for 1987 and 1988. In addition, the 1989 Prefeasibility Study for Flood Control in Bangladesh (carried out by GoB with funding from France) gives data for 1985 and 1986. There are, therefore, four years' data to use in making estimates of expected annual damage avoided. This is not adequate, and a different approach had to be used, as described below.

Initially, a detailed analysis of damage figures for 1987 and 1988 was undertaken. Damage assessment reports were collected showing the value of damage to roads, embankments and bridges under BWDB (1987 and 1988), LGEB (1987 and 1988) and R & H (1988 only). Additional data were collected for the following sectors: energy, industry, sugar, health, education, telecommunications, infrastructure, housing and livestock. Data on the last three sectors were available in the GoB/French Consortium Flood Study referred to above. The other data were collected from the Planning Commission and respective State bodies. The sectoral breakdown by Old District is shown in Table 4.18.

In addition, an attempt was made to get figures relating to health costs and indicators of human distress resulting from floods. The data collected were however incomplete and not considered usable in the economic analysis.

The data collected by this study were combined with the data from the GoB/French Consortium Study to give a fairly comprehensive coverage of non-crop damage by Old District for 1985-88. As noted above, four years' data are insufficient to derive a flood damage - frequency curve, so the following method was used.

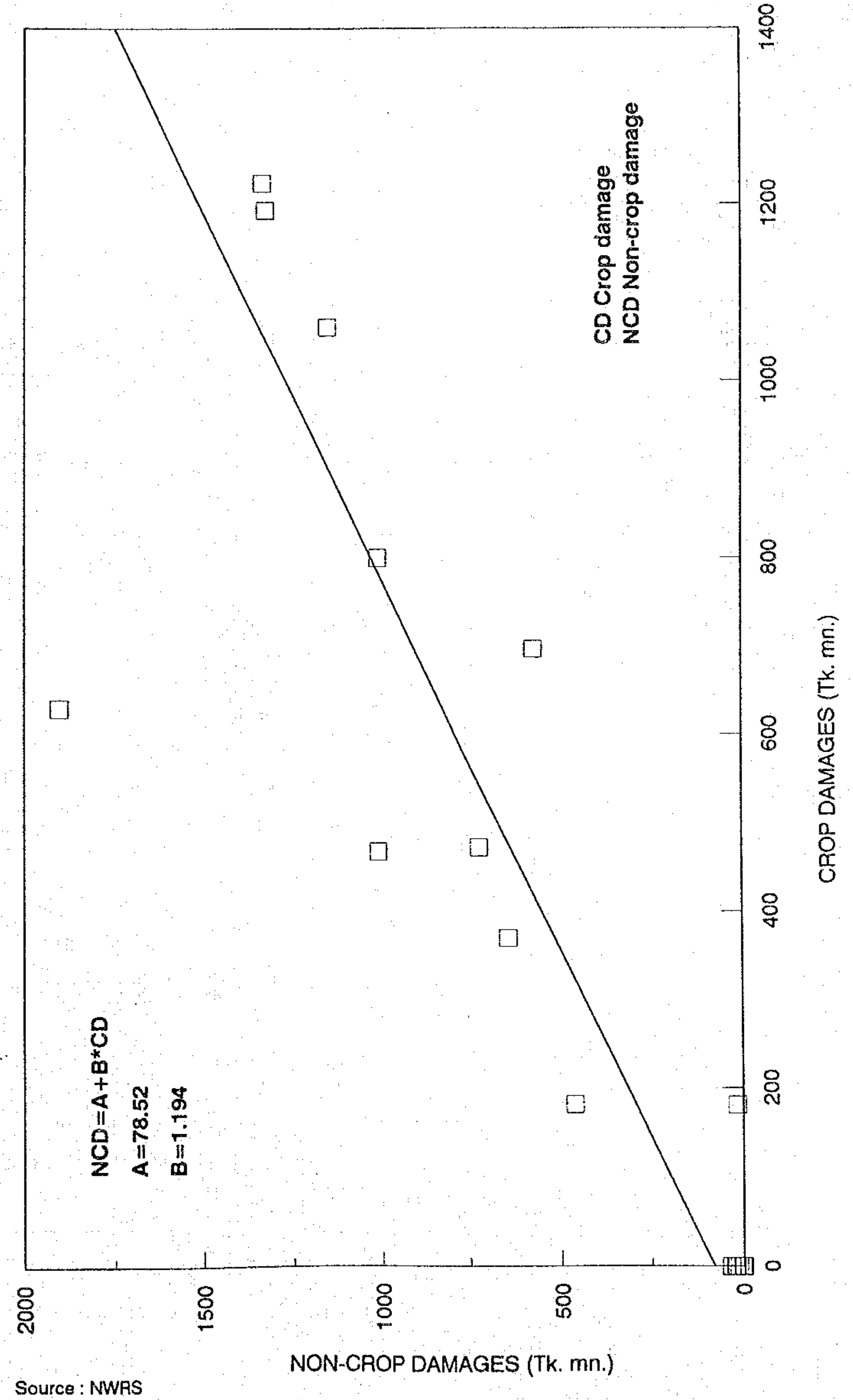
First, a statistical relationship was derived between crop damage and non-crop damage using the pooled cross-section and time-series data (i.e. five Districts over four years, twenty pairs of observations). It is reasonable to suppose that there is a relationship between crop damage and non-crop damage, particularly in years with high floods. Fig. 4.1 shows the derived relationship.

Next, this relationship was used to derive non-crop damage data for the years 1971-84 based on the crop damage data for those years. This gave a data series for non-crop damage for the period 1971-88, from which non-crop damage - frequency curves and expected annual damage were estimated. Table 4.19. gives the resulting figures.

Figure 4.1

CROP AND NON-CROP DAMAGES

ANNUAL VALUES FOR 1985-88



Source : NWRS

C:\MANIR01\FIG5_2.DRW

Table 4.18 Infrastructure and Property damage by Old District, 1985–88

1988 (TK IN MILLION)

DISTRICTS	EDUCATION	HEALTH	INDUSTRY	TELCOM	SUGMILLS	RAILWAY	ENERGY	OTHER	DWELLING	BWDB,LGEB,R&	TOTAL
BOGRA	42.90	67.87	58.00	8.14	3.30	42.12	6.59	34.20	89.30	660.75	1013.17
DINAJPUR	71.45	28.67	119.33	11.84	30.53	12.79	7.49	49.59	61.60	252.99	646.28
PABNA	132.71	55.76	342.67	17.62	0.00	225.57	5.39	94.69	268.01	761.54	1903.96
RAJSHAHI	77.25	148.69	282.70	12.60	11.25	0.77	2.35	25.53	58.25	391.35	1010.74
RANGPUR	96.10	122.32	282.89	15.86	59.71	307.03	20.04	72.15	74.45	274.37	1324.90
NWRS TOT	420.41	423.30	1085.60	66.06	104.78	588.28	41.86	276.16	551.61	2341.00	5899.05

1987 (TK IN MILLION)

DISTRICTS	ROADS	EMBNK	OFF. BIDG	BRDG/CULV	CATTLE	DWELLING	BWDB,LGEB	INDUSTRY	TOTAL
BOGRA	223.90	23.90	20.80	62.70	10.50	139.50	36.73	58.00	576.03
DINAJPUR	112.50	5.90	10.50	51.80	22.30	80.75	61.18	119.33	464.26
PABNA	72.90	0.00	58.80	17.00	10.20	118.45	104.55	342.67	724.57
RAJSHAHI	216.70	99.00	59.30	138.20	2.50	213.30	140.86	282.70	1152.57
RANGPUR	416.00	91.40	11.10	171.30	15.10	154.50	190.24	282.89	1332.53
NWRS TOT	1042.00	220.20	160.50	441.00	60.60	706.50	533.56	1085.60	4249.96

1986 (TK IN MILLION)

DISTRICTS	DWELLINGS	CATTLE	ROADS	EMBNK	OFF. BIDG	BRDG/CULV	TOTAL
BOGRA	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DINAJPUR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PABNA	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RAJSHAHI	0.19	0.21	5.22	15.75	0.15	0.00	21.52
RANGPUR	0.91	0.00	0.32	0.00	0.75	0.00	1.98
NWRS TOT	1.10	0.21	5.54	15.75	0.90	0.00	23.50

1985 (TK IN MILLION)

DISTRICTS	DWELLINGS	CATTLE	ROADS	EMBNK	OFF. BIDG	BRDG/CULV	TOTAL
BOGRA	0.75	0.00	0.00	0.00	0.00	0.00	0.75
DINAJPUR	20.49	0.00	0.00	0.00	0.00	0.00	20.49
PABNA	32.61	0.00	0.00	0.00	0.00	0.00	32.61
RAJSHAHI	12.48	0.11	0.15	0.54	0.00	0.00	13.28
RANGPUR	15.28	0.02	0.00	0.00	1.05	0.00	16.35
NWRTOT	81.61	0.13	0.15	0.54	1.05	0.00	83.48

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Table 4.19 Estimated average annual non-crop damage by old district

A. BOGRA DISTRICT

Frequency (non-exceed-ence)	Return Period (yr)	Estimated damage (Tk mn, 1988 prices)	Cost & frequency differ-ential (Tk mn)	Cumulated costs (Tk mn)
0	0	0		
			0	0
0.02	1.02	0		
			0	0
0.05	1.05	0		
			0	0
0.09	1.11	0		
			0	0
0.2	1.25	0		
			27.75	27.75
0.5	2	185		
			48.3	76.05
0.8	5	507		
			10.65	86.7
0.9	10	720		
			5.125	91.825
0.95	20	925		
			3.975	95.8
0.98	50	1190		
			0.99	96.79
0.99	100	1388		

Average annual damage avoided by protection
upto specified return period d(Tk mn,1988 prices)

	1:5	1:10	1:20	1:50	1:100
Total	76.05	86.7	91.83	95.8	96.8
Tk per ha NCA	220.5	251.3	266.2	277.7	280.6

Convert to 1991-92 prices using GDP deflator:

	1:5	1:10	1:20	1:50	1:100
Total	92.0205	104.907	111.1143	115.918	117.128
Tk per ha NCA	266.805	304.073	322.102	336.017	339.526

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B. DINAJPUR DISTRICT

Frequency (non-exceed-ence)	Return Period (yr)	Estimated damage (Tk mn, 1988 prices)	Cost & frequency differ-ential (Tk mn)	Cumulated costs (Tk mn)
0	0	0		
			0	0
0.02	1.02	0		
			0	0
0.05	1.05	0		
			0	0
0.09	1.11	0		
			0	0
0.2	1.25	0		
			19.35	19.35
0.5	2	129		
			31.65	51
0.8	5	340		
			6.95	57.95
0.9	10	479		
			3.375	61.325
0.95	20	614		
			2.595	63.92
0.98	50	787		
			0.65	64.57
0.99	100	917		

Average annual damage avoided by protection
upto specified return period d (Tk mn)

	1:5	1:10	1:20	1:50	1:100
Total	51	58	61.3	63.9	64.6
Tk per ha NCA	84.2	95.8	101.3	105.6	106.7

Convert to 1991-92 prices using GDP deflator:

	1:5	1:10	1:20	1:50	1:100
Total	61.71	70.18	74.173	77.319	78.166
Tk per ha NCA	101.882	115.918	122.573	127.776	129.107

C. PABNA DISTRICT

Frequency (non-exceed-ence)	Return Period (yr)	Estimated damage (Tk mn, 1988 prices)	Cost & frequency differ-ential (Tk mn)	Cumulated costs (Tk mn)
0	0	0		
			0	0
0.02	1.02	0		
			0	0
0.05	1.05	0		
			1.832	1.832
0.09	1.11	91.6		
			8.151	9.983
0.2	1.25	239.8		
			52.29	62.273
0.5	2	588.4		
			70.35	132.623
0.8	5	1057.4		
			15.53	148.153
0.9	10	1367.9		
			7.445	155.598
0.95	20	1665.7		
			5.784	161.382
0.98	50	2051.3		
			1.445	162.827
0.99	100	2340.2		

Average annual damage avoided by protection upto specified return period d (Tk mn)

	1:5	1:10	1:20	1:50	1:100
Total	132.6	148.2	155.6	161.4	162.8
Tk per ha NCA	330.5	369.4	387.8	402.3	405.8

Convert to 1991-92 prices using GDP deflator:

	1:5	1:10	1:20	1:50	1:100
Total	160.446	179.322	188.276	195.294	196.988
Tk per ha NCA	399.905	446.974	469.238	486.783	491.018

D. RAJSHAHI DISTRICT

Frequency (non-exceed-ence)	Return Period (yr)	Estimated damage (Tk mn, 1988 prices)	Cost & frequency differ-ential (Tk mn)	Cumulated costs (Tk mn)
0	0	0		
			0	0
0.02	1.02	0		
			0.444	0.444
0.05	1.05	29.6		
			1.628	2.072
0.09	1.11	111		
			6.083	8.155
0.2	1.25	221.7		
			39.06	47.215
0.5	2	482.1		
			52.56	99.775
0.8	5	832.5		
			11.6	111.375
0.9	10	1064.4		
			5.565	116.94
0.95	20	1286.9		
			4.32	121.26
0.98	50	1574.9		
			1.08	122.34
0.99	100	1790.8		

Average annual damage avoided by protection upto specified return period d (Tk mn)

	1:5	1:10	1:20	1:50	1:100
Total	99.78	111.38	116.94	121.26	122.34
Tk per ha NCA	116.2	129.7	136.2	141.2	142.5

Convert to 1991-92 prices using GDP deflator:

	1:5	1:10	1:20	1:50	1:100
Total	120.7338	134.7698	141.4974	146.7246	148.0314
Tk per ha NCA	140.602	156.937	164.802	170.852	172.425

E. RANGPUR DISTRICT

Frequency (non-exceed-ence)	Return Period (yr)	Estimated damage (Tk mn, 1988 prices)	Cost & frequency differ-ential (Tk mn)	Cumulated costs (Tk mn)
0	0	0		
			0.0914	0.0914
0.02	1.02	9.13		
			1.404	1.4954
0.05	1.05	102.67		
			1.844	3.3394
0.09	1.11	194.9		
			6.908	10.2474
0.2	1.25	320.4		
			44.31	54.5574
0.5	2	615.7		
			59.58	114.1374
0.8	5	1012.9		
			13.16	127.2974
0.9	10	1276		
			6.31	133.6074
0.95	20	1528.3		
			4.899	138.5064
0.98	50	1854.8		
			1.224	139.7304
0.99	100	2099.5		

Average annual damage avoided by protection upto specified return period d (Tk mn)

	1:5	1:10	1:20	1:50	1:100
Total	114.1	127.3	133.6	138.5	139.7
Tk per ha NCA	139.2	155.3	162.9	168.9	170.4

Convert to 1991-92 prices using GDP deflator:

	1:5	1:10	1:20	1:50	1:100
Total	138.061	154.033	161.656	167.585	169.037
Tk per ha NCA	168.432	187.913	197.109	204.369	206.184

	NCA (ha)		NCA (ha)
BOGRA	344948	RAJSHA	858742
DINAJPUR	605369	RANGPU	819898
PABNA	401191		

avnerdam

The next step was, as for crop damage, to disaggregate the Old District-level data by thana and project area. Since no data for non-crop damage existed at thana level, it was decided to apply the same weights as were used in the crop damage disaggregation. This simplification is reasonable given that a relationship between crop damage and non-crop damage has been shown to exist, but obviously the resulting relative weights cannot be regarded as totally correct.

Comparison of the damage data for crop damage and non-crop damage shows that non-crop damage values are greater, by 10-20% in Bogra, Rajshahi and Rangpur Districts, and by more than 100% in Dinajpur and Pabna Districts. This pattern appears logical: the greater proportionate damage in Dinajpur reflects the low level of crop damage there in normal years, while the high degree of damage in Pabna reflects specific damage due to breaches in the BRE to the Bogra-Rangpur highway, other infrastructure and the BRE itself by flood water entering through breaches in the BRE.

4.6 Other Socio-Economic Effects

Other possible benefits from flood control could include, for example, reduction in human suffering and discomfort, and increased mobility along embankments. As noted above, an attempt was made to collect data relating to health costs and supply of relief materials as an indicator of human suffering, but the data was too incomplete to allow inclusion in the analysis. The benefits of major embankments in providing settlement for landless and displaced families are recognised, but it is difficult to imagine that embankments would be built actually to serve that purpose. Indeed, embankments on both sides of a river can cause a confining effect which might itself force those living outside the embankments to move: therefore embankments can cause displacement as well as provide a solution for it.

However, for feasibility-level planning the multi-purpose use of embankments needs to be investigated. There is little prospect that the majority of embankment dwellers will move, unless large -scale char formation occurs, so their needs should be planned for, possibly in conjunction with arrangements to maintain the embankment.

In regard to increased mobility, this benefit is considered to be rather small, and usually less significant than the dis-benefits caused by disrupting navigation routes. In areas of generally medium-high land, embankments often run parallel to pre-existing rural roads which already provide adequate access. In low-lying areas with fewer roads the integrity of the embankments can rarely be totally maintained, thereby reducing their potential role as a means of communications. It seems reasonable to conclude therefore that these potential benefits are in practice generally not very large, and can be excluded from the economic analysis.

4.7 Navigation and Rural Transport

Table 4.20. gives indicators of the rural transport situation in the NW Region. The table allows some initial, broad conclusions to be made, although some of the data are prior to the spread of boat mechanisation which has transformed the potential for the country boat sector:

(i) Boats are relatively more important for household mobility in Pabna and Rajshahi districts, and least important in Dinajpur district;

(ii) Conversely, carts are more widely used in Dinajpur, and also in Rajshahi districts;

Table 4.20 Rural Transport in NW Region

	BOATS						BULLOCK CART			RICKSHAW		
	% sample hh. with boats	Average carrying capacity	% cap. <50 mds	% cap. 50-149 m	% cap. 150+ mds	Av. no. mths used	% sample hh. with boats	Average carrying capacity	Av. no. mths used	% sample hh. with boats	Average carrying capacity	Av. no. mths used
Bogra	0.45	27	86	14	0	8.1	8.1	14.6	6.6	0.74	9.3	10.4
Dinajpur	0.06	34.4	44	56	0	5	20.7	18	5.7	0.19	16	10.2
Pabna	5.3	68	75	14	11	4.8	3.3	18.3	7.6	0.33	11.4	11.4
Rajshahi	2.3	24.5	87	12	1	5.5	22.8	12.6	5.9	0.21	5.6	11.3
Rangpur	0.66	28.18	79	21	0	4.9	8.7	13.7	7	0.35	10.3	9.5

Source: The Bangladesh Census of Agriculture and Livestock: 1983-84
Bangladesh Bureau of Statistics, May 1988

(iii) The majority of boats are small, with a carrying capacity of less than 50 maunds (slightly less than 2 m.t.), although in Pabna some boats (about 11%) have a capacity over 150 maunds;

(iv) On average boats are used for about 5 months in the year, i.e. the main monsoon months: boats in Bogra are used longer (about 8 months) which partly reflects the fact that very few boats in Bogra exceed 50 maunds' carrying capacity and are therefore more able to ply in the dry season. It could also reflect a higher level of internal trade in Bogra where rabi crops are widely grown.

Based on these broad figures, flood control projects in Pabna and Rajshahi districts can be expected to have a greater effect on local boat transport than projects in other districts (at a more local level this generalisation may not hold).

The navigation study has given initial estimates of the potential for development of the country boat sector, especially in the Lower Atrai basin. It is clear that opening up of the system of natural channels within the polders could result in significant increases in boat cargoes, with real economics benefits. A more detailed survey will however be needed to estimate the extent of this benefit, and therefore it has not been included in the basic economic analysis.

4.8 Economic Dislocation

Severe flooding causes temporary economic dislocation by, for example, cutting bridges, inundating factories etc. The GoB/France study referred to earlier estimated total indirect negative impacts of floods to be around 2% of the non-agricultural sector's growth, due to the temporary disruption of economic activity and to irrecoverable losses on investment. That study included avoidance of such secondary impacts as a benefit to the proposed flood protection strategy.

While such negative secondary impacts do occur, it would be inconsistent to count them and not other multiplier effects. Also, the strategy proposed in this plan will not fully protect against major flood events, and therefore it would be misleading to claim such a benefit. In the case of the GoB/France study, the proposed strategy being analysed put more emphasis on large-scale engineering works which would aim to exclude even major floods.

The approach followed in this study, therefore, is to follow the recommendation of the Guidelines and exclude secondary impacts.

4.9 Estimation of Project Economic Costs

Capital Costs

Financial cost estimates for each proposed project were estimated for two alternative construction methods, mechanical and manual. In the regional planning economic analysis only the manual cost estimates were used (sensitivity analysis was carried out between the two methods for the Gaibandha project, and results are discussed in the Gaibandha report, Volume 5, and the Gaibandha section of this Annex).

Table 4.21 Estimation of Economic Capital Costs

Item	Skilled labour	Unskille labour	Transport		Cement		Steel		Machinery eqpt		Gravel/ Bricks	Weighted Av. Conversion Factor
	local cost	local cost	local cost	F.E. cost	local cost	F.E. cost	local cost	F.E. cost	local cost	F.E. cost	local cost	
Conversion	0.87	0.65	0.68	1	0.79	1	0.75	1	0.62	1	0.87	
Factor			Share of costs(%)									
Earth												
Embankments	6	94	0	0	0	0	0	0	0	0	0	0.66
Groynes	1	6	0	0	32	21	1	1	0	0	38	0.86
Canal												
re-excavation												
(navigation)	5	95	0	0	0	0	0	0	0	0	0	0.66
Major drains	5	95	0	0	0	0	0	0	0	0	0	0.66
Small drainage												
channels	5	95	0	0	0	0	0	0	0	0	0	0.66
Regulators	2	7	1	1	10	15	10	34	5	5	10	0.89
Navigation locks	2	7	1	1	10	15	10	34	5	5	10	0.89
Overflow weirs												
Culverts/												
sluices	2	7	1	1	10	15	10	34	5	5	10	0.89
Roads (HBB)	2	8	1	1	17	12	0	0	1	1	57	0.85
Bridges	2	7	1	1	10	15	10	34	5	5	10	0.89
	0.87	0.65	0.68	1	0.79	1	0.75	1	0.62	1	0.87	

Economic capital costs were derived by breaking down the main forms of construction project into their basic cost items (labour, cement, bricks etc.), dividing each cost item according to local and foreign costs, and then applying the relevant conversion factor to the local element of costs. The outcome is a composite conversion factor which is then applied to the financial cost estimates. The calculation of economic capital costs is shown in Table 4.21.

The composite conversion factors range between 0.66 for earthworks and 0.89 for structures. The difference between financial and economic capital costs in the analysis is however greater than the conversion factor, because the cost of land acquisition is taken out of the economic capital cost.

The timing of economic capital costs, and proportions of expenditure in each year, are taken to be the same as for the financial costs: for most projects the construction period is 4 years, but for large projects it is 6-8 years.

O&M Costs

the annual economic cost of O & M has been derived as a proportion of the economic capital cost, using the following proportions:

earthworks	-	5% of capital cost
structures	-	3% of capital cost.

Costs of Land Acquisition

The economic cost of land acquisition is the value of production foregone from the land acquired. This was derived in the analysis by assuming that the "without project" cropping pattern for the project area would also have been grown on the acquired land. The net return from this land in economic prices was then calculated, and deducted from the benefits in each year.

5. Price Issues and Financial Returns to Enterprises

5.1 Rice Prices

As described in section 1.3., both the financial and economic prices of rice and other crops are based on the average market prices over the period 1989-91, converted on a 1992 constant price basis, the same price basis as the project costs.

In the past, rice has always been treated as an import substitute, and its economic price was therefore calculated on an import parity basis. The underlying assumption has been that Bangladesh, with limited land resources and growing population, will normally continue to have an import deficit in rice in the foreseeable future. Increased rice production from flood control projects would therefore be valued for its contribution to reducing imports.

However, the trends discussed in section 2.1. have altered the situation quite dramatically. Table 5.1. shows the increase in rice production and decline in imports over the period 1975/76 to 1991/92: in three of the last four years rice imports were negligible, to the extent that it can be said that Bangladesh is now more or less self-sufficient in rice production. By contrast, output of wheat has practically stagnated and is unlikely to increase much further, so that imports of wheat (mostly under grant or other aid programmes) are 50-100% higher than domestic output.

Table 5.1

Bangladesh Rice and Wheat Production and Imports, 1975/6 to 1991/92 (000tonnes)

Year	Rice Production	Rice Imports	Wheat Production	Wheat Imports
1975/76	12763	395	222	1065
1976/77	11753	195	265	613
1977/78	12970	304	349	1341
1978/79	12849	54	498	1101
1979/80	12740	712	829	2070
1980/81	13881	184	1110	892
1981/82	13630	144	856	1111
1982/83	14216	317	1095	1527
1983/84	14508	180	1211	1877
1984/85	14622	692	1463	1898
1985/86	15041	36	1042	1163
1986/87	15406	261	1091	1507
1987/88	15414	593	1048	2329
1988/89	15544	61	1022	2076
1989/90	17867	300	878	891
1990/91	17852	10	1004	1567
1991/92	17979	39	900(1)	1561(1)

Source: Bangladesh Bureau of Statistics and the Ministry of Food

Note: (1) Estimate

As discussed earlier, there appears to be great potential for further expansion of rice production particularly in conjunction with the further spread of irrigation, so that at least in the medium term self-sufficiency will probably be maintained and there may even be a small surplus. Wheat, on the other hand, will remain in deficit. If a rice surplus arises on any scale, since the prospects for export are not particularly promising, domestic farm-gate prices, which have been declining slowly in real terms in recent years, are likely to continue to come down, perhaps sharply.

In view of these factors, the Guidelines base the economic price of rice on the average of the import parity and export parity values rather than, as in the recent past, om import parity alone. This study accepts the Guidelines' selection in this regard, although there may be some doubt about whether self-sufficiency can be maintained in the long-term.

This change in the basis of rice pricing has a major impact on benefit levels and economic returns. On the basis of 1989-91 financial prices, and otherwise using the values for marketing costs etc. assumed by FPCO in their derivation of economic prices, the conversion factors for rice should be:

Basis of Economic Pricing	Conversion Factor
Import parity	1.19
Export parity	0.69
Average of import and export parity	0.94

Tables 5.2. and 5.3. show the calculation of import parity and export parity prices.

Use of the combined import/export parity conversion factor reduces rice gross returns by 21% compared to returns on an import parity pricing basis. If production costs are equivalent to about 35% of gross returns a 21% reduction in the economic price of rice will result in a 32% reduction in net returns, a large decrease.

Comparison of the import parity and export parity conversion factors derived for 1989-91 shows that the financial price was much closer to the import parity value than the export parity value. The inference is that, at present, market prices of rice in Bangladesh are geared primarily to import prices, with rice being valued as an import substitute. However, a switch into a surplus situation would cause market prices to move nearer to the export parity value.

5.2 Degree of Competition in the Rice Market

A brief analysis was made of historic market prices in each of the FAP planning regions, to see whether these reflect the overall rice supply and demand situation in the country. Table 5.4. shows the average wholesale market prices of aman paddy for the five regions for the period 1981/82 to 1985/86.

Table 5.4 shows that the differences between regions in average market prices were small but that prices in the NW Region were clearly lower than elsewhere. This reflects the realities of the general rice supply and demand situation in Bangladesh; the NW Region is generally the largest producer of rice surpluses for other regions.

A recent study by IFPRI-BIDS supports the conclusion that the rice market (and other agricultural markets) is generally competitive. The study (Sultan Hafeez Rahman, Analysis of Agricultural Commodity Markets and Prices in Bangladesh, Draft, April 1992) estimates a rate of return on

Table 5.2

Derivation of Import Parity Price Conversion Factors for Rice Prices (per tonne at 1991 constant prices)

Item	FPCO Calculation of February 1992	1989-1991 Average Price
World Bank-quoted price in 1985 constant prices (Thai rice FOB Bangkok), adjusted to 1991 constant price by MUV index of 1.5345	US$ 270(1)	US$ 327
Price adjusted for 20% lower quality of Bangladesh rice	216	262
Plus: Freight and insurance	38	38
Price CIF Bangladesh Port	254	300
Equivalent in Taka (Tk. 36/US$)	Tk. 9,144	Tk. 10,800
Plus: Port transport and other costs between port and primary distribution point	1365	1,365
Plus: Costs between primary distribution point and secondary market	488	488
Value ex-store/market	10,997	12,653
Minus: Transport, processing and other costs between store/market and farm	583	583
Rice milling ratio	0.62	0.62
Farm-gate import parity price of paddy	6457	7,483
Price per kg. of paddy	6.46	7.48
Financial price 1989-1991	6.30	6.30
Conversion factor derived	1.02(2)	1.19

Source: Table A11.1 of the FPCO special study on Economics: Estimation of Economic Prices of Selected Commodities for use in FAP Planning Studies, February 1995, plus, Consultant's Estimate of 1989-1991 Import Parity Price.

Notes: 1. Based on the World Bank Projected Price for 1995. This is in fact Virtually Identical to that for 2005 given in the Bank's April, 1992 Forecasts.

2. For the Reasons given in Section 1.3 this is not a valid Conversion Factor.

Table 5.3

Derivation of Export Parity Price Conversion Factors for Rice Prices (per tonne at 1991 constant prices)

Item	FPCO Calculation of February 1992	1989-1991 Average Price
FOB price of Bangladesh rice (Table 5.2) Equivalent in Taka, Tk. 36/US$	US$ 216(1) Tk. 7,776	US$ 262
Minus: Costs incurred between secondary market and FOB Bangladesh Port (Table 5.2)	1,853	1,853
Value ex-store/market	5,923	7,579
Minus: Costs between market and farm	583	583
Rice milling ratio	0.62	0.62
Farm-gate export parity price of paddy	3,311	4,338
Price per kg. of paddy	3.31	4.34
Financial price 1989-1991	6.30	6.30
Conversion factor derived	0.53(2)	0.69

Source: As per Table 5.2

Notes: 1 Based on the World Bank Projected Price for 1995. This is in Fact Virtually Identifical to the 2005 Projected Price given in the Bank's April 1992 Forecasts

2 For the Reasons given in Section 1.3 this is not a Valid Conversion Factor.

Table 5.4

Comparison of Regional Wholesale Prices of Aman Paddy, 1981-82 to 1985-86 (Tk. tonne in December to February Period) (1)

FAP Region (Old District)	1981-82	1982-83	1983-84	1984-85	1985-86	Average	Difference from NW Region
North West (Dinajpur, Rangpur, Bogra, Rajshahi, Pabna)	3467	3892	4178	5017	4263	4168	-
North Central (Jamalpur, Mymensingh, Tangail, Dhaka)	4094	4070	4704	5398	4791	4611	+9.8%
North East (Sylhet)	4126	3831	4447	5126	4769	4460	+7.0%
North East (Kushtia, Jessore, Khulna, Barisal, Patuakhali, Faridpur)	3739	3995	4353	5230	4441	4353	+4.4%
South East (Comilla, Noakhali)	4050	4072	4670	5246	4719	4551	+9.2%

Source: Consultant's Calculations, using Data from A Data Base on Agriculture and Foodgrains in Bangladesh (1947-48) to 1989-90); Mohammed Abdul Hamid 1991. Original Data from the Directorate of Agricultural Marketing.

Note : The Price Data were Available only upto 1985-86.

traders' capital in foodgrains trading of 14-19%, which is comparable with financial rates of interest in the financial markets. There is no sign of excess profits. The same study also finds that the farmgate price of rice was about 75% of the urban wholesale price, and that there is a high degree of market integration across the country.

In general, therefore, it can be concluded that the foodgrains market is generally competitive. This means that market prices can be used with confidence as the basis of the economic analysis (i.e. by adjusting market prices by the respective conversion factor).

5.3 Fish Prices

The issue of economic valuation of fisheries output, as well as wider socio-economic impacts resulting from continued decline in capture fisheries, has been particularly addressed during the study, including collaborative work with FAP 16 (the Environment Study) and FAP 17 (the Fisheries Study). It is now generally accepted that capture fisheries have been seriously declining and that part of this decline can be attributed to FCD projects which hitherto paid little or no attention to the issue. Since capture fisheries are an important source of nutrition and income for a large proportion of the rural population, continued decline has serious implications for poor households.

There are a number of ways in which these issues can be addressed, but the likelihood of rising real prices due to increasing scarcity can be addressed directly in the economic analysis through the pricing system chosen. An analysis carried out by the study for selected species did show an increase in real prices for most of the species, as shown in Fig. 5.1 and Table 5.5.: if the increase is not generally as dramatic as might be expected, that can be partly attributed to the ineffectiveness (in their own terms) of previous FCD projects (the ulcerative fish disease might have also contributed by causing a reduction in demand in the late 1980s). Therefore, if FCD projects were working to full effectiveness, a further decline in capture fisheries could be anticipated.

There are no readily available perfect substitutes for capture fisheries. Although culture fisheries can increase output of certain species, the costs involved in completely making up lost output would be enormous. In addition, capture fisheries are part of the natural resource stock of the country, and any intervention which results in depletion of the stock should not be reflected only in terms of loss of the stream of income, but also in terms of loss of the capital stock itself.

Taking the above factors into account, it was decided that fish output in the economic analysis would be valued at 25% above current market prices, i.e. a 25% increase in real prices. This premium was applied equally to capture and culture fisheries. It is felt that this adjustment is clearly justified by current trends, and it is interesting to note that, for example, the World Bank applies a scarcity premium in the pricing of projects relating to tropical hardwoods.

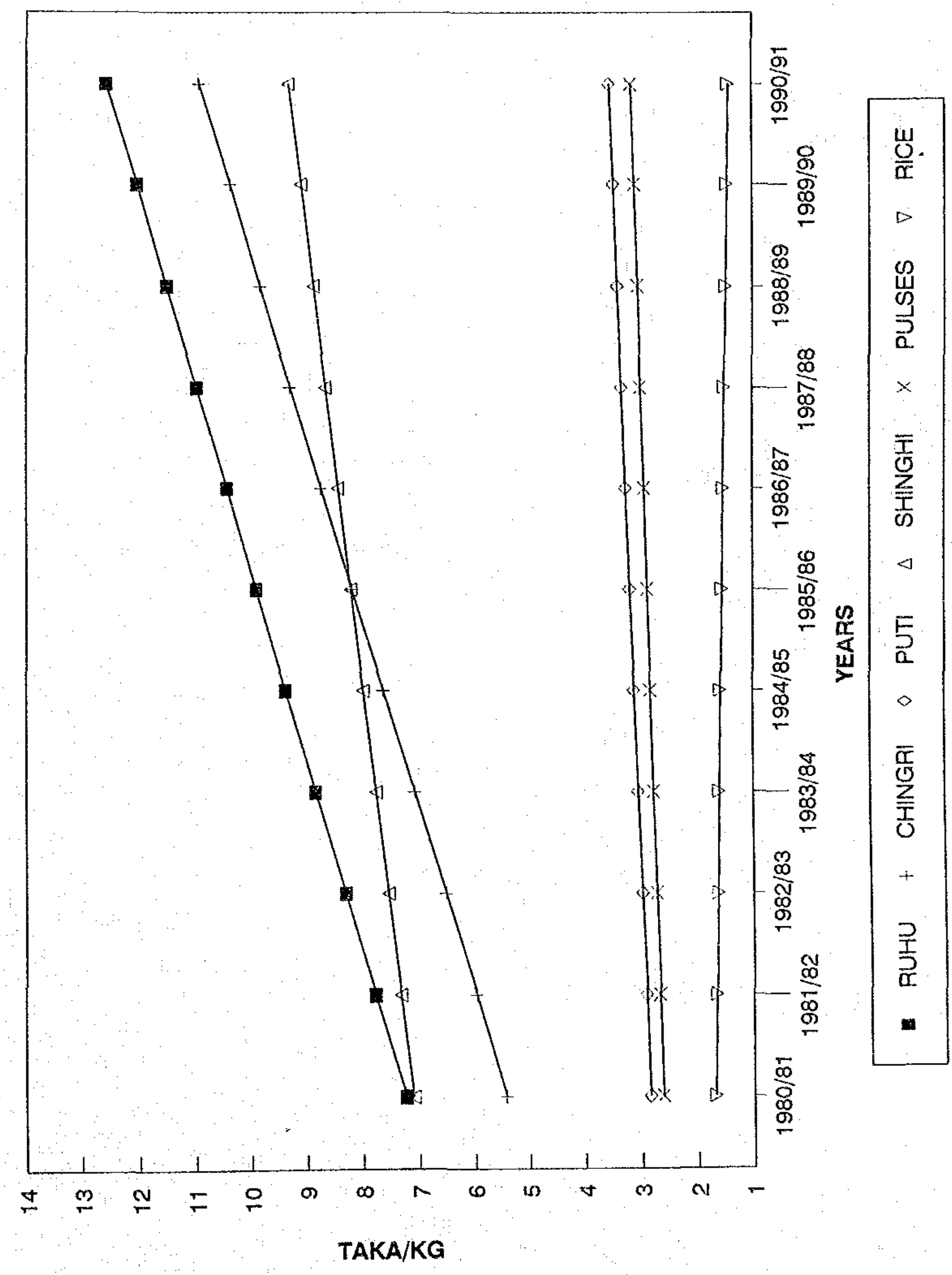
5.4 Financial Returns

Before describing results of the economic analysis, financial data are provided to show the relative profitability of the various activities that are or could be included in the benefit stream. Table 5.6 shows financial net returns to crops included in the analysis.

In terms of paddy crops, the crop with the highest net returns is HYV t. aman. Returns to this crop are higher than returns to HYV boro even though yields of the latter are greater: this is primarily because of the high and increasing costs of irrigation.

Figure 5.1

TREND OF REAL PRICES OF RICE, FISH AND PULSES IN RAJSHAHI



Source : Estimated from BBS (GOB).

C:\MANR01\TRND-RAJ.DRW

Table 5.5 Real price of fish species, Rajshahi District

Year	NOMINAL PRICES							REAL PRICES					
	Ruhu	Chingri	Puti	Shingi	Pulses	Rice	72-73 GDPDEFL	Ruhu	Puti	Chingri	Shingi	Pulses	Rice
1980/81	25.12	16.92	9.25	22.3	9.75	5.05	3.26	7.72	2.84	5.20	6.85	2.99	1.55
1981/82	26.09	22.79	10.71	24.33	11.73	6.2	3.67	7.11	2.92	6.21	6.63	3.20	1.69
1982/83	30.82	23.43	10.84	27.16	9.9	6.9	3.85	8.00	2.81	6.08	7.05	2.57	1.79
1983/84	40.72	26.44	11.45	37.31	10.28	7.23	4.49	9.08	2.55	5.89	8.32	2.29	1.61
1984/85	42.14	30.22	14.2	37.14	10.66	8.24	5.15	8.18	2.76	5.86	7.21	2.07	1.60
1985/86	65.33	45.67	26.01	51.02	14.78	7.4	5.45	11.99	4.77	8.38	9.36	2.71	1.36
1986/87	66.23	77.4	20	59.8	19.61	9.75	5.98	11.07	3.34	12.94	9.99	3.28	1.63
1987/88	68.33	76.64	21.16	64.3	21.2	10.79	6.64	10.29	3.19	11.54	9.68	3.19	1.62
1988/89	76.46	67.42	22.3	62.29	21.8	10.77	7.15	10.69	3.12	9.43	8.71	3.05	1.51
1989/90	92.38	71.9	27.25	60.66	24.05	10.35	7.70	11.99	3.54	9.33	7.87	3.12	1.34
1990/91	104.12	73.8	26.72	69.5	26.9	11.34	8.08	12.89	3.31	9.14	8.60	3.33	1.40

Source:BBS,Monthly Statistical Bulletin Various Issues

TABLE 5.6 FINANCIAL NET RETURNS TO CROPS
(Tk., 1991-92 prices)

Per ha. RETURNS

CROPS	GROSS RETURN	COST OF INPUTS	IRRIGATION COST	COST OF CREDIT (12%)	MISCELL. COSTS (10%)	TOTAL PROD. COST	NET RETURN
HYV Boro	32895.00	10600.00	5950.00	0.00	0.00	16550.00	16345.00
HYV T.Aman	26625.00	9233.00	661.00	0.00	0.00	9894.00	16731.00
DW Aman	12344.00	5387.00	0.00	0.00	0.00	5387.00	6957.00
L.T.Aman	16313.00	6458.00	0.00	0.00	0.00	6458.00	9855.00
B.Aus	10832.00	7305.00	0.00	0.00	0.00	7305.00	3527.00
HYV Aus	24525.00	9651.00	2380.00	0.00	0.00	12031.00	12494.00
Jute	23851.00	9187.00	0.00	0.00	0.00	9187.00	14664.00
Pulse	14464.00	3237.00	0.00	0.00	0.00	3237.00	11227.00
Oilseed	9582.00	4856.00	0.00	0.00	0.00	4856.00	4726.00
Wheat	12184.00	6891.00	0.00	0.00	0.00	6891.00	5293.00
Potato	45800.00	17205.00	0.00	0.00	0.00	17205.00	28595.00
Onion	72400.00	10302.00				10302.00	62098.00
Brinjal	37463.00	12417.00	0.00	0.00	0.00	12417.00	25046.00
Tobacco	24780.00	10606.00	0.00	0.00	0.00	10606.00	14174.00
Sugarcane	42420.00	17346.00	0.00	0.00	0.00	17346.00	25074.00
Banana	117250.00	20435.00	1500.00	0.00	0.00	21935.00	95315.00

Notes: Data for onion, brinjal and banana from David Gisselquist, Demonstrating Command Area Development, TADP/BRDB Project, 1989.

There are many rabi crops that have higher net returns than paddy: particularly spices and vegetable crops. Markets are limited for these crops however. In contrast, crops which are important nutritionally such as pulses and oilseeds generally have low yields and therefore low net returns.

Annual crops such as bananas (particularly), pineapple, watermelon and sugarcane all have quite high returns. Opinions seem to differ on jute, but farmers continue to plant significant areas to the crop and appear to value it for its many uses.

Turning to other potential outputs, pond culture fisheries has high returns, ranging from Tk20-40,000 if adequate inputs are used and depending on whether the pond is owned or leased.
Capture fisheries has low per hectare returns but a per hectare return is not a particularly good measure of returns in this case.

These returns are for existing enterprises at present levels of development. There are other possible developments, such as integrated rice-fish farming, that could considerably raise returns, as well as perhaps require a broader concept of water resource management than is envisaged in the current generation of FAP studies and projects.

6. Economic Analysis

6.1 Scope of Analysis

For every proposed project and scenario, three measures of economic viability have been calculated:

- *net present value* (NPV)
- IRR
- NPVR(1).

The NPVR is the appropriate economic measure to use when ranking projects, on the assumption that public investment funds are the major limiting constraint on investment. The NPVR(1) is defined as the net present value of all net benefits minus project costs (all in economic prices), divided by the public capital and O & M costs in financial prices.

Although the NPVR should be used for ranking on economic grounds, it is again emphasised that an overall assessment of a project's viability must include other factors which in reality can determine the success or failure of a project. For that purpose, the multi-criteria analysis, which incorporates the economic analysis and other factors, is the appropriate analysis to guide decision making.

In order to allow direct comparisons of projects, the analysis is made as if they could all be carried out at the same time, i.e. the same assumptions about yield increases, same sets of prices etc. are applied to all projects. In reality it is not possible to implement all projects during the same period, as is reflected in the plan phasing. Any future re-appraisal will therefore be dealing with a different set of conditions with respect to prices, yields etc., and may therefore produce different results, but clearly the current analysis can only be based on trends which are apparent now.

6.2 Results

Scenarios

(a) Lower Atrai

Results of the economic analysis and other analyses are shown in Table 6.1 and summary indicators are shown in the Appendix. The analysis for the Lower Atrai considered three basic scenarios, full FCD, full FCD with major drains, and "Green River". The first two analyses were conducted at the Interim Report stage.

Full FCD was analysed in the Interim Report as a series of projects (polder rehabilitation). Most of these showed theoretical high returns. However, it appears to be not possible to attain full FCD conditions in the Lower Atrai, and therefore the full FCD analysis was not considered as a feasible scenario.

Full FCD with the major drains was analysed as a scenario for the Lower Atrai. The Diversion Drain, draining out into the Ganges, and the Interceptor Drain, draining to the Jamuna, were analysed in terms of their impact on the Lower Atrai. The Diversion Drain had an IRR of 2% and the Interceptor Drain a negative IRR. The very high costs of these developments made them clearly infeasible and they have not been analysed further.

The analysis for the Lower Atrai during the final stage of planning has therefore focussed on the "Green River" scenario. This essentially comprises a combination of FCD set much further back from the river, and flow areas close to the river. These proposals have been analysed for every sub-unit of the basin, and then in overall terms. The general approach appears to be economically viable as well as having benefits in terms of reducing social conflicts induced by major differences in water levels inside and outside the polders. The IRR of the Lower Atrai basin as a whole is 21%. Benefits comprise some increases in HYV t. aman in the FCD areas, and some increases in deepwater aman and fisheries in some of the flow areas. There are also benefits in terms of damage reductions. Conversely, disbenefits are relatively small.

(b) Upper Karatoya

The Upper Karatoya scenario is primarily intended to address development in the lower part of the Upper Karatoya basin, where crop and non-crop damage can be quite significant. Different options were considered for the area but the option to be analysed involves full FCD works on both banks of the Upper Karatoya, and construction of a shortened interceptor channel, the "Bangali Floodway", to discharge flows out to the Jamuna, leaving a residual flow to go down the Bangali River. The Bangali Floodway was analysed on its own merits but also following the planning principle that increased discharges should not be passed downstream.

Benefits from the proposal include changes in cropping patterns on the Upper Karatoya left bank (increases in HYV t. aman) and reductions in damage on both the left and the right bank. Further damage reductions were expected downstream of the Bangali Floodway in the Middle Bangali planning unit. Although the main development to benefit this area would be the effective sealing of the BRE, crop and non-crop damage would still occur as a result of flooding greater than a 1:5 year return period. Therefore damage reduction benefits were included for the difference between a 1:20 and a 1:5 return period. Fisheries disbenefits are significant, with a 30% decline in the total value of fisheries output, but purely in value terms these disbenefits are far outweighed by the benefits.

Table 6.1 Results of Economic Analysis of Scenarios

	Lower Atrai Major drain	Lower Atrai Gr. River	Up. Karatoya (Bangali F.way)	Gaibandha (incl. Teesta RB)	Teesta LB (B'water Embkt)	L. Jamuna R. Bank	Mohananda 20 Year
Net Cultivable Area(ha)	382756	355692	(180000)	(197780)	51021	9500	15073
Total Cost (Tk '000)	16023000	1498010	2182147	1670080	452397	33584	159418
O&M Cost (Tk '000)	480000	47138	57802	42619	13033	898	4088
IRR(%)	2	21%	5%	10%	9%	16%	5 %
NPVR(1)	-0.5	+0.48	-0.28	-0.03	-0.23	0.16	- 0.27

The project is extremely costly, however, and on cost grounds it is clearly unviable. It is probable that Upper Karatoya developments without the Bangali Floodway would approach viability, but they would also worsen conditions downstream, and such developments have therefore not been considered in this analysis.

(c) Gaibandha

The scenario and analysis for Gaibandha is described in the second part of this report and is not repeated here.

(d) Teesta Left Bank

Earlier analyses for the Teesta Left Bank included river training works. Inclusion of such works resulted in a negative rate of return and therefore they could not be economically justified. Although erosion does occur on the left bank, the Teesta is not generally moving landwards on the left side, so that omission of river training works appears logical at this stage.

The remaining project, comprising a backwater embankment on the Sati River, a tributary of the Teesta, has an IRR of 9%. This reflects the fact that most of the land area is medium-high or high land, so that major cropping pattern shifts cannot be assumed. In addition, most damages occur as a result of overland flow from the north, and would only be partially alleviated by development on the Sati River. Fisheries disbenefits are highly significant, showing a projected decline of 62% in the value of total fisheries output.

(e) Little Jamuna Right Bank

This relatively small scheme is proposed to mitigate the specific problems of crop and non-crop damage north of Naogaon caused by spillages from the Little Jamuna. Costs are small and benefits have been assessed only in terms of damage reductions. Other benefits or disbenefits have not been considered. The project as analysed has an IRR of 16%.

(f) Mohananda

The Mohananda area is affected by spills from the Mohananda and backwater from the Ganges. The proposed project essentially involves rehabilitating and heightening an existing embankment. Mohananda has specific characteristics resulting from proximity to the Indian border: cultivation of t. aman is extremely low even where conditions allow it. Cultivation of HYV boro is also low due to groundwater constraints. Trade, including cross-border trade, is important, so that the area is relatively important for navigation. Opportunities for relatively high wage employment also exist, so that a significant labour constraint stands in the way of agricultural intensification. Under these circumstances, even where a major shift in flood phases can be brought about through flood control, it is not at all clear that there would be a major response in terms of increased farm output.

The result of analysis taking the above limiting factors into account is an IRR of only 5%.

Lower Atrai Projects

A detailed analysis of the sub-units within the Lower Atrai basin has also been made, although for future development purposes it is important that the basin continue to be considered in its entirety. A brief summary of the main points of the sub-unit analysis is nonetheless given here. Table 6.2. presents results of the analysis.

Table 6.2 Result of Economic Analysis of Lower Atrai Polder

	Polder 2 Gr. River	Polder 3 Gr. River	SIRDP Gr. River	Hurasagar S Gr. River	Polder A Gr. River	Polder B Gr. River	Polder C Gr. River	Polder D Gr.Riv	Hurasagar N CFD	Hurasagar S CFD
Net Cultivable Area(ha)	52089	55578	64275	6225	27716	29411	42498	52650	25250	6225
Total Cost (Tk '000)	223589	98270	153704	63145	159171	162901	163184	239466	226281	86804
O&M Cost (Tk '000)	6156	2770	9115	1958	4622	4565	4431	7115	6456	2265
IRR(%)	24%	22%	36%	7%	14%	25%	14%	15%	– ve	21%
NPVR(1)	0.78	+ 0.58	+1.64	–0.23	+ 0.13	+ 0.99	+ 0.13	+ 0.16	–0.58	+0.69

(i) The highest returns occur in the SIRDP area. These returns are a combination of many positive factors: increased crop production (particularly HYV t. aman), considerable reductions in crop and non-crop damage which at present are significant, and increases in fisheries output since SIRDP includes a large flow area. It should be noted, however, that many of these gains are contingent on sealing of the BRE and the re-opening of the Taras embankment.

(ii) Relatively high returns (above 20%) are found for Bogra Polders 2 and 3, Chalan Beel Polder B, and Hurasagar South. In all these areas increases in HYV t. aman are set against relatively low project costs. Fisheries disbenefits are quite significant in three of these areas, however, emphasising the general conflict between FCD and capture fisheries (the setting-back of FCD structures has reduced the extent of this conflict, however, and net fisheries benefits are found in some polders).

(iii) Areas with lower returns are Chalan Beel Polders A, C and D, and Hurasagar North (and Hurasagar South flow option). The reason for lower returns in Polders A and C is the smaller areas which are planned for full protection, and therefore the smaller changes in crop output that are forecast. In Polder D a further factor is the problem of high external water levels resulting from the completed Barnai project, which are likely to cause continued cutting of embankments and continued damage. At the same time, major fisheries disbenefits are predicted for Polder D.

(iv) Hurasagar can to some extent be considered separately, since it is not subject to the confinement effect experienced elsewhere in the basin. Hurasagar North appears to have low returns because sealing of the BRE would bring about the major improvement, and other measures would not result in significant cropping changes. In Hurasagar South, two options were considered. It is obvious that the option showing the higher returns is the FCD option since it has been established that if FCD can be made effective, it can in principle create the conditions for major increases in HYV t. aman production. Therefore, although the outcome between the two options is predictable, it is still not clear that FCD in Hurasagar South can be made to be more viable than it is at present.

This brief review of the individual polders in a sense underlines the reasons why such a piecemeal approach is undesirable. It is not valid to compare two interdependent areas and select between them solely on the basis of their relative rates of return: for example, the rate of return in Polder B is higher because of the measures in Polder C which make returns there lower; again, any failure of the system in Polder D will make returns in Polder C lower than predicted; and so on. It is esential to regard the Lower Atrai as an interdependent system and to look at the proposals for the basin as a single plan.

6.3 Sensitivity Analysis

A large number of sensitivity tests were carried out on the options/scenarios in the plan. These tests were of three types:

(i) to calculate "switching values" for different elements of the cost-benefit analysis (switching values are the % change in the value of a variable to bring the IRR to 12%);

(ii) to test the particular role of rice prices in the viability of a project;

(iii) to test the impact of other specific factors (only one such analysis is reported here, the effect of loss of natural soil fertility due to embanking).

The results of these tests are discussed below:

(i) Change in net value of agricultural output with project

All projects have been found to be quite sensitive to the level of agricultural benefits forecast in with-project conditions. Relatively small percentage increases in the area under HYV t. aman can have a large impact on project viability (an increase of only 100 ha. would be enough to increase the net value of output by Tk 1 mn). Increases in yields would also tend to increase benefits significantly. Conversely, relatively small decreases in net value can also significantly reduce project viability.

The sensitivity analyses to test this impact found that, particularly in the Lower Atrai where rates of return are not far above 12% in some cases, reductions of 1-5% in the net value of agricultural output with-project would reduce the IRR to 12%. For the Lower Atrai scenario as a whole, a reduction of about 2.5% brings the IRR to 12%.

The project with the lowest rate of return is the Upper Karatoya/Bangali Floodway development. In this case an increase in net value of output of 25% would be needed to make the project economically viable.

(ii) Change in capital + O&M costs

Conversely, projects are not very sensitive to large changes in construction and O & M costs (these two variables were considered together since they are positively related). It would require an increase in costs of 90% to reduce the IRR on the Lower Atrai scenario to 12%. Conversely, a reduction of 65% would be required to make the Bangali Floodway viable.

No other sets of switching values are reported here, since other factors - delays in implementation time, delays in the stream of benefits etc.- appear to have little influence.

(iii) Import parity pricing for rice

The recommended economic valuation of paddy production now uses the mean of the import and export parity prices, to reflect the situation of near self-sufficiency which has developed. It is possible that in the future import parity pricing may again be appropriate, which would result in a higher economic value for paddy. This sensitivity analysis considered the impact of import parity pricing. The FAP Guidelines for Project Assessment derive a conversion factor of 1.02, but a more appropriate figure appears to be 1.19. Sensitivity was conducted with both conversion factors. The Teesta Left Bank project was tested: the base case IRR of 9% increased to 15% with the 1.19 conversion factor, and to 12% for the 1.02 conversion factor. The Bangali Floodway was also tested: the base case of 5% was increased to 8% with the higher conversion factor, and 6% for the lower factor.

The changes in rate of return are moderated since the different conversion factors would boost without-project net benefits as well as with-project benefits.

(iv) Changing soil fertility

The ecology report has highlighted the likelihood of loss of natural soil fertility if FCD embankments prevent any spillage of river flows onto the fields. The extent of such loss is not clear, but one sensitivity analysis was carried out to assess the impact of a 50% increase in use of nitrogenous fertiliser without any change in benefits. The analysis was carried out for Chalan Beel Polder C, and showed no change in the basic rate of return. This is not surprising since N fertiliser costs still form a relatively small part of total costs. However, such an increase may have important longer-term impacts.

7. Plan Financing Requirements and Phasing

Table 7.1. shows the financing requirements and phasing for the Regional Plan. Assuming design work on the first parts of the plan can start in FY 1993-94, expenditure for the remaining years of the Fourth Five Year Plan (FFYP) is estimated at Tk. 240mn (US$ 6.3mn). For the following 5 year period plan expenditure is estimated at about Tk. 2 bn (US$ 53mn). These figures may be compared with the total planned expenditure under the whole National Water Plan for the FFYP period of Tk. 42 bn. Of the latter, about 50% are non-discretionary funds, leaving net funds available of Tk. 24.6 bn (US$ 650mn). Assuming roughly 25% of this expenditure in the NW region, the net funds available would be Tk. 6.2 bn (US$ 163mn). The proposed expenditure over the following 5 year period in the NW regional plan is only about 30% of this figure. Therefore, although the plan does not include all projects being planned for the region, it appears to be well within the limits of current planned expenditures.

Table 7.1 Financial Requirements and Phasing of Regional Plan

Year	1993		Short-Term			1998				Medium-Term					2007	OTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
FINANCIAL REQUIREMENTS																
A. Short-Term																
Gaibandha	41.7	54.4	218.1	399.8	470.2	230.5	91.3	35.6	41.7	60.3	26.5					1670.1
Lower Atrai																
Sub-Reg Plan	50	50														100
Polders C & D	20.2	20.2	20.2	51.6	120.4	137.6	34.4									404.6
Little Jamuna R.B		3.4	9.1	15.1	6											33.6
Other Areas																
Sub-Total	111.9	128	247.4	466.5	596.6	368.1	125.7	35.6	41.7	60.3	26.5	0	0	0	0	2208.3
B. Medium-Term																
Polder 3				9.8	13.3	31	35.4	8.8								98.3
SIRDP					7.7	7.7	7.7	21.9	51.2	58.5	14.6					169.3
Polders A & B						16.2	16.2	16.2	41.3	96.4	110.2	27.5				324
Teesta Left Bank						22.6	22.6	22.6	64.5	150.4	171.9	43				497.6
Other Areas																
Sub-Total				9.8	21	77.5	81.9	69.5	157	305.3	296.7	70.5	0	0	0	1089.2
TOTAL	111.9	128	247.4	476.3	617.6	445.6	207.6	105.1	198.7	365.6	323.2	70.5	0	0	0	3297.5
PLAN OUTPUTS																
A. Increm. paddy output('000 m.t.)					3.8	7.6	17.8	28.2	39.5	53.5	69	78.5	87.6	93.9	93.9	
B. Change in Fish Output (mt)					-3.8	-7.6	-21	-29.4	-37.8	-41.4	-59.8	-68.6	-82.4	-96.2	-111	
C. Incremental Ag. Employment (000 m-days)					187	374	839	1327	1850	2417	3061	3429	3774	4003	4003	
D. Constr Empl. (000m-days)			1453	3128	4349	3135	1203	460	1738	3432	3193	716	0	0	0	

APPENDIX A

SUMMARY INDICATORS FOR SCENARIOS /PROJECTS

SUMMARY INDICATORS FOR SCENARIOS/PROJECTS

LOWER ATRAI GREEN RIVER

	w/o project	with project	% change
Total NCA (ha)		355692.00	
Capital cost(Tk m.)		1498.00	
Cap.cost per ha(Tk'000)		4.21	
O&M cost (Tk m.)		47.10	
O&M cost per ha(Tk'000)		0.13	
Paddy production ('000m.t.)	1801.00	1879.00	4.33
Fish production ('000m.t.)	17.91	17.06	-4.75
Net ann.value(econ.) of ag. output(Tk m.)	6164.00	6406.00	3.93
Net ann.value(econ.) of fish output(Tk m.)	717.00	673.00	-6.14
Net returns per ha. from ag.output(econ) (Tk'000)	17.33	18.01	3.93
Ag.employ('000m-d)	95464.00	99149.00	3.86
Total construction employment('000m-d)		10035.00	
Damage reductions (econ) (Tk m.)		102.30	
Land acquisition(ha)		601.00	
IRR (%)		21.00	
NPVR		0.48	

SUMMARY INDICATORS FOR SCENARIOS/PROJECTS

UPPER KARATOYA

	w/o project	with project	% change
Total NCA (ha)		180000.00	
Capital cost(Tk m.)		2182.00	
Cap.cost per ha(Tk'000)		12.12	
O&M cost (Tk m.)		57.80	
O&M cost per ha(Tk'000)		0.32	
Paddy production ('000m.t.)	290.00	310.00	6.90
Fish production ('000m.t.)	1.20	0.83	-30.83
Net ann.value(econ.) of ag. output(Tk m.)	1187.00	1267.00	6.74
Net ann.value(econ.) of fish output(Tk m.)	51.50	38.80	-24.66
Net returns per ha. from ag.output(econ) (Tk'000)	6.59	7.04	6.74
Ag.employ('000m-d)	18124.00	19016.00	4.92
Total construction employment('000m-d)		30360.00	
Damage reductions (econ.) (Tk m.)		91.80	
Land acquisition(ha)		3421.00	
IRR (%)		5.00	
NPVR		-0.28	

SUMMARY INDICATORS FOR SCENARIOS/PROJECTS

TEESTA LEFT BANK

	w/o project	with project	% change
Total NCA (ha)		51021.00	
Capital cost(Tk m.)		452.40	
Cap.cost per ha(Tk'000)		8.87	
O&M cost (Tk m.)		13.00	
O&M cost per ha(Tk'000)		0.25	
Paddy production ('000m.t.)	240.20	248.10	3.29
Fish production ('000m.t.)	0.72	0.27	-62.50
Net ann.value(econ.) of ag. output(Tk m.)	820.40	849.80	3.58
Net ann.value(econ.) of fish output(Tk m.)	27.60	11.90	-56.88
Net returns per ha. from ag.output(econ) (Tk'000)	16.08	16.66	3.58
Ag.employ('000m-d)	15216.00	15530.00	2.06
Total construction employment('000m-d)		4280.00	
Damage reductions (econ) (Tk m.)		9.20	
Land acquisition(ha)		293.00	
IRR (%)		9.00	
NPVR		-0.23	

SUMMARY INDICATORS FOR SCENARIOS/PROJECTS

L. JAMUNA RIGHT BANK

	w/o project	with project	% change
Total NCA (ha)		9500.00	
Capital cost(Tk m.)		33.60	
Cap.cost per ha(Tk'000)		3.54	
O&M cost (Tk m.)		0.90	
O&M cost per ha(Tk'000)		0.09	
Paddy production ('000m.t.)	0.00	0.00	0.00
Fish production ('000m.t.)	0.00	0.00	0.00
Net ann.value(econ.) of ag. output(Tk m.)	0.00	0.00	0.00
Net ann.value(econ.) of fish output(Tk m.)	0.00	0.00	0.00
Net returns per ha. from ag.output(econ) (Tk'000)	0.00	0.00	0.00
Ag.employ('000m-d)	0.00	0.00	0.00
Total construction employment('000m-d)		290.00	
Damage reductions (econ) (Tk m.)		4.30	
Land acquisition(ha)		30.00	
IRR (%)		16.00	
NPVR		0.16	

SUMMARY INDICATORS FOR SCENARIOS/PROJECTS

MOHANANDA

	w/o project	with project	% change
Total NCA (ha)		15073.00	
Capital cost(Tk m.)		159.40	
Cap.cost per ha(Tk'000)		10.58	
O&M cost (Tk m.)		4.10	
O&M cost per ha(Tk'000)		0.27	
Paddy production ('000m.t.)	24.30	29.10	19.75
Fish production ('000m.t.)	0.28	0.27	-3.57
Net ann.value(econ.) of ag. output(Tk m.)	121.10	132.70	9.58
Net ann.value(econ.) of fish output(Tk m.)	12.30	12.30	0.00
Net returns per ha. from ag.output(econ) (Tk'000)	8.03	8.80	9.58
Ag.employ('000m-d)	2035.00	2191.00	7.67
Total construction employment('000m-d)		1300.00	
Damage reductions (econ) (Tk m.)		1.42	
Land acquisition(ha)		166.00	
IRR (%)		5.00	
NPVR		-0.27	

SUMMARY INDICATORS FOR SCENARIOS/PROJECTS

GAIBANDHA

	w/o project	with project	% change
Total NCA (ha)		197780.00	
Capital cost(Tk m.)		1670.00	
Cap.cost per ha(Tk'000)		8.44	
O&M cost (Tk m.)		42.60	
O&M cost per ha(Tk'000)		0.22	
Paddy production ('000m.t.)	310.90	334.80	7.69
Fish production ('000m.t.)	0.69	0.68	-1.45
Net ann.value(econ.) of ag. output(Tk m.)	1217.90	1305.80	7.22
Net ann.value(econ.) of fish output(Tk m.)	29.90	30.30	1.34
Net returns per ha. from ag.output(econ) (Tk'000)	6.16	6.60	7.22
Ag.employ('000m-d)	18980.00	20150.00	6.16
Total construction employment('000m-d)		9760.00	
Damage reductions (econ.) (Tk m.)		53.20	
Land acquisition(ha)		425.00	
IRR (%)		10.00	
NPVR		-0.03	

B. GAIBANDHA IMPROVEMENT PROJECT

1. Introduction

1.1 Economic Analysis of the Gaibandha Project

The economic analysis at feasibility level of the Gaibandha Improvement Project has been used both to assess the viability of the selected option and, at an earlier stage, to assist in the choice between options. Sensitivity analyses to test specific alternatives within the selected option have also been carried out. Some partial analyses have also been conducted, for example to assess the viability of measures to assist navigation development.

1.2 Links with Regional Planning

The Gaibandha project is essentially the first stage in the more detailed preparation of projects and scenarios proposed in the regional plan. Also, its preparation has been based on the same principles as those applied elsewhere in the region, for example the intention not to worsen conditions downstream is part of the project concept.

The economic analysis, too, provides links between the project preparation and the regional planning, since the impact of measures which bring about improvements in Gaibandha is also felt elsewhere in the region. These impacts have where possible been included in the economic analysis of the project even where they fall outside the project area.

2. The Agro-Economic Survey

2.1 Introduction

In order to gain a greater understanding of village-level production conditions in the project area and its periphery, an agro-economic survey was carried out in early-mid 1992. Some of the results of this survey have yet to be analysed, but the following sections discuss some of the relevant results emerging from the survey.

2.2 Methodology

The survey was conducted in six villages. The villages were purposively selected to represent areas at different land elevations experiencing flooding problems of different types. No claims are made that the sample selected in the villages is in a statistical sense representative of the population in the project area as a whole. Purposive selection was however preferred to random sampling over the project area, because the incidence of flooding in the project area is not a random phenomenon: it seemed more useful to concentrate on assessing possible changes in those locations that would be affected by the project.

A questionnaire was drawn up, which asked questions on basic crop production and input use, land elevations, crop damage, constraints to production, sharecropping arrangements, etc. For each village, a complete village list of households with their land holding distribution was compiled. This list was then used to draw a sample which was to be approximately proportionate to the number of farm

households in a particular farm-size category, and which would number 35 households in total in each village. The most common sample selection by farm size was tenants 5, large farmers 15, medium farmers 10, large farmers 5.

Once the questionnaires were filled out, the data were entered onto coding sheets and from there into d base. Analysis was then carried out using SPSS.

2.3 Characteristics of Sample Villages

Basic land elevation data for the villages are given in Table 2.1.

	% total cultivable land				
	F0	F1	F2	F3	F4
Digtari	2	22	33	28	15
Ghagoa	0	41	47	12	0
Gopalcharan	6	40	45	9	0
Kismat Malibari	2	31	53	14	0
Manduar	13	30	50	7	0
Parbaguria	0	5	16	71	8
Gaibandha project area(based on MPO flood phase data)	21	61	11	6	1

Source: Consultants' Agro-economic Survey

It can be seen that, in comparison with average conditions in the project area, the selected villages have considerably less F0 land and more F2-F3 land in particular. In most of the villages F1-F2 land dominates, but in Parbaguria, north of the Manas regulator where drainage congestion is considerable, most of the land is deep flooded F3 land.

Table 2.2. gives the total village household distribution by farm-size category.

	% of total households				
	Landless	Pure Tenant	Small Farmers	Medium Farmers	Large Farmers
Digtari	21	9	43	21	6
Dhagoa	9	16	61	10	4
Gopalcharan	16	6	61	13	4
Kismat Malibari	34	8	35	14	8
Manduar	30	12	40	16	2
Parbaguria	35	9	48	5	3

Source: Consultants' Agro-economic Survey

The most striking characteristic is the large number of small farmers, as well as a significant number of landless households. Evidence from the 1983/84 Census of Agriculture confirms the view that the majority of households in the Gaibandha District in general are small farmers (some of whom also sharecrop land) or landless labouring households. There are however also a fairly large number of medium farmers in most villages and pure tenants in some villages.

2.4 Cropping Patterns

The remaining analyses are based on the sample farmers. Cropping patterns were collected according to farm size, but initially they are presented in aggregate according to land elevation. It should be noted that the original questionnaire explored cropping patterns and land elevation separately: the exercise of putting them together has been done using the same rules for allocation as were used in the development of cropping patterns for regional planning analysis.

The cropping patterns by land elevation for each village are shown in Tables 2.3. to 2.8. Overall cropping intensities vary from 121% in Manduar to 188% in Kismat Malibari. While it might be assumed that cropping intensities will be higher in those villages with a higher proportion of F0-F1 land, this is not necessarily the case: in fact Manduar is the village with the highest percentage of F0 land but with the lowest cropping intensity. The reasons for this are not wholly clear, but inspection of the cropping pattern for Manduar does show only a small number of rabi crops being grown and a relatively low irrigation rate. The high cropping intensity for Kismat Malibari reflects the high proportion of F1-F2 land and high irrigation rate there. Almost all available land is used for t. aman, more than 50% of NCA is cultivated by HYV boro, and a significant amount of jute is also grown. This village is the only one in the sample with a cropping intensity above the average for the project area which, on the basis of 1989 BBS statistics, is 170%. It would be expected that most of the sample villages would have lower cropping intensities to the extent that they suffer from flooding. Kismat Malibari was however chosen as a relatively flood-free village.

Other features of the overall cropping patterns include the following points:

(i) Irrigation rates, as measured by the area under HYV boro, are high for all villages except Manduar, around 50%. This is surprising given that BBS data suggest an irrigation rate of about 30%.

(ii) T. aman areas are in most cases reasonably high: the exception is the deeply flooded village of Parbaguria where almost no t. aman is grown (instead, the area under oilseeds is very high in this village). The selection between HYV and local t. aman also varies between villages but, for example, Gopalcharan which has the highest area of HYV t. aman has very little F0 land, implying the HYV t. aman must be grown on F1 land.

(iii) Jute is an important crop in the area and this is reflected in the project areas, where it is far more important than local aus.

(iv) Wheat is quite important in the sample areas.

2.5 Land Elevation and Cropping Patterns by Farm Size

The distribution of land owned by farm size in each village is shown in Tables 2.9. to 2.14. In most villages there is a tendency for large and medium farmers to own a higher proportion of lower-lying land (F2-F4) compared with small farmers. This might be a reflection of land selling practices, or it might partly reflect the ability of bigger farmers to gain access to previously khas land on the edge of beels. Whatever the reason, since cropping intensities are generally higher on F0-F1 land, it follows that small farmers are likely to have higher cropping intensities overall than medium-large farmers. This would be consistent with the frequently observed tendency for small farmers to achieve higher land productivity.

Table 2.3 Cropping patterns by flood phase, for village: Digtar

LAND TYPE	AMOUN	% OF NCA	IRRIGATION BALANCE	
F0	1		HYV BO	36
F1	6		WHEAT	21
TOTAL	7		HYV AU	0
F2	61			
F3	37		TOTAL	57
TOTAL	97			
F4	5			
GTOYAL	109			

DISTRIBUTION OF LAND BY IRRIGATION STATUS BY FLOOD PHASE

LAND TYPE	IRRIGAT AREA	NONIRR AREA	TOTAL AREA	% IRRIG
F0	0.00	0.63	0.63	0.00
F1	0.48	5.54	6.02	8.00
TOTAL	0.52	6.17	6.65	7.82
F2	27.31	33.37	60.68	45.00
F3	29.22	7.30	36.52	80.00
F4				
TOTAL	57.04	51.58	108.62	52.51

CROPS ON F0+F1

RABI SEASON		AUS SEASON		AMAN SEASON		ANNUAL CROPS	
HYV BORO	0	B. AUS	6	HYV TA	3	SUGARC	0
WHEAT	2	HYV AU	0	L.T. AM	4	ORCHAR	0
POTATO	0	JUTE	0	VEGETA	0		
TOBACCO	0	OILSEEE	0	SPICES	0		
PULSES	0	SPICES	0				
OILSEED	0	VEGETA	0				
SPICES	1						
VEGETABLES	0						
Sub-Total	3	Sub-Total	6	Sub-Total	7	Sub-Total	0
TOTAL	16						
CROPPING INTENSITY	235						

CROPS ON F2 LANDS

HYV BORO	7
DW AMAN	0
BAUS	5
SPICES	1
PULSES	0
LTAMAN	48
JUTE	27
oilseed	0
WHEAT	20
L.BORO	0
Sub-Total	108
CROPPING INTENSITY	178

CROPS ON F3 LAND

HYV BORO	29
LOCAL BORO	0
D.W.AMAN	7
OTHER	2
OILSEED	0
PULSES	2
Sub-Total	41
CROPPING INTENSITY	111

Table 2.4 Cropping patterns by flood phase, for village: Ghagoa

LAND TYPE	AMOUN	% OF NCA	IRRIGATION BALANCE	
F0	2		HYV BO	54
F1	40		WHEAT	0
TOTAL	42		HYV AU	0
F2	45			
F3	13		TOTAL	54
TOTAL	58			
F4	0			
GTOYAL	100			

DISTRIBUTION OF LAND BY IRRIGATION STATUS BY FLOOD PHASE

LAND TYPE	IRRIGAT AREA	NONIRR AREA	TOTAL AREA	% IRRIG
F0	0	2	2	0
F1	9	31	40	23
TOTAL	9	33	42	22
F2	31	13	45	70
F3	13	0	13	100
F4			0	
TOTAL	54	46	100	54

CROPS ON F0+F1

RABI SEASON		AUS SEASON		AMAN SEASON		ANNUAL CROPS	
HYV BORO	10	B. AUS	0	HYV TA	57	SUGARC	0
WHEAT	3	HYV AU	0	L.T. AM	0	ORCHAR	0
POTATO	2	JUTE	10	VEGETA	0		
TOBACCO	0	OILSEEE	0	SPICES	0		
PULSES	0	SPICES	0				
OILSEED	0	VEGETA	1				
SPICES	2						
VEGETABLES	0						
Sub-Total	17	Sub-Total	11	Sub-Total	57	Sub-Total	0
TOTAL	84						
CROPPING INTENSITY	199						

CROPS ON F2 LANDS	
HYV BORO	31
HYVTAMAN	14
BAUS	0
SPICES	0
PULSES	5
LTAMAN	11
JUTE	9
OILSEED	0
WHEAT	7
L.BORO	0
TOTAL	77
CROPPING INTENSITY	172

CROPS ON F3 LAND	
HYV BORO	13
LOCAL BORO	0
D.W.AMAN	0
OTHER	0
oilseed	1
PULSES	0
TOTAL	14
CROPPING INTENSITY	109

Table 2.5 Cropping patterns by flood phase, for village: Gopalcharan

LAND TYPE	AMOUN	% OF NCA	IRRIGATION BALANCE	
F0	2		HYV BO	54
F1	40		WHEAT	0
TOTAL	42		HYV AU	0
F2	45			
F3	13		TOTAL	54
TOTAL	58			
F4	0			
GTOYAL	100			

DISTRIBUTION OF LAND BY IRRIGATION STATUS BY FLOOD PHASE

LAND TYPE	IRRIGAT AREA	NONIRR AREA	TOTAL AREA	% IRRIG
F0	0.00	2.13	2.13	0.00
F1	9.39	30.63	40.02	23.46
TOTAL	9.39	32.76	42.15	22.27
F2	31.28	13.41	44.69	70.00
F3	13.01	0.00	13.01	100.00
F4			0.00	
TOTAL	53.68	46.19	99.87	53.75

CROPS ON F0+F1

RABI SEASON		AUS SEASON		AMAN SEASON		ANNUAL CROPS	
HYV BORO	10	B. AUS	0	HYV TA	57	SUGARC	0
WHEAT	3	HYV AU	0	L.T. AM	0	ORCHAR	0
POTATO	2	JUTE	10	VEGETA	0		
TOBACCO	0	OILSEEE	0	SPICES	0		
PULSES	0	SPICES	0				
OILSEED	0	VEGETA	1				
SPICES	2						
VEGETABLES	0						
Sub-Total	17	Sub-Total	11	Sub-Total	57	Sub-Total	0
TOTAL	84						
CROPPING INTENSITY	199						

CROPS ON F2 LANDS	
HYV BORO	31
HYVTAMAN	14
BAUS	0
SPICES	0
PULSES	5
LTAMAN	11
JUTE	9
OILSEED	0
WHEAT	7
L.BORO	0
TOTAL	77
CROPPING INTENSITY	172

CROPS ON F3 LAND	
HYV BORO	13
LOCAL BORO	0
D.W.AMAN	0
OTHER	0
OILSEED	1
PULSES	0
TOTAL	14
CROPPING INTENSITY	109

Table 2.6 Cropping patterns by flood phase, for village: Kismat

LAND TYPE	AMOUN	% OF NCA	IRRIGATION BALANCE	
F0	3		HYV BO	58
F1	33		WHEAT	0
TOTAL	36		HYV AU	0
F2	39			
F3	22		TOTAL	58
TOTAL	61			
F4	1			
GTOYAL	98			

DISTRIBUTION OF LAND BY IRRIGATION STATUS BY FLOOD PHASE

LAND TYPE	IRRIGAT AREA	NONIRR AREA	TOTAL AREA	% IRRIG
F0	0.00	2.80	2.80	0.00
F1	9.96	23.52	33.48	29.75
TOTAL	9.96	26.32	36.28	27.45
F2	27.55	11.81	39.35	70.00
F3	20.43	1.08	21.51	95.00
F4			0.66	
TOTAL	57.94	39.86	97.80	59.24

CROPS ON F0+F1

RABI SEASON		AUS SEASON		AMAN SEASON		ANNUAL CROPS	
HYV BORO	10	B. AUS	0	HYV TA	31	SUGARC	0
WHEAT	12	HYV AU	0	L.T. AM	6	ORCHAR	0
POTATO	3	JUTE	15	VEGETA	0		
TOBACCO	0	OILSEEE	0	SPICES	0		
PULSES	0	SPICES	0				
OILSEED	2	VEGETA	1				
SPICES	2						
VEGETABLES	1						
Sub-Total	29	Sub-Total	16	Sub-Total	36	Sub-Total	0
TOTAL	81						
CROPPING INTENSITY	224						

CROPS ON F2 LANDS

HYV BORO	28
HYVTAMAN	0
BAUS	0
SPICES	0
PULSES	5
LTAMAN	36
JUTE	9
oilseed	0
WHEAT	0
L.BORO	0
TOTAL	77
CROPPING INTENSITY	196

CROPS ON F3 LAND

HYV BORO	20
LOCAL BORO	1
D.W.AMAN	0
OTHER	0
POLSEED	4
PULSES	0
TOTAL	25
CROPPING INTENSITY	118

Table 2.7 Cropping patterns by flood phase, for village: Manduar

LAND TYPE	AMOUN	% OF NCA	IRRIGATION BALANCE	
F0	17		HYV BO	36
F1	50		WHEAT	0
TOTAL	67		HYV AU	0
F2	38			
F3	12		TOTAL	36
TOTAL	49			
F4	0			
GTOYAL	116			

DISTRIBUTION OF LAND BY IRRIGATION STATUS BY FLOOD PHASE

LAND TYPE	IRRIGAT AREA	NONIRR AREA	TOTAL AREA	% IRRIG
F0	0	17	17	0
F1	5	44	50	11
TOTAL	5	61	67	8
F2	23	15	38	60
F3	7	4	12	65
F4			0	
TOTAL	36	81	116	31

CROPS ON F0+F1

RABI SEASON		AUS SEASON		AMAN SEASON		ANNUAL CROPS	
HYV BORO	5	B. AUS	4	HYV TA	8	SUGARC	1
WHEAT	6	HYV AU	0	L.T. AM	44	ORCHAR	1
POTATO	3	JUTE	12	VEGETA	0		
TOBACCO	0	OILSEEE	0	SPICES	0		
PULSES	1	SPICES	0				
OILSEED	0	VEGETA	1				
SPICES	0						
VEGETABLES	0						
Sub-Total	15	Sub-Total	16	Sub-Total	52	Sub-Total	1
TOTAL	84						
CROPPING INTENSITY	126						

CROPS ON F2 LANDS	
HYV BORO	23
HYVTAMAN	0
BAUS	2
SPICES	0
PULSES	2
LTAMAN	10
JUTE	7
OILSEED	0
WHEAT	3
L.BORO	0
TOTAL	46
CROPPING INTENSITY	122

CROPS ON F3 LAND	
HYV BORO	7
LOCAL BORO	2
D.W.AMAN	2
OTHER	0
OILSEED	1
PULSES	0
TOTAL	13
CROPPING INTENSITY	110

Table 2.8 Cropping patterns by flood phase, for village: Parbagharia

LAND TYPE	AMOUN	% OF NCA	IRRIGATION BALANCE	
F0	0		HYV BO	47
F1	5		WHEAT	0
TOTAL	5		HYV AU	0
F2	30			
F3	40		TOTAL	47
TOTAL	70			
F4	1			
GTOYAL	76			

DISTRIBUTION OF LAND BY IRRIGATION STATUS BY FLOOD PHASE

LAND TYPE	IRRIGAT AREA	NONIRR AREA	TOTAL AREA	% IRRIG
F0	0.00	0.03	0.03	0.00
F1	1.13	3.87	5.00	22.54
TOTAL	1.13	3.90	5.03	22.40
F2	7.46	22.39	29.85	25.00
F3	38.82	1.16	39.98	97.10
F4			0.92	
TOTAL	47.41	28.37	75.78	62.56

CROPS ON F0+F1

RABI SEASON		AUS SEASON		AMAN SEASON		ANNUAL CROPS	
HYV BORO	1	B. AUS	0	HYV TA	0	SUGARC	0
WHEAT	1	HYV AU	0	L.T. AM	3	ORCHAR	0
POTATO	0	JUTE	2	VEGETA	0		
TOBACCO	0	OILSEEE	1	SPICES	0		
PULSES	0	SPICES	0				
OILSEED	1	VEGETA	0				
SPICES	0						
VEGETABLES	0						
Sub-Total	4	Sub-Total	3	Sub-Total	3	Sub-Total	0
TOTAL	10						
CROPPING INTENSITY	198						

CROPS ON F2 LANDS

HYV BORO	7
HYVTAMAN	0
BAUS	0
SPICES	0
PULSES	1
LTAMAN	4
JUTE	1
OILSEED	27
WHEAT	7
L.BORO	0
TOTAL	47
CROPPING INTENSITY	158

CROPS ON F3 LAND

HYV BORO	39
LOCAL BORO	1
D.W.AMAN	0
OTHER	0
OILSEED	10
PULSES	0
TOTAL	50
CROPPING INTENSITY	125

Analysis of cropping patterns by land elevation and farm size is shown for two of the villages, Manduar and Gopalcharan. The hypothesis that large farmers have the lowest cropping intensities is borne out by the analysis, but the hypothesis that small farmers have highest cropping intensities applies in Manduar but not in Gopalcharan, where medium farmers have higher intensities. Cropping intensities on sharecropped land are generally around 200%, as would be expected for land sharecropped for a whole year.

Despite some differences in elevation of land owned and in cropping intensities, different farm-size groups are generally growing the same crops in similar proportions. In both villages -in fact in all of them except for Parbaguria- the approximate order of priority is t. aman, HYV boro, jute, wheat, oilseeds, other crops.

If farmers are tending to grow the same crops it could be supposed that any flood control project would affect them to equal extents. But this is not necessarily the case: much depends on the initial distribution of land owned according to land elevation, since flood control projects will only benefit certain types of land. An analysis is carried out later to provide an example of possible income distributional effects of flood control measures.

2.6 Variations in Input Use and Crop Production

Statistical tests were carried out to see if there were significant differences in yields and input use between farm size groups. The tests were carried out on the pooled data from all six villages, i.e. for a total of approximately 30 tenants, 90 small farmers, 60 medium farmers and 30 large farmers. The results are summarised here.

(a) Yields

Tests were carried out for differences in average yields of HYV boro, HYV t. aman and local t. aman, considering all operated land of each farm-size group. A separate test was then made for differences on the owned and sharecropped land operated by tenants.

The tests for boro yields found that yields of tenants and small farmers were significantly higher than yields of large farmers (all tests are t tests with 95% level of confidence), but no significant differences could be found between yields of medium farmers and any other farm size group. These findings tend to support the hypothesis that tenants and small farmers farm more intensively, and large farmers farm the least intensively. Tenant yields on own land were also significantly greater than yields on sharecropped land.

The tests for HYV t. aman and local t. aman yields found no significant difference in yields between any farm size group. This is presumably a reflection of the lower input requirements for these crops.

(b) Input Use

It would be expected that tests for per acre input use would support the findings on yields: in general they do so, although with some anomalies. Tests were made of total use of purchased fertilisers per acre, and total man-days per acre. The results are summarised here.

There is no significant difference in fertiliser use for HYV t. aman and local t. aman between any farm size group. In terms of labour use, for local t. aman there is no significant difference between

Table 2.9 **Land owned by farmsize group and flood phase distribution, for Digtari**

LAND OWNED BY FARM SIZE, FLOOD PHASE AND NO. OF PLOTS.

FARM SIZE	NO. OF FARMERS	LAND TYPE	TOTAL LAND	LAND PE FARMER	TOTAL PLOTS	PLOTS PER FARMER
TENANTS	5.00	F0	0.00	0.00	0.00	0.00
		F1	0.03	0.01	1.00	0.20
		F2	0.17	0.03	4.00	0.80
		F3	0.00	0.00	0.00	0.00
		F4	0.00	0.00	0.00	0.00
		TOTAL	0.20	0.04	5.00	1.00
SMALL FARMER	15.00	F0	0.33	0.02	1.00	0.07
		F1	3.82	0.25	11.00	0.73
		F2	10.57	0.70	45.00	3.00
		F3	3.84	0.26	21.00	1.40
		F4	0.00	0.00	0.00	0.00
		TOTAL	18.56	1.24	78.00	5.20
MEDIUM FARMER	10.00	F0	0.00	0.00	0.00	0.00
		F1	1.51	0.15	12.00	1.20
		F2	17.76	1.78	62.00	6.20
		F3	11.19	1.12	41.00	4.10
		F4	0.77	0.08	3.00	0.30
		TOTAL	31.23	3.12	118.00	11.80
LARGE FARMER	5.00	F0	0.00	0.00	0.00	0.00
		F1	0.33	0.07	1.00	0.20
		F2	26.59	5.32	63.00	12.60
		F3	18.67	3.73	27.00	5.40
		F4	4.00	0.80	4.00	0.80
		TOTAL	49.59	9.92	95.00	19.00

DIGTARI

TOTAL LAND ALLOCATION		%
F0	0.63	0.58
F1	6.02	5.54
F2	60.68	55.86
F3	36.52	33.62
F4	4.77	4.39
TOTAL	108.62	

ditab2

Table 2.10 Land owned by farmsize group and flood phase distribution, for Ghagoa

LAND OWNED BY FARM SIZE, FLOOD PHASE AND NO. OF PLOTS.

FARM SIZE	NO. OF FARMERS	LAND TYPE	TOTAL LAND	LAND PER FARMER	TOTAL PLOTS	PLOTS PER FARMER
TENANTS	5.00	F1	0.04	0.01	1.00	0.20
SMALL FARMER	14.00	F0	0.00	0.00	0.00	0.00
		F1	5.74	0.41	31.00	2.21
		F2	2.40	0.17	9.00	0.64
		F3	3.56	0.25	14.00	1.00
		F4	0.45	0.03	8.00	0.57
		TOTAL	12.15	0.87	62.00	4.43
MEDIUM FARME	11.00	F0	1.00	0.09	4.00	0.36
		F1	9.91	0.90	35.00	3.18
		F2	11.28	1.03	33.00	3.00
		F3	10.93	0.99	34.00	3.09
		F4	0.00	0.00	3.00	0.27
		TOTAL	33.12	3.01	109.00	9.91
LARGE FARMER	5.00	F0	0.00	0.00	0.00	0.00
		F1	7.76	1.55	22.00	4.40
		F2	14.99	3.00	41.00	8.20
		F3	25.22	5.04	56.00	11.20
		F4	0.00	0.00	0.00	0.00
		TOTAL	47.97	9.59	119.00	23.80

TOTAL LAND ALLOCATION		%
F0	1.00	1.02
F1	25.33	25.82
F2	29.84	30.42
F3	41.47	42.28
F4	0.45	0.46
TOTAL	98.09	

ghtab2

Table 2.11 Land owned by farmsize group and flood phase distribution, for Gopalcharan

LAND OWNED BY FARM SIZE, FLOOD PHASE AND NO. OF PLOTS.

FARM SIZE	NO. OF FARMERS	LAND TYPE	TOTAL LAND	LAND PER FARMER	TOTAL PLOTS	PLOTS PER FARMER
TENANT	5.00	F0	0.04	0.01	1.00	0.20
		F1	0.06	0.01	2.00	0.40
		F2	0.03	0.01	1.00	0.20
SMALL FARMER	17.00	F0	0.10	0.01	1.00	0.06
		F1	7.88	0.46	34.00	2.00
		F2	7.65	0.45	38.00	2.24
		F3	1.88	0.11	10.00	0.59
		F4	0.00	0.00	0.00	0.00
		TOTAL	17.51	1.03	83.00	4.88
MEDIUM FARMER	8.00	F0	0.99	0.12	5.00	0.63
		F1	14.79	1.85	43.00	5.38
		F2	16.90	2.11	57.00	7.13
		F3	0.48	0.06	2.00	0.25
		F4	0.00	0.00	0.00	0.00
		TOTAL	33.16	4.15	107.00	13.38
LARGE FARMER	5.00	F0	1.00	0.20	3.00	0.60
		F1	14.12	2.82	30.00	6.00
		F2	15.57	3.11	31.00	6.20
		F3	9.66	1.93	18.00	3.60
		F4	0.00	0.00	0.00	0.00
		TOTAL	40.35	8.07	82.00	16.40

TOTAL LAND ALLOCATION		%
F0	2.13	2.13
F1	40.02	40.08
F2	44.69	44.76
F3	13.01	13.03
F4	0.00	0.00
TOTAL	99.85	

gotab2

Table 2.12 Land owned by farmsize group and flood phase distribution, for Kismat Malibari

LAND OWNED BY FARM SIZE, FLOOD PHASE AND NO. OF PLOTS.

FARM SIZE	NO. OF FARMERS	LAND TYPE	TOTAL LAND	LAND PER FARMER	TOTAL PLOTS	PLOTS PER FARMER
SMALL FARMER	16.00	F0	0.71	0.04	6.00	0.38
		F1	5.37	0.34	23.00	1.44
		F2	5.51	0.34	21.00	1.31
		F3	1.91	0.12	5.00	0.31
		F4	0.00	0.00	0.00	0.00
		TOTAL	13.50	0.84	55.00	3.44
MEDIUM FARMER	9.00	F0	0.33	0.04	1.00	0.11
		F1	11.80	1.31	23.00	2.56
		F2	14.66	1.63	43.00	4.78
		F3	6.99	0.78	23.00	2.56
		F4	0.66	0.07	2.00	0.22
		TOTAL	34.44	3.83	92.00	10.22
LARGE FARMER	5.00	F0	0.56	0.11	2.00	0.40
		F1	12.93	2.59	39.00	7.80
		F2	17.52	3.50	51.00	10.20
		F3	9.66	1.93	22.00	4.40
		F4	0.00	0.00	0.00	0.00
		TOTAL	40.67	8.13	114.00	22.80

TOTAL LAND ALLOCATION		%
F0	2.80	2.86
F1	33.48	34.23
F2	39.35	40.24
F3	21.51	21.99
F4	0.66	0.67
TOTAL	97.80	

kmtab2

Table 2.13 Land owned by farmsize group and flood phase distribution, for Manduar

LAND OWNED BY FARM SIZE, FLOOD PHASE AND NO. OF PLOTS.

FARM SIZE	NO. OF FARMERS	LAND TYPE	TOTAL LAND	LAND PE FARMER	TOTAL PLOTS	PLOTS PER FARMER
SMALL FARMER	15.00	F0	2.44	0.16	11.00	0.73
		F1	4.70	0.31	17.00	1.13
		F2	6.56	0.44	20.00	1.33
		F3	1.31	0.09	4.00	0.27
		F4	0.00	0.00	0.00	0.00
		TOTAL	15.01	1.00	52.00	3.47
MEDIUM FARMER	10.00	F0	2.52	0.25	7.00	0.70
		F1	11.73	1.17	26.00	2.60
		F2	18.59	1.86	38.00	3.80
		F3	6.46	0.65	17.00	1.70
		F4	0.00	0.00	0.00	0.00
		TOTAL	39.30	3.93	88.00	8.80
LARGE FARMER	5.00	F0	10.97	2.19	24.00	4.80
		F1	29.84	5.97	50.00	10.00
		F2	10.33	2.07	34.00	6.80
		F3	3.00	0.60	20.00	4.00
		F4	0.00	0.00	0.00	0.00
		TOTAL	54.14	10.83	128.00	25.60

TOTAL LAND ALLOCATION		%
F0	17.05	14.69
F1	49.51	42.66
F2	37.96	32.72
F3	11.52	9.93
F4	0.00	0.00
TOTAL	116.04	

matab2

Table 2.14 Land owned by farmsize group and flood phase distribution, for Parbaguria

LAND OWNED BY FARM SIZE, FLOOD PHASE AND NO. OF PLOTS.

FARM SIZE	NO. OF FARMERS	LAND TYPE	TOTAL LAND	LAND PER FARMER	TOTAL PLOTS	PLOTS PER FARMER
TENANT	5.00	F1	0.03	0.01	1.00	0.20
SMALL FARMER	22.00	F0	0.00	0.00	0.00	0.00
		F1	2.20	0.10	11.00	0.50
		F2	11.15	0.51	43.00	1.95
		F3	9.39	0.43	34.00	1.55
		F4	1.10	0.05	5.00	0.23
		TOTAL	23.84	1.08	93.00	4.23
MEDIUM FARMER	5.00	F0	0.00	0.00	0.00	0.00
		F1	0.80	0.16	3.00	0.60
		F2	9.89	1.98	23.00	4.60
		F3	8.71	1.74	16.00	3.20
		F4	0.00	0.00	0.00	0.00
		TOTAL	19.40	3.88	42.00	8.40
LARGE FARMER	5.00	F0	0.00	0.00	0.00	0.00
		F1	2.00	0.40	4.00	0.80
		F2	5.66	1.13	15.00	3.00
		F3	10.66	2.13	30.00	6.00
		F4	7.32	1.46	18.00	3.60
		TOTAL	25.64	5.13	67.00	13.40

TOTAL LAND ALLOCATION		%
F0	0.03	0.04
F1	5.00	6.60
F2	29.85	39.39
F3	31.98	42.20
F4	8.92	11.77
TOTAL	75.78	

farm size groups, but for HYV t. aman tenants use significantly more labour than any other farm size group, and there are no differences in labour use between the other groups. In terms of differences between tenant owned land and sharecropped land, labour use is higher on owned land for HYV t. aman but higher on sharecropped land for local t. aman. There is no obvious reason for this finding.

In general, though, the finding that tenants use more labour ("self-exploitation") than other groups is not surprising. The finding is repeated in the case of HYV boro, and it is also found that tenants use more fertiliser per acre on boro than any other group, even though the terms of tenancy require tenants to supply all fertilisers themselves (for a 50% crop-share). Tenants have an urgent requirement to maximise yields not only for immediate use but also to ensure continuation of the tenancy. The results also show significantly higher fertiliser use by tenants on sharecropped land compared to owned land, but the opposite trend for labour use.

There are no significant differences in input use for boro between other farm size groups.

The main findings of the analysis are therefore that tenants have the most intensive input use, particularly for boro, and that this is reflected in boro yields which are higher for tenants (and small farmers) than for other groups.

2.7 Crop Damage

Data were collected on crop damage for the years 1987-91. Complete analysis of these data has not been possible at this stage, but an indicative analysis for 1987-90 pooling data for five of the six survey villages has been carried out. The results are shown in Table 2.15.

The main conclusions to be drawn from the table are that damage to t. aman areas is quite high in the five villages, and also that there is not the great difference between damage in 1987-88 and the other years that one might expect. One reason for this is that the villages were selected because they tended to be flood-prone (with the exceptions of Gopalcharan and Kismat Malibari). But this raises an important point, that many areas in Gaibandha and elsewhere in the region suffer persistent flooding even when flood return periods are not very high, for reasons of drainage congestion, poor planning of flood control structures, predominance of low-lying land etc. Protection against major floods will not necessarily solve these problems and in some cases might make them worse (if drainage congestion occurs behind large embankments).

The finding, from an admittedly small sample, also seems to support the regional analysis of crop damage where it was found that the average annual reduction in flood damage due to protecting from events upto 1:5 return periods was only about 25-30% lower than the reduction achieved by protecting upto a 1:20 return period.

2.8 Agricultural Income by Farm Size

The analysis of net income for all six villages has not yet been completed. An indicative analysis of one village, Manduar, has been carried out, not only to give information on net returns, but also to allow an analysis of income distribution changes due to the project to be carried out. The income distribution analysis is reported later.

The patterns shown in the analysis for Manduar are probably fairly representative of the other villages, with the possible exception of Parbaguria where t. aman production is virtually impossible.

Table 2.15 Results of Crop Flood Damage analysis for 5 Villages in Gaibandha Project Area

Year	Approx. Flood Return Period	LT Aman			HYV Aman			Total Aman		
		ha. damaged	% of farmed area	output lost (ha)	ha. damaged	% of farmed area	output lost (ha)	ha. damaged	% of farmed area	output lost (ha)
1990	1 in 2	35.4	14	65	17.9	7	46	53.3	21	111
1989	1 in 3	28.2	11	48	19.1	8	49	47.3	19	97
1988	1 in 15	51.4	21	69	39.3	16	119	90.7	37	158
1987	1 in 25	32.1	13	62	19.4	8	53	51.5	21	115

Source : Data from Consultants' Agro-economic Survey of Gaibandha

Tables 2.16. to 2.20. show cropping patterns by farm size group for a "standard" farmer and the resulting measures of net returns. A number of points can be made about the figures.

(i) Tenant net returns are reported before the crop-share. When the landlord's share is deducted, tenant net returns at cash cost fall from Tk9,763 to Tk3,244.

(ii) In a similar way, the net return at cash cost from small farmers' sharecropped land falls from Tk6,140 to Tk1,623.

(iii) Total net returns at cash cost per "standard" farmer are therefore as follows:

		% tenant income
Tenants	Tk 3,244	100
Small farmers	Tk12,940	400
Medium farmers	Tk17,994	555
Large farmers	Tk27,547	850

Therefore, large farmers incomes from this first-round analysis are 8-9 times greater than incomes of tenants. Even small farmers incomes are four times greater. If further analyses of income flows within the village economy were carried out, the income gap between large farmers and others would almost certainly increase, since they also tend to be the suppliers of land for sharecropping, credit for cultivation and other purposes, water for irrigation, draught power for ploughing etc.

(iv) Comparison of the figures for net income and net return at cash cost reveals the impact of farmer resource availability on cash returns. The net income figure is calculated as net returns at full cost plus the imputed value of family labour. The figure for net returns at cash cost is calculated as gross returns less actual expenditure on inputs. If there is only a small difference between net income and net returns at cash cost it means that, with the possible exception of own labour, most other inputs have been purchased. In contrast, if net returns at cash cost are considerably higher than net income, it implies that there is a big difference between the value of inputs at full cost and that at cash costs, i.e. a high proportion of inputs are actually own inputs.

The differences are shown here (net return-net income):

Tenants	-	+222
Small farmers	-	+1645
Medium farmers	-	+2700
Large farmers	-	+5580

Therefore it is clear that, as farm sizes increase, farmers are more able to supply their own inputs such as irrigation water, draught power and seeds, whereas tenants in particular have to purchase almost all inputs except labour. In this way tenants are further disadvantaged.

2.9 Employment and Wages

The tables above also show the proportion of hired labour use to total labour use by farm size. In this respect, the tendency to supply own inputs is reversed: as farm sizes increase, a higher proportion

TABLE 2.16 CROPPING PATTERNS AND NET RETURNS BY FARM-SIZE GROUP

PRESENT CONDITION

TENANT FARMER STANDARD FARMER

SHARE CROPPED LAND	PERFARM LAND (ACRES)	NET RETURN FULLCOST)	NET INCOME	NET RETURN (CASH COST)	CASH COST	IRED LAB/ OTAL LAB.
NET LAND	3.13					
L BPRO						
HYVBORO	0.56	4039.12	4543.12	2679.04	4643.36	0.33
WHEAT	0.07	260.94	297.90	113.98	317.70	0.28
POTATO						
JUTE	0.07	240.49	278.77	73.92	284.97	0.49
B.AMAN						
LTAMAN	0.39	4263.49	4421.09	408.58	4517.23	0.47
HYVAMAN						
OIL						
OTHER						
TOTAL	1.09	8804.04	9540.88	3275.52	9763.26	0.37

CI 173.48

TABLE 2.17 CROPPING PATTERNS AND NET RETURNS BY FARM-SIZE GROUP

PRESENT CONDITION

SMALL FARMS

OWN LAND	PERFARM LAND (ACRES)	NET RETURN FULLCOST)	NET INCOME	NET RETURN (CASH COST)	CASH COST	IRED LAB/ OTAL LAB.
HYVBORO	0.71	4749.88	5231.32	2940.32	5618.60	0.47
WHEAT	0.23	988.81	1082.67	345.66	1189.21	0.35
JUTE	0.28	847.48	1007.17	257.99	1063.06	0.49
LTAMAN	0.84	1162.17	1498.17	717.36	1858.53	0.47
HYVAMAN	0.20	1093.73	1200.16	239.87	1324.59	0.51
OIL	0.10	216.89	243.41	90.17	263.20	0.28
TOTAL	2.49	9058.96	10262.91	4591.37	11317.20	0.47

CI 213.00

TABLE 2.18 CROPPING PATTERNS AND NET RETURNS BY FARM-SIZE GROUP

PRESENT

SMALL SHARE CROPPED

SHARE CROPPED LAND	PERFARM LAND (ACRES)	NET RETURN FULLCOST)	NET INCOME	NET RETURN (CASH COST)	CASH COST	IRED LAB/ OTAL LAB.
HYVBORO	0.59	3406.97	3856.89	2391.68	4180.72	0.40
WHEAT	0.00	0.00	0.00	0.00	0.00	0.13
JUTE	0.01	33.86	41.14	9.76	43.98	0.38
LTAMAN	0.53	1048.68	1346.60	433.05	1574.83	0.36
HYV AMAN	0.06	269.67	304.47	60.36	340.95	0.40
TOTAL	1.20	4759.18	5549.10	2894.85	6140.47	0.38

CI 195.37

TABLE 2.19 CROPPING PATTERNS AND NET RETURNS BY FARM-SIZE GROUP

PRESENT CONDITION STANDARDFARMER

MEDIUM FARMERS

OWN LAND	PERFARM LAND (ACRES)	NET RETURN (FULLCOST)	NET INCOME	NET RETURN (CASH COST)	CASH COST	HIRED LAB/ TOTAL LAB.
LBORO	0.07					
HYVBORO	0.88	5046.82	5398.82	6233.94	3535.84	0.70
WHEAT	0.28	1040.02	1124.92	1250.85	386.58	0.50
POTATO	0.10					
JUTE	0.96	2730.43	3056.15	3368.46	921.60	0.67
LTAUS	0.05					
B.AUS	0.30	491.29	568.77	698.11	146.32	0.55
B.AMAN	0.23					
LTAMAN	2.01	2323.01	2684.45	3708.53	1028.10	0.63
HYVAMAN	0.37	2212.84	2300.44	2554.85	496.77	0.76
BANANA	0.07					
OTHERS	0.06					
OIL	0.06	149.89	160.33	179.18	50.46	0.44
TOTAL	5.42	13994.30	15293.88	17993.91	6565.65	0.64

CI 136.55

TABLE 2.20 CROPPING PATTERNS AND NET RETURNS BY FARM-SIZE GROUP

PRESENT CONDITION STANDARD FARM

LARGE FARMERS

OWN LAND	PERFARM LAND (ACRES)	NET RETURN FULLCOST)	NET INCOME	NET RETURN (CASH COST)	CASH COST	IRED LAB/ OTAL LAB.
HYVBORO	2.07	11469.01	11882.21	8036.74	14390.33	0.85
WHEAT	0.40	1482.61	1530.61	594.40	1820.61	0.79
PULSES	0.07	377.95	385.87	30.62	411.87	0.68
POTATO	0.17					
ONION	0.04					
JUTE	0.93	2655.39	2804.51	1085.78	3087.84	0.85
LTAUS	0.66					
B.AUS	0.53	760.14	876.30	158.40	1222.67	0.58
LTAMAN	2.99	3695.29	4053.61	3057.66	6099.02	0.86
HYVAMAN	0.00	0.00	0.00	0.00	0.00	0.85
OIL	0.20	402.62	434.30	171.47	514.49	0.60
TOTAL	8.04	20843.02	21967.42	13135.08	27546.84	0.84

CI 121.14

of labour is hired. From the point of view of agricultural labour, therefore, they have more prospects of additional employment if there is growth on large farms compared with growth on small farms. In that sense it is unfortunate that large farmers have lower cropping intensities than other farm size groups.

Wages are very low, however, between Tk20-30, with slight peaks at harvest and transplanting time. The analysis of Manduar calculated total wage payments to hired labour to be about Tk214,000 (assuming average labour payments per standard farmer, multiplied by the number of farmers in each category in the village). There are 62 landless labour households in the village: on the rough assumption that only one household member is involved in agricultural labour, and that only these households do the agricultural labour work required in the village, the resulting annual income per labour is about Tk3,450. At a daily wage of Tk20 this means that a labourer could get work for 172 days per year, i.e. about 50%.

These are only very approximate figures: clearly the actual labour supply in the village would be greater, and therefore the number of days work available per labourer would be less. The rough calculation does therefore provide an index of the need for out-migration in search of work that so many labourers from Gaibandha undertake each year.

3. Economic Analysis of the Gaibandha Improvement Project

3.1 Introduction

The agro-economic survey discussed above has been used primarily to shed light on the financial conditions of farmers and labourers in the project area, and the extent to which farm practices are affected by floods.

The economic analysis has not been based on the farm survey to any great extent: rather, it has been carried out using the same basic methodology as for the regional planning, but for project options which have been prepared to a greater level of detail. Therefore analyses could be undertaken, for example of the choice between bank protection and embankment retirement, or the external impact of specific project measures, which could not be done adequately at the regional planning stage.

The methodology and data sources for the Gaibandha analysis are therefore generally the same as for the regional plan, and are fully discussed in the earlier sections of this volume. The discussion below only goes into detail where a different approach or data source was used.

The main components which have been included in the economic analysis are:

A. Project costs:

- construction and O & M costs
- economic cost of land acquisition

B. Project benefits/disbenefits:

- crop intensification benefits
- benefits/disbenefits for fisheries
- benefits of reduced crop and non-crop flood damage
- benefits from avoidance of erosion losses on the Teesta River
- disbenefits from erosion losses on the Brahmaputra River.

The benefits/disbenefits have, as much as possible, been evaluated both for the impacted area as well as for the project area.

A partial analysis has also been conducted on the potential for navigation development: this analysis is reported with the results of the main analysis.

As with the regional plan volume, data limitations have restricted the extent to which ecological and other environmental impacts could be taken into account, and the same overall approach to analysis and utilisation of results has been used, i.e. in general to bring the results of the economic analysis and the Environmental Impact Assessment together in the multi-criteria analysis. It should be noted, however, that the economic analysis has also given physical outputs - physical quantities of crops and of inputs used- which have been inputs into the EIA matrix.

3.2 Estimation of Incremental Crop Production Benefits

Cropping Patterns

The two approaches to cropping pattern analysis were discussed earlier. In the Gaibandha analysis the two approaches were both used, and gave slightly different results:

(i) The model-based analysis for Gaibandha was more detailed than for the regional plan areas. It was based on a more refined model and the cropping patterns used in analysis were adjusted to take account of present cropped areas (given by BBS). The resulting cropping patterns and methodology are fully discussed in the Agriculture Annex (Volume 13). There was very little change in cropping patterns between without-project and with-project conditions using this approach. This was basically because the model showed very high existing proportions of F0 land with little scope for improvement, and, where F2-F4 land is dominant, project measures were unable to have a great impact because of the backwater effect of the Brahmaputra.

(ii) The modified MPO approach followed the methodology described earlier. Comparison of MPO and model present-condition flood phase data showed a much higher proportion of F0 land predicted by the model. Since this over-prediction appears to have been fairly consistent in the regional plan as well, it was reasonable to assume a lower proportion of F0 land and a higher proportion of F1 land, with total F0+F1 land unchanged. With a revised flood phase distribution, there was more scope for small improvements in flood depths, i.e. some shift from F1 to F0 land. The assumed changes are still only small: the model gives no other guidance to justify assuming a substantial shift in flood phasing.

The comparisons of MPO and model flood phasing, and assumed flood phasing for the analysis, are shown below.

	F0	F1	F2	F3	F4
MPO present	21	61	11	6	1
Model present	83	12	5	1	0
Model future w.	84	12	3	1	0
Assumed present/ future w/o	31	51	11	6	1
Assumed future w.	40	47	7	5	1

Under the assumed conditions, there is a larger increase in HYV t. aman partly offset by a decrease in local t. aman as more land is shifted from F1 to F0 land. Tables 3.1-3.2 show without-project and with-project cropping patterns under the modified MPO approach.

It should be noted that the benefitted area under the second approach includes the area downstream of the Alai regulator, i.e. immediately south of the project area. Benefits in that area are expected to arise not only from reduced crop damage (discussed below), but also from changes in flood phasing and cropping patterns. The hydro-dynamic model and drainage analysis were used to calculate the changes in flood phasing likely to occur in the area, and cropping pattern changes were then calculated and included in the analysis. Since the southern part of this area lies on the left bank of the Upper Karatoya, care was taken in the model and drainage analysis to distinguish between changes due to upstream developments and those due to the proposed Bangali Floodway development downstream.

Input-output data for the economic analysis are unchanged from those used in the regional planning analysis. Prices, yields etc. are generally not very different from those prevailing elsewhere in the region. The main possible source of difference could be wage rates. It is known that Gaibandha is an area of high underemployment and seasonal out-migration where wages are low. The agro-economic survey conducted by FAP 2 indicates daily wage rates of about Tk 20-30. Nonetheless, the financial wage rate assumed in the regional plan is only Tk 30, i.e. in the upper range of observed wages in Gaibandha, and therefore the assumed financial wage rate for Gaibandha of Tk30 is reasonable.

3.3 Benefits/Disbenefits for Fisheries

The analysis of fisheries impacts has also followed the approach used and described in the Regional Plan. Productivity rates for different habitat-types have been determined for future-without and future-with project conditions. Prices received by fishermen/pond owners have been used as financial prices, and these have been increased in the analysis by 25% to account for future scarcity, particularly of capture fisheries species. The areas of floodplain fisheries are determined from the Gaibandha hydro-dynamic model and relevant productivity rates applied to these areas.

3.4 Benefits of Reduced Crop and Non-Crop Damage

The methodology for deriving crop and non-crop damage described in the regional plan section of this volume has basically been used for the Gaibandha analysis. In addition to the basic damage avoidance benefits within the project area, there are further damage reduction benefits in the impacted area beyond the project area. These benefits can be attributed to two measures in particular: sealing of the TRE upstream, and closing off of the Alai River with a regulator. Damage reduction within the project area is assumed to apply to all damage caused by events upto the 1:20 year return period.

In the impacted area, since this area is not specifically protected against 1:20 year floods by the project, damage reductions have been worked out by comparing with- and without-project inundation areas for 1:5 year and 1:20 year water levels: some of the impacted area with-project becomes protected against 1:5 year floods but not 1:20 year floods, therefore the damage reduction has been calculated as the difference between expected annual damage from floods upto 1:20 and expected annual damage from floods upto 1:5. A smaller part of the impacted area does become protected from all floods upto 1:20.

The total expected annual damage avoided through project works is considerable. The damage estimates are shown in Table 3.3.

TABLE 3.1 FUTURE WITHOUT CROPPING PATTERNS BASED ON FLOOD PHASE ANALYSIS

LAND TYPE	AMOUNT(HA)
F0	15230
F1	25056
TOTAL	40287
F2	5404
F3	2948
TOTAL	8352
F4	491
GTOYAL	49130

IRRIGATION BALANCE	
HYV BOR	20143
WHEAT	0
HYV AUS	0
TOTAL	20143

DISTRIBUTION OF LAND BY IRRIGATION STATUS BY FLOOD PHASE

LAND TYPE	IRRIGATE AREA	NONIRRI AREA	TOTAL AREA	% IRRIG
F0	3415	11815	15230	22
F1	10022	15034	25056	40
TOTAL	13437	26849	40286	33
F2	4053	1351	5404	75
F3	2653	295	2948	90
TOTAL	6706	1646	8352	80
F4			491	
TOTAL	20143	28987	49130	41

CROPS ON F0+F1

RABI SEASON		AUS SEASON		AMAN SEASON		ANNUAL CROPS	
HYV BORO	13437	B. AUS	716	HYV TAM	19468	SUGARC	223
WHEAT	3009	HYV AUS	0	L.T. AMA	21396	ORCHAR	22
POTATO	55	JUTE	9000	VEGETAB	100		
TOBACCO	442	OILSEED	0	SPICES	0		
PULSES	1766	SPICES	0				
OILSEED	0	VEGETAB	232				
SPICES	0						
VEGETABLES	322						
Sub-Total	19031	*Sub-Total*	9948	*Sub-Total*	40964	*Sub-Total*	245
Total	70188						
CROPPING INTENSITY	174						

CROPS ON F2 LANDS

HYV BORO	4053
DW AMAN	0
AUS	1169
WHEAT	1351
OILSEED	200
PULSES	118
JUTE	182
L.BORO	0
Total	7073
CROPPING INTENSITY	131

CROPS ON F3 LAND

HYV BORO	2653
LOCAL BORO	0
D.W.AMAN	242
OILSEED	548
Total	3443
CROPPING INTENSITY	117

TABLE 3.2 FUTURE WITH CROPPING PATTERNS BASED ON FLOOD PHASE ANALYSIS

LAND TYPE	AMOUNT(HA)		IRRIGATION BALANCE	
F0	19652		HYV BORO	20143
F1	23091		WHEAT	0
TOTAL	42743		HYV AUS	0
F2	3439			
F3	2457	49130	TOTAL	20143
TOTAL	5896			
F4	491			
GTOYAL	49130			

DISTRIBUTION OF LAND BY IRRIGATION STATUS BY FLOOD PHASE

LAND TYPE	IRRIGATED AREA	NONIRRIGA AREA	TOTAL AREA	% IRRIG
F0	6116	13536	19652	31
F1	9236	13855	23091	40
TOTAL	15353	27390	42743	36
F2	2579	860	3439	75
F3	2211	246	2457	90
TOTAL	4791	1105	5896	81
F4			491	
TOTAL	20143	28987	49130	41

CROPS ON F0+F1

RABI SEASON		AUS SEASON		AMAN SEASON		ANNUAL CROPS	
HYV BORO	15353	B. AUS	1025	HYV TAMA	23552	SUGARCA	223
WHEAT	3991	HYV AUS	0	L.T. AMAN	19718	ORCHARD	22
POTATO	55	JUTE	9000	VEGETABL	100		
TOBACCO	442	OILSEEED	0	SPICES	0		
PULSES	1884	SPICES	0				
OILSEED	0	VEGETABLE	232				
SPICES	0						
VEGETABLES	322						
Sub-Total	22047	Sub-Total	10257	Sub-Total	43370	Sub-Total	245
Total	75919						
CROPPING INTENSITY	178						

CROPS ON F2 LANDS	
HYV BORO	2579
DW AMAN	0
AUS	860
WHEAT	860
OILSEED	300
PULSES	0
JUTE	182
L.BORO	0
Total	4781
CROPPING INTENSITY	139

CROPS ON F3 LAND	
HYV BORO	2211
LOCAL BORO	0
D.W.AMAN	242
OILSEED	448
Total	2901
CROPPING INTENSITY	118

Estimates of damage avoided varied according to the option being examined. For example, it was assumed that the option without Teesta sealing downstream would not prevent erosion losses, and would also result in less avoidance of losses in Sundergonj thana than under the option of downstream sealing.

3.5 Benefits from Avoidance of Erosion Losses on the Teesta River

This category of benefits is highly significant in terms of the project concept and its justification. The Teesta River is moving south-west into the project area at a rate causing estimated erosion losses of 180 hectares per year in downstream reaches, and 60 hectares per year in upstream reaches. If this erosion continued, large amounts of agricultural land would be lost, infrastructure and property would be washed away, Sundergonj thana headquarters would be likely to be washed away, and considerable dislocation of hundreds or thousands of households would occur.

The technological choice between river training and embankment retirement was analysed and is discussed later in this volume. The justification for river training is largely to avoid the losses listed above, as well as to reduce the possibility of long-term morphological change. Conversely, if embankment retirement is carried out, it would imply accepting the high erosion losses that presently exist.

The benefits in this category have, therefore, been considered in three locations:

- erosion losses in the Teesta upstream reaches, 60 ha. per year
- erosion losses in the Teesta downstream reaches, 180 ha. per year
- loss of property and infrastructure at Sundergonj.

The valuation of lost land is in terms of production foregone (net returns per hectare based on without-project cropping patterns are taken as the basis for the analysis.). The valuation of loss of property and infrastructure at Sundergonj is based largely on costs developed by the FAP 1 study which examined similar dangers at six locations on the BRE. These costs are shown in Table 3.4.

3.6 Disbenefits from Erosion Losses on the Brahmaputra River

Since measures along the BRE fall within the plan being prepared by FAP 1, no major measures are proposed here to stabilise the stretch of the BRE bordering the project area. In general westward erosion is slow in this reach, at present, but there will be some need for embankment retirement. The policy of retirement implies accepting some land loss due to erosion: it has been assumed that land loss will be limited to 16 hectares per year. The cost of annual retirement is included as a project cost. Retirement along a 25 km. stretch is envisaged on an annual basis over the whole project period, i.e. an average length of about 0.83 km. per year.

3.7 Project Costs

Construction Costs

The method for deriving economic capital costs follows that used for and described in the Regional Plan (Volume 1). Two alternative methods of construction were considered: results of the comparison of these alternatives are discussed later in this volume. For the basic analysis, it was assumed that the

Table - 3.3 Estimated Average Annual Value of Damage in Project and Impacted Area

	(Tk. mn) 1991-1992 Financial Prices	
	Crop Damage	Non-Crop Damage
TRE Planning Unit	9.69	10.17
TRE Impacted Area	2.75	2.89
Ghagot Right Bank	3.9	4.1
Alai Right Bank	8.92	9.38
Sonail Embankment	0.79	0.83
Gaibandha Project Area	16.3	17.12
Gaibandha Town	-	0.5
Total:	42.35	44.99

Table - 3.4 Assumed Erosion Losses at Sunderganj

	No	Financial Unit Cost (Tk.mn)	Total Cost (Tk.mn)	Conversion Factor	Total Economic Cost (Tk.mn)
A. Property Losses					
Pucca Public buildings	10	2	20	0.85	17
Semi Pucca Public Buildings	20	0.2	4	0.80	3.2
Pucca House and Shops	10	0.25	2.5	0.85	2.13
Semi Pucca House and Shops	950	0.01	9.5	0.80	7.6
Katcha Houses and Shops	950	0.003	2.9	0.67	1.95
Village Houses	5000	0.001	5	0.67	3.55
B. Infrastructure Losses					
Roads: - Semi Pucca	3	1	3	0.85	2.55
- Katcha	9	3.2	3.2	0.66	2.11
- Bridges/Culverts	5	0.2	1	0.89	0.89
					40.78

Note : Unit rates adapted from FAP1 Second Interim Report, December, 1991.

manual construction method would be used. The latter is 30% cheaper than the method using more mechanised means and provides significant employment in an area of considerable underemployment and poverty.

The phasing of economic capital costs follows the implementation schedule.

O&M Costs

The method for deriving economic O & M costs again follows that used for the Regional Plan. Annual O & M costs are calculated as 5% of capital costs in the case of earthworks, and 3% in the case of structures.

Economic Costs of Land Acquisition

The economic cost of land acquisition is calculated as the net value (in economic prices) of production foregone from the acquired land, using the without-project cropping pattern to derive net value. These land acquisition costs enter the cash flow according to the implementation schedule as land is acquired for different components of the overall work.

A total of about 713 hectares would have to be acquired for the project works (including 121 ha for routine retirement of the BRE).

4. Results of Economic Analysis

Economic analyses were conducted to meet a number of objectives:

(i) to facilitate selection between different development options;

(ii) to choose between different technological options;

(iii) to analyse the base case;

(iv) to conduct sensitivity analyses on the base case;

(v) to conduct partial analyses of components not included in the base case.

The results of these different analyses are discussed in turn.

4.1 Selection between development options

After a procedure of developing options and screening them out without economic analysis, a stage was reached when the selection of the base case required a choice between two options which could best be done on the basis of economic analysis. The main difference between the two options was the presence or absence of compartmentalisation.

The analysis was conducted as an incremental analysis, i.e. a comparison of the incremental benefits resulting from the incremental costs of compartmentalisation. The analysis showed a high rate of return to the incremental expenditure, and compartmentalisation was therefore included in the base case.

It should be noted however that this choice was made on the basis of a straight economic comparison: other potential problems with the compartmentalisation component were not included in the formal analysis.

A further analysis of a highly simplified form examined the returns from extending the Ghagot left embankment north of Bamandanga. This was found to have effectively no impact on cropping patterns but did result in reduced damage in high flood years. A preliminary analysis gave an IRR of 8%. The component was however included in the base case to give consistency of flood protection in the project area.

4.2 Choice between technological options

Two types of analyses were conducted here:

(a) analysis of the choice between bank protection and embankment retirement under three different retirement cycles, and

(b) analysis of the viability of the base case using alternative construction methods (a manual method similar to current practice, and a mechanical/manual method to improve construction quality).

The first analysis focussed on the Teesta downstream section. The analysis involved (i) variations in capital and O & M costs, and (ii) variations in benefits particularly in terms of erosion losses.

Comparative capital costs are (in financial prices):

Bank protection option	-	Tk 613 mn
Retirement 5 year cycle	-	Tk 1511 mn
Retirement 10 year cycle	-	Tk 841 mn
Retirement 15 year cycle	-	Tk 625 mn

The costs of the retirement options are distributed over the whole project period and therefore costs in net present value terms are closer to or less than the bank protection costs. The main difference between the options however lies in the benefit side. It is estimated that current erosion rates are of the order of 180 hectares per year. The production foregone from this land accumulates with each year, and therefore the disbenefits of the retirement options are considerable.

The outcome of the comparative analysis in terms of NPVs is:

		NPV (Tk mn)
Bank protection	-	126
Retirement 5 year	-	326
Retirement 10 year	-	178
Retirement 15 year	-	135

Although no option has a positive NPV (IRR of 12% or more), the bank protection option gives the highest, or least negative, NPV. In addition this option is clearly preferred by local communities, and therefore it has been recommended as the preferred technological option.

The other analysis in this category of technological options examined the returns from manual and mechanical construction methods. It was assumed that the construction period for the mechanical method would be two years less than for the manual method, and O & M costs would be slightly reduced (4% of the cost of earthworks instead of 5%).

Under these assumptions alternative analyses were made of the base case. Under the manual method, the IRR is 10%. With the mechanical method, even allowing for the differences discussed above, the IRR fell to 7%. The manual construction method not only gives a higher rate of return but is clearly socially preferable in terms of employment generation in an area of chronic under-employment. low wages and seasonal out-migration. Benefits to poor groups could be further maximised by implementing earthworks using LCS groups.

4.3 Economic Analysis of the Base Case

The base case is described in detail in the Gaibandha Main Report (Volume 5) and the relevant engineering reports. The main components are sealing of the Teesta Right Embankment at two separate locations, internal developments including a new regulator on the Manos River and a regulator on the Alai River, backwater embankments on both sides of the Ghagot River, a form of compartmentalisation, and retirement works on the BRE. Each of these developments has impacts which, as far as possible, have been measured and valued.

The main areas of benefit/disbenefit are:

(i) General reduction in water levels primarily due to upstream sealing of the Teesta.

(ii) Further reduction in water levels and prevention of damage due to extension of embankments on the Ghagot River.

(iii) Reduction of flows down the Alai River causing a reduction in water levels and damage downstream of Gaibandha.

(iv) Prevention of losses due to erosion by the Teesta River, particularly in the downstream reaches around Sundergonj.

(v) Alterations in drainage patterns to reduce the amount of water draining across the whole area.

(vi) Reductions in water levels and damages in the impacted area.

Most of the measures result in some reduction in water levels. This reduction has some impact in terms of increasing crop production, but the impact is not very great since most of the area is already high or medium-high land, and in the areas of deepest flooding the backwater influence of the Brahmaputra prevents any major change in flood depths. Significant reductions in damage should be achieved as a result of the project. This is important since Gaibandha is the worst affected new district in the Greater Rangpur District in terms of crop damage, and by association also suffers considerable damage to infrastructure and property.

One of the greatest positive impacts of the project will be in terms of reducing erosion losses. Current rates of erosion by the Teesta River on its right bank vary, but it has been assumed that in the upstream area 60 hectares of land would be lost every year, and in the downstream reaches 180 hectares. In the downstream reaches the Sundergonj thana headquarters is also threatened by erosion. Not only will river training prevent these losses, but it should also aim to make the river more stable and reduce the morphological risks associated with the current processes.

The reduction in water levels will inevitably have a negative impact on capture fisheries, but the overall impact appears to be rather small. This is partly a reflection of the relatively small area of effective floodplain, and also of the gradual reclamation of what were previously quite widespread beel areas. A specific mitigation and development project is proposed for the fisheries sector in the Gaibandha Main Report.

Construction costs are high, but this is unavoidable given the need for river training works. The high cost measures on the Teesta River nevertheless have a wide impact, particularly the upstream sealing. Although this work lies outside the project area, it has a major impact on the area and was therefore included in the project. Since upstream sealing also affects a wider area, the impact felt in this area in terms of reduced crop and non-crop damage was also included in the benefits.

The IRR for the base case is 10%. The analysis is shown in Table 4.1.

The rate of return puts the project in the marginal category in basic economic terms, but it is nonetheless recommended for implementation. There are a number of reasons for recommending that the project be taken up:

(i) The benefit assessment may be understating the full benefits to be gained in the wider impact area particularly from sealing the Teesta upstream. The analysis at this stage did not allow an assessment of potential changes in cropping patterns in the impact area (except for the Alai area).

(ii) The risks of not undertaking the most costly works, i.e. river training work on the Teesta, could be considerable. If the Teesta was not sealed downstream, for example, and the compartmentalisation works were used instead to give flood protection, the risks of erosion would be great. If, instead of river training, the embankment was retired, this option would again result in considerable erosion losses.

(iii) The option of bank protection is strongly supported by all people living in the area; conversely, continued retirement and land acquisition increase landlessness and poverty.

(iv) The costs of the project are increased by the unavoidable need to replace the Manos regulator, on the assumption that it is washed away.

(v) The construction work creates almost 10 million man-days of employment, in an area of chronic under-employment and poverty. This work would make a significant contribution to development of what is a generally depressed area. It is further recommended that as much of this work as possible should be carried out through LCS groups, including women's groups, to maximise the income actually received by labourers, and to ensure good quality work.

TABLE 4.1 GAIBANDHA IMPROVEMENT PROJECT, ECONOMIC ANALYSIS: BASE CASE WITH FLOOD PHASE-BASED CROPPING PATTERNS
+ TRE SEALING U/S, TRE SEALING D/S, EROSION LOSS AVOIDANCE, INTERNAL DEVELOPMENTS, *ALAI D/S* BENEFITS

(Tk mn, 1991-92 prices)

Year	Cap. Cost	O&M Cost	Total Cost	Net Ag. Returns w/o Pro	Net Prod. Lost	Crop Loss Avoid.	Sund-ergonj Loss Avoid.	Net Ag. Returns w.Pro.	Red. Crop Damag	Ag. Benefits w.Pro.	Net Fish Return w/oPr	Net Fish Return w.Pro	Fish Bene-fits w.Pro	Red.Non Crop Dam.	Total Net Benefit	Net Cash Flow	Disc. Factor (12%)	Present Value of Benefits	Total Public Cost	PV of Public Costs
0																				
1	51.88	0.00	51.88	1217.87	0.08	-0.34	0.00	1217.87	0.00	-0.42	29.88	29.88	0.00	0.00	-0.42	-52.30	0.89	-46.70	327.91	292.82
2	51.88	0.00	51.88	1217.87	1.50	-0.68	0.00	1217.87	0.00	-2.18	29.88	29.88	0.00	0.00	-2.18	-54.06	0.80	-43.09	497.51	396.52
3	164.19	0.00	164.19	1217.87	3.59	-1.02	0.00	1217.87	0.00	-4.61	29.88	29.88	0.00	0.00	-4.61	-168.80	0.71	-120.19	998.94	711.25
4	297.76	0.00	297.76	1217.87	6.40	-1.36	4.10	1217.87	0.00	-3.66	29.88	29.88	0.00	0.00	-3.66	-301.42	0.64	-191.70	1263.37	803.50
5	346.78	31.34	378.12	1217.87	8.91	4.71	4.10	1231.94	25.85	39.82	29.88	30.03	0.15	27.34	67.31	-310.81	0.57	-176.23	1400.62	794.15
6	179.82	31.34	211.16	1217.87	10.07	9.42	4.10	1246.01	25.85	57.44	29.88	30.03	0.15	28.16	85.75	-125.41	0.51	-63.58	1066.17	540.55
7	74.69	39.10	113.79	1217.87	10.87	14.13	4.10	1260.08	34.39	83.96	29.88	30.33	0.45	37.89	122.30	8.51	0.45	3.84	718.30	324.67
8	31.59	45.64	77.23	1217.87	11.37	18.84	4.10	1274.15	34.39	102.24	29.88	30.33	0.45	39.02	141.71	64.48	0.40	26.05	604.83	244.35
9	18.25	45.64	63.89	1217.87	12.20	23.55	4.10	1288.22	34.39	120.19	29.88	30.33	0.45	40.19	160.83	96.94	0.36	35.00	606.42	218.92
10	25.42	47.24	72.66	1217.87	13.02	28.26	4.10	1288.22	34.39	124.08	29.88	30.33	0.45	41.40	165.93	93.27	0.32	30.03	687.97	221.53
11	14.31	47.24	61.55	1217.87	13.31	32.97	4.10	1294.08	37.26	137.23	29.88	30.33	0.45	45.62	183.30	121.75	0.29	34.94	417.33	119.77
12	4.66	47.24	51.90	1217.87	13.39	37.68	4.10	1299.94	37.26	147.72	29.88	30.33	0.45	46.99	195.16	143.26	0.26	36.82	46.91	12.06
13	4.66	47.24	51.90	1217.87	13.47	42.39	4.10	1305.81	37.26	158.22	29.88	30.33	0.45	48.40	207.07	155.17	0.23	35.53	46.91	10.74
14	4.66	47.24	51.90	1217.87	13.55	47.10	0.00	1305.81	37.26	158.75	29.88	30.33	0.45	49.85	209.05	157.15	0.21	32.22	46.91	9.62
15	4.66	47.24	51.90	1217.87	13.63	51.81	0.00	1305.81	37.26	163.38	29.88	30.33	0.45	51.35	215.18	163.28	0.18	29.88	46.91	8.58
16	4.66	47.24	51.90	1217.87	13.71	56.52	0.00	1305.81	37.26	168.01	29.88	30.33	0.45	52.89	221.35	169.45	0.16	27.62	46.91	7.65
17	4.66	47.24	51.90	1217.87	13.79	61.23	0.00	1305.81	37.26	172.64	29.88	30.33	0.45	54.47	227.56	175.66	0.15	25.65	46.91	6.85
18	4.66	47.24	51.90	1217.87	13.87	65.94	0.00	1305.81	37.26	177.27	29.88	30.33	0.45	56.11	233.83	181.93	0.13	23.65	46.91	6.10
19	4.66	47.24	51.90	1217.87	13.95	70.65	0.00	1305.81	37.26	181.90	29.88	30.33	0.45	57.79	240.14	188.24	0.12	21.84	46.91	5.44
20	4.66	47.24	51.90	1217.87	14.03	75.36	0.00	1305.81	37.26	186.53	29.88	30.33	0.45	59.52	246.50	194.60	0.10	20.24	46.91	4.88
21	4.66	47.24	51.90	1217.87	14.11	80.07	0.00	1305.81	37.26	191.16	29.88	30.33	0.45	61.31	252.92	201.02	0.09	18.69	46.91	4.36
22	4.66	47.24	51.90	1217.87	14.19	84.78	0.00	1305.81	37.26	195.79	29.88	30.33	0.45	63.15	259.39	207.49	0.08	17.22	46.91	3.89
23	4.66	47.24	51.90	1217.87	14.27	89.49	0.00	1305.81	37.26	200.42	29.88	30.33	0.45	65.04	265.91	214.01	0.07	15.84	46.91	3.47
24	4.66	47.24	51.90	1217.87	14.35	94.20	0.00	1305.81	37.26	205.05	29.88	30.33	0.45	66.99	272.49	220.59	0.07	14.56	46.91	3.10
25	4.66	47.24	51.90	1217.87	14.43	98.91	0.00	1305.81	37.26	209.68	29.88	30.33	0.45	69.00	279.13	227.23	0.06	13.41	46.91	2.77
26	4.66	47.24	51.90	1217.87	14.51	103.62	0.00	1305.81	37.26	214.31	29.88	30.33	0.45	71.07	285.83	233.93	0.05	12.40	46.91	2.49
27	4.66	47.24	51.90	1217.87	14.59	108.33	0.00	1305.81	37.26	218.94	29.88	30.33	0.45	73.21	292.60	240.70	0.05	11.31	46.91	2.20
28	4.66	47.24	51.90	1217.87	14.67	113.04	0.00	1305.81	37.26	223.57	29.88	30.33	0.45	75.40	299.42	247.52	0.04	10.40	46.91	1.97
29	4.66	47.24	51.90	1217.87	14.75	117.75	0.00	1305.81	37.26	228.20	29.88	30.33	0.45	77.66	306.31	254.41	0.04	9.41	46.91	1.74
30	4.66	47.24	51.90	1217.87	14.83	122.46	0.00	1305.81	37.26	232.83	29.88	30.33	0.45	79.99	313.27	261.37	0.03	8.63	46.91	1.55
TOTAL																	NPV=	-126.32		4767.48
																	IRR=	0.10		
																	NPVR	-0.03		

irr

(vi) The increased agricultural output due to the project will result in approximately 1 million additional man-days of agricultural labour per year. While a significant percentage of this increase will be taken up by farm families thenselves, it will still result in a substantial increase in employment for agricultural labourers.

Although these positive reasons can be put forward, there are further investigations and more detailed design work to be done before the project could proceed. Areas where more work is needed are mentioned particularly in the Impact Analysis section of the Gaibandha Main Report.

4.4 Sensitivity Analyses

A number of sensitivity analyses were carried out on the base case. Results are reported and discussed here.

(a) Import parity pricing for rice

The economic price assumed for paddy crops in the basic analyses has been based on the mean of the import and export parity price, i.e. it implies a position of approximate self-sufficiency in rice output. While this appears to be the position at present, it is not yet clear whether the output increases of the past can be maintained. If Bangladesh again reverted to a position where import parity pricing was appropriate, the economic price assumed for paddy would increase.

The FAP Guidelines for Project Assessment calculate a conversion factor of 1.02 for paddy for import parity pricing. This study estimates the appropriate conversion factor to be 1.19. Sensitivity analyses have been done for both conversion factors:

	Conversion Factor 1.19	Conversion Factor 1.02
IRR	12.7%	11.3%

The analysis with conversion factor of 1.19 increases the IRR to just above 12%.

(b) 10% increase in with-project agricultural net returns

A 10% increase in the value of with-project agricultural net returns increases the IRR to about 17%. This indicates the relative sensitivity of this project, and others analysed for the Regional Plan, to changes in agricultural returns.

(c) 20% increase in construction and O & M costs

This increase in costs causes the IRR to fall to about 8%. Since the cost estimates are based on rates well above existing rates, and the implementation period is long, there are no particular reasons for such cost overruns to occur.