Government of the People's Republic of Bangladesh

Flood Plan Coordination Organisation,
Ministry of Irrigation, Water Development and Flood Control

BANGLADESH FLOOD ACTION PLAN

FAP 12
FCD/I AGRICULTURAL STUDY

PROJECT IMPACT EVALUATION OF MEGHNA-DHONAGODA IRRIGATION PROJECT

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Hunting Technical Services Limited

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The present report is one of a series produced by Flood Action Plan components 12, the FCD/I Agricultural Study and 13, the Operation and Maintenance Study.

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Inception Report (joint with FAP 13)
Methodology Report (2 Volumes)
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Chalan Beel Polder D
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[1] Revised versions of these reports were issued in December 1991.

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Meghna-Dhonagoda Irrigation Project

Project Summary Sheet

Project Name : Meghna-Dhonagoda Irrigation Project

Project Type : Flood Control, Drainage and Irrigation

Location

FAP Region : South-East
District : Chandpur

Area (ha.) : 17 584 ha. (gross)
14 367 ha. (cultivable)

Funding Agency : ADB

Implementing Agency : BWDB

Construction started : FY 1977/78

Scheduled Completion : FY 1983/84

Actual Completion : FY 1987/88

Original Cost Estimate : Tk.

Final Cost Estimate : Tk. 2418.8 million (1991 prices)

Major Flood Damage: : 1987, 1988

Repair/rehabilitation in : 1989 to present

Overview:

A very high cost Project (even as appraised, and much more so as built) incorporating pumped drainage and canal irrigation as well as flood control. Construction was protracted due to poor planning and site investigation, and the embankment failed twice in the first two years after completion due to poor investigation and reduction of design standards. Hydrological impact and agricultural performance subsequently have been very good, and there are clear indications of increased wellbeing in the Project population, but EIRR is only 6.7 per cent (including fishery losses, but assuming no further failures). Economic performance has been worsened by the long delay in completion, cost overruns and breaches, but is fundamentally due to unrealistic estimates of agricultural benefits based on inaccurate assessment of without-project yields.

MEGHNA-DHONAGODA IRRIGATION PROJECT

SUMMARY OF FINDINGS

Location

The Meghna-Dhonagoda Irrigation Project (MDIP) is situated in Chandpur District in the south-east of Bangladesh. and is located in the FAP South-East Region (see Figure 1.1). The Project has a gross area of 17 584 ha. and is located on an island, surrounded by the Meghna River on the north and west, and by the Dhonagoda (also called the Gumti in some reaches), a distributary of the Meghna, on the east and south (see Figure 1.2). The topography is a variable pattern of ridge-and-trough throughout the Project area, so that the typical saucer-shaped relief of many FCD projects does not occur. The peripheral rivers have not yet had time to establish commanding levees which would define a central depression, although the process has begun. As a result, there are no large beels, but the Project area intersected by a network of khals which pre-Project were fresh water, but tidal.

The control area is situated to the south-east of the Project, in an unprotected and unimpacted area of similar topography, but without the direct influence of the main rivers, such as the Meghna, on erosion (see Figure 1.3).

Project Objectives

MDIP is a combined Flood Control, Drainage and Irrigation Project. Before the Project large areas flooded to a depth of 2 to 3 metres every year, and almost all areas experienced some flooding, while soil moisture was deficient for agriculture in the rabi and early kharif seasons. The Project objective was to protect the interior of the island from river flooding and drainage congestion, in order to encourage agriculture, and especially cultivation of HYV Aman, during the monsoon, to increase the security of the population, crops and livestock during the monsoon, and to promote rabi cropping, and especially HYV Boro, by providing an irrigation system.

Project History

The Project was identified in the 1964 Master Plan and a feasibility study was conducted in 1967. It was shelved until a second feasibility was conducted in 1976-77, and the Project was appraised by ADB in 1977. Construction commenced in 1978, but part of the embankment was eroded during construction and it was not closed until 1987, four years after the scheduled completion date. Breaches of the embankment occurred on the eastern (Dhonagoda) side in both 1987 and 1988, causing deep and rapid flooding, sand deposition and substantial damage to the irrigation system. A rehabilitation programme is being implemented by BWDB, but in 1991 over 3000 ha. of the irrigable area remained without canal irrigation supply due to unrepaired flood damage.

Construction and Design

The main engineering features are a 60 km. ring embankment around the perimeter of the island, internal networks of irrigation canals (218 km) and drainage channels (126 km), 62 drainage structures, 72 bridges and two pumping stations, one in the north and one in the south, which pump drainage water out of the area in the monsoon season, and lift water into the irrigation canals for dry season irrigation. Within the Project area irrigation water distribution is mainly by gravity flow, but there are also two internal booster pump stations to lift water to higher areas. The canal system commands a total of 14 367 ha., the remainder being excluded as it was considered to be too high to be irrigated economically.

Various features of Project design were changed at the detailed design and construction stages. The reasons are not well documented, but it is clear that serious cost and time overruns were an important factor.

BWDB's own Project Completion Report (1988) recognised some of the survey and design problems associated with the Project. The foundation designs of both pumping stations were inadequate, probably due to inadequate research into sub-soil conditions. One gave many problems during construction, the other's foundation cracked and has had to be rehabilitated.

There have been two major embankment failures since Project construction, stemming from two causes. The design standards of the embankment were reduced during detailed design and there seems to have been inadequate understanding of sub-soil conditions. During embankment construction labour intensive methods and manual compaction techniques were used. These have resulted in inadequate compaction, which cannot be justified in such a major structure. Further failures are threatened by continuing erosion hazard on the Meghna side, the extent of which appears to have been inadequately assessed in the feasibility studies.

Hydrological Impact

Since 1988 the Project has had a very major impact on flood conditions in the area, with great reductions in annual flood depths on medium low, low and very low land. 65 per cent of land operated by surveyed households is no longer flooded in a normal monsoon season, whereas all land had experienced annual flooding before the Project. Likewise, prior to the Project 70 per cent of land was under water for four months or more, while now only 14 per cent is still similarly affected. There has been no change in control area flood depth and duration over the same period. The irrigation system by 1991 was very successful, and is used almost entirely to irrigate Boro and Aus. All irrigation water in the Project ultimately comes from the main pumping stations, but 65 per cent of irrigated land is supplied direct by gravity turnouts from BWDB canals, while 30 per cent is supplied by low-lift pumps from khals and borrowpit canals filled from the BWDB system. The balance is supplied by traditional methods.

In 1987 and 1988 the embankment breaches resulted in greater damage to crops than would have occurred without the Project, due to the sudden rise in water level and the change to less flood tolerant but higher yielding paddy varieties in anticipation of stable water levels. This has not only reduced the flow of benefits in those two years, but also the future potential, due to sand deposition over some areas, and damage to the irrigation system which delayed the spread of irrigation. The risk of future failures is unknown, but there has been no testing flood since 1988, while erosion continues and the embankment south of Durgapur (near the previous breaches) remains in a dangerous condition; hence the risk may be quite high.

Operation and Maintenance

Considerable thought went into the O&M arrangements for MDIP, and a detailed O&M manual was prepared. The latter has not been used, partly because it was in English and was not geared to the requirements of those who would actually be involved in O&M. A detailed network of committees and associations was also proposed, but again has not been implemented. It was intended that farmers would contribute to irrigation costs by paying water charges, commencing with the first season in which they received irrigation water. The level of water charges has not yet been fixed and no charges have been levied. While it might be argued that flood damage has prevented the move to permanent O&M arrangements, it is also clear that inadequate attention was paid to establishing the required institutional framework during the implementation and rehabilitation periods.

BWDB spends a great deal on O&M of MDIP (about Tk 2400 per hectare, or 3 to 5 times the cost of most other FCD/I projects). The high costs relate particularly to the pumping requirements, but there are also other O&M costs, and the costs of repair and rehabilitation of the damaged irrigation canals, which is not being carried out to a high standard. It seems very unlikely that even O&M costs will be recovered by BWDB, although private LLP contractors recover similar amounts of money for irrigation services.

Agricultural Impact

MDIP has resulted in a very large growth in paddy output, estimated at some 74 000 mt. annually, which has transformed the area from grain deficit to grain surplus. Mean yield over all types of paddy is about 4.4 mt./ha., compared with 2.5 mt./ha. in the control area, and cropping intensity for paddy is also over 60 per cent higher than in the control. The yield increase is associated with the replacement of B Aman and Aus/Aman by HYV Aman, and of L Boro by HYV Boro. The gains in intensity have taken place largely in the Aus season, with introduction of an HYV Aus crop; in an interesting indigenous farming system development, some farmers are sowing HYV Aus broadcast to minimise time and cost requirements. The Project area is at present almost a paddy monoculture, which accurately reflects the financial returns to production of paddy and non-paddy crops when water is free, as it is to the majority of MDIP farmers.

Impressive though the agricultural impact is, it is considerably less than was estimated during the feasibility study and appraisal. While planning estimates of with-project yields match closely the actual performance, without-project yield estimates (as assessed both by FAP 12 and by the 1987 CIRDAP study) appear to have been grossly underestimated, producing a spuriously high estimate of potential benefits.

Livestock Impact

A comparison of the MDIP with the control area shows substantial differences in the livestock sector. At MDIP the proportion of households owning bovine animals is higher, the average holding size is substantially higher, and as a result the availability of draught power per household is much greater. Nevertheless there is probably still a seasonal shortage of draught power for medium and large farmers in both the Aman and Boro seasons.

The populations of sheep and goats, and of chickens and ducks, are slightly lower in the MDIP than in the control area. Despite this, gross and net incomes from livestock overall are higher in the Project area, possibly reflecting greater purchasing power being used for protein foods, and it would appear that the livestock sector has benefited from the flood protection provided.

Fisheries Impact

The success of the Project in reducing flood levels and the inundated area has, inevitably, had a devastating effect on the floodplain subsistence and capture fisheries. Blockage of the khals has prevented fish migration, halted the annual natural restocking of internal water bodies, and also reduced the residual stocks in the rivers.

Many fishermen have been forced to seek other work, and even for the remainder average daily catches have fallen by 40 per cent in the Project area; this compares with a 34 per cent decline in the control area. The decline has affected all the major fish species groups.

Fish farmers have benefited from flood protection and production from Project area ponds now averages 1400 kg./ha. compared with 1200 kg./ha. in the control area; in both cases pre=Project yields would have been under 1000 kg./ha.. Increased fishpond output is estimated to be now about 160 mt. per year and is still growing, but is insufficient to offset the annual loss of capture fisheries which is estimated to be close to 400 mt..

Infrastructure and Communications

The embankment has provided an improved road transport route, but the internal road network originally intended as part of the Project was dropped during construction, and internal road transport is seriously deficient. The Project has severely impeded boat transport, and the number of boatmen inside the Project has fallen substantially. Original feasibility study proposals included navigation locks to provide access to the interior khals, but these were eliminated from the final design. Overall, the Project has facilitated transport around the periphery, but has made access to the interior of the Project area much more difficult at the same time that movement of paddy cultivation inputs and outputs has increased greatly.

Socio-Economic Impact

Despite only having been 'completed' for a short period, the Project does appear to have had important socio-economic impacts because of sharp changes in the local economy - for the worse when the embankment failed, and for the better in the years since 1988.

The majority of labourers found work building or repairing Project infrastructure, and there has been growth in secondary economic activities such as rickshaw pulling, trading (paddy and agricultural inputs) and paddy milling. However, there have been important adverse impacts on minority occupations and employment. Fishermen and boatmen are generally regarded as having lost income or been displaced.

Agricultural labourers obtain about 12 per cent more work than in the control area, though agricultural changes have generated some 25 per cent more work per hectare, and now a much higher proportion of work is done by hired labour than in the control area. Wage rates, however, are the same as in the control area, implying in-migration at peak periods. Overall, incomes are substantially higher in the Project than in the control area for virtually all landholding categories.

More households reported changes in holding size in the Project area than in the control, reflecting a high incidence of land acquisition (affecting 29 per cent of households) and transactions (mostly in 1988 and 1989) which may reflect flood losses and/or landowners realising increased land values. Compensation for 77 per cent of land acquired for the Project was paid only after a bribe. The acquisition process was strongly contested, even though there was reportedly widespread support for the Project, partly because erosion and embankment retirement led to potential beneficiaries losing land to the embankment and the river.

The Project appears to have increased the food security of cultivating households, which on average produce 9 months' grain supply in the Project area compared with 7.5 months' in the control. Houses inside the Project are also in better condition and there are more houses built of durable materials (mostly corrugated iron) than in the control area. However, most households were flooded in 1988, when flood depths were greater than in the control area, and damages per household were considerably higher. The main problems created by the Project were reportedly embankment failures and some waterlogging, along with the fishery and water transport impacts.

Women's workloads were reported to have increased significantly due to the Project, particularly in the post-harvest processing of paddy. Unusually, there has been no diversion of rice-husking to men, presumably because STW/LLP engines are not required for irrigation in the areas where the canal system is functioning properly, and are therefore not available to power husking mills.

Environmental Evaluation

As in most of Bangladesh, negative ecological changes in the last few decades have been substantial, and would have continued regardless of whether the Project was built. It is difficult to assess the additional impact of the Project, which is superimposed on these trends, but it seems certain that the Project area already had a predominantly anthropic landscape by 1978, and that additional negative biotic impacts have therefore been very limited.

Both the physical and human environmental impacts frequently conflict with one another. Even the overall assessment of individual environmental issues is often a net value derived from both positive and negative significant impacts. This reflects the marked contrast between the largely negative impacts arising during construction and especially in the 1987-88 embankment failures, and the very positive agricultural and socio-economic impacts (albeit still subject to a significant risk factor) since then.

There is an immediate high risk of catastrophic flooding through failure of the embankment south of Durgapur, and a long-term risk in the south-west, near the Meghna-Dhonagoda confluence, and in the west, where rapid erosion seems likely to continue.

There is cause for concern in the apparent decline in soil physical characteristics, and possibly also in fertility.

Economic Appraisal

MDIP has given substantial financial benefits to the farmers in the area, particularly as they are not yet contributing to the irrigation costs. However the Project is extremely costly. Capital costs at Tk 160 000 per benefited hectare are almost ten times the cost of the next most expensive project studied by FAP 12. O&M costs, at over Tk 2400 a hectare, are 3 to 5 times those found elsewhere. These high costs mean that even the high level of agricultural benefits achieved (the greatest of any project studied by FAP 12) cannot justify the expenditure. The Project has an estimated EIRR of 6.7 per cent and a Benefit:Cost Ratio of 0.56, including a conservative estimate of fisheries losses. Even these estimates assume that there will be no further breaches comparable with 1987-88, which is unlikely in view of the rapid erosion taking place.

The poor economic performance of MDIP is therefore fundamental. The long implementation period, the cost overruns, and the further loss of and delay in benefits and increase in costs caused by the failures of 1987 and 1988, have worsened the Project's economic performance, but even if these factors are discounted the Project is non-viable. The implication is that pumped drainage is not an acceptable option for future FCD projects.

Recommendations

The pumped drainage/irrigation FCD/I project concept represented by MDIP should not be replicated. Even if the construction and operating costs can be substantially reduced below those incurred at MDIP, they are unlikely to approach the levels of simpler concepts which have far better economic performance and which can be replicated over much larger areas due to their cheapness.

The capital and rehabilitation costs of MDIP itself are now sunk, and the infrastructure permits a highly successful agricultural system to continue. In order to ensure the Project's sustainability it is essential that a system of cost recovery from irrigation be introduced. Farmers often pay considerably more than Tk. 2000 per hectare for irrigation elsewhere, so it should be possible for an irrigation fee to be levied which would cover BWDB's irrigation and drainage O&M costs and contribute to recovery of the FCD related expenditures.

Even so, a careful reassessment of the erosion and failure risks is needed, since expensive bank protection may be difficult to justify economically. Urgent attention should be given to the Nandalapur-Durgapur stretch of the embankment, where the greatest immediate risk of breach occurs.

MDIP offers excellent opportunities for monitoring two major aspects of FCD projects for which little or no data now exist:

- water quality in ponds, khals, drainage effluent, rivers and (especially) groundwater, to establish baseline values and then to assess the impacts of agrochemicals and sewage; and

- soil physical characteristics and fertility under the paddy monoculture created by the Project.

In view of the past problems and continued high risk to physical and human environmental issues, there appears to be a need for a full project environmental audit at a time after the rehabilitation of the eastern and south-western stretches of the embankment has been completed.

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ABBREVIATIONS AND GLOSSARY

ADB	Asian Development Bank
AED	Agro-ecological Division
AER	Agro-ecological Region (FAO)
AES	Agro-ecological Subregion
Aman	Main monsoon paddy crop
Aus	Early monsoon paddy crop
BIDS	Bangladesh Institute of Development Studies
Boro	Winter season paddy crop
BRDB	Bangladesh Rural Development Board
BSS	Bittahin Samabaya Samiti (Landless Cooperative Society)
BWDB	Bangladesh Water Development Board
chai	kind of fish trap
CIRDAP	Centre for Integrated Rural Development in Asia and the Pacific
crore	ten million (10,000,000)
DOF	Department of Fisheries
DRA	Dhonagoda-Gumti Riverine Area
DTW	Deep Tubewell (with displacement-type pump)
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
FAP	Flood Action Plan
FCD/I	Flood Control and Drainage with or without Irrigation
FCDI	Flood Control Drainage and Irrigation
FPCO	Flood Plan Coordination Organisation
ghat	landing place
ha	Hectare (2.47 acre)
HYV	High Yielding Variety (esp. of paddy)
ICDDR,B	International Centre for Diahorreal Disease Research, Bangladesh
IEE	Initial Environmental Examination
JICA	Japan International Cooperation Agency
kani	measure of land area, 0.4 acres in MDIP area
khal	Natural channel/minor river/tidal creek
kharif	monsoon agricultural season
KSS	Krishak Samabaya Samiti (Farmers' Cooperative Society)
lakh	one hundred thousand (100,000)
LLP	Low Lift Pump (for irrigation from surface water body)
m-d	Man-day
MBSS	Mahila Bittahin Samabaya Samiti (Landless Women's Cooperative Society)
md	Maund (unit of weight = 37.3 kg.)
MDIP	Meghna-Dhonagoda Irrigation Project
MPO	Master Plan Organisation (of Ministry of Irrigation, Water Development & Flood Control) (now National Water Plan Organisation)
MRA	Meghna Riverine Area
MSS	Mahila Samabaya Samiti (Women's Cooperative Society)
mt.	metric tonne (1,000 kg., 2,204 lb.)
NGO	Non-governmental Organisation
NPV	Net Present Value
O&M	Operation and Maintenance
ODA	United Kingdom Overseas Development Administration

PCC	Project Coordination Committee
PCR	Project Completion Report
PEP	Preliminary Environmental Post-evaluation
pH	Positive Hydrogen Ion Concentration
PIE	Project Impact Evaluation
PP	Project Proforma
PVC	Polyvinyl Chloride (plastic)
RRA	Rapid Rural Appraisal
SAR	Staff Appraisal Report
SCF	Standard Conversion Factor (from financial to economic prices)
TIA	Turnout Irrigation Association
Union	Administrative level below Upazila (q.v.), typically 10 per Upazila
Upazila	Administrative unit above Union & below Zila (460 Upazilas in Bangladesh)
rabi	winter agricultural season

THE BENGALI CALENDAR

The Bengali calendar was used for interviewing because of its greater familiarity to most respondents, and some tabulations and figures are presented by Bengali months. The Bengali calendar is almost exactly half a month out of phase with the Gregorian calendar, the months starting on the 15th to 17th of the Gregorian months. The year starts on 1st Baishakh, 15 April.

Bengali Month	**Gregorian Month**
Baishakh	April
Jaistha	May
Ashar	June
Sraban	July
Bhadra	August
Aswin	September
Kartik	October
Aghrayan	November
Poush	December
Magh	January
Falgun	February
Chaitra	March

1 INTRODUCTION

1.1 THE FAP 12 STUDY

The FAP 12 Study is one of the 26 numbered component studies of the Bangladesh National Flood Action Plan, and is jointly supported by the United Kingdom Overseas Development Administration (ODA) and the Japan International Cooperation Agency (JICA). It is being conducted by a group of Bangladeshi and international consulting organisations, comprising Hunting Technical Services Limited of the United Kingdom, Sanyu Consultants Inc. of Japan, the Bangladesh Institute of Development Studies (BIDS), the Flood Hazard Research Centre of Middlesex Polytechnic, UK, Hunting Fishtech of UK, and Technoconsult International Limited of Bangladesh.

The objective of FAP 12 is to conduct post-evaluations of a total of 17 projects, representative in type and location, of the FCD/I projects so far executed in Bangladesh (see Figure 1.1). The results of these evaluations will be passed to other FAP components for guidance in developing strategies for improved flood control and management for the future.

Of the 17 projects for study, 5 have been assessed mainly by Project Impact Evaluation (PIE) methods, using a formal questionnaire approach and probability sampling. The remainder have been assessed by Rapid Rural Appraisal (RRA) methods, and RRA has also been used for preliminary reconnaissance of the 5 PIE projects. The present report describes the combined findings of the RRA and PIE of the Meghna-Dhonagoda Irrigation Project (MDIP).

1.2 PROJECT DESCRIPTION

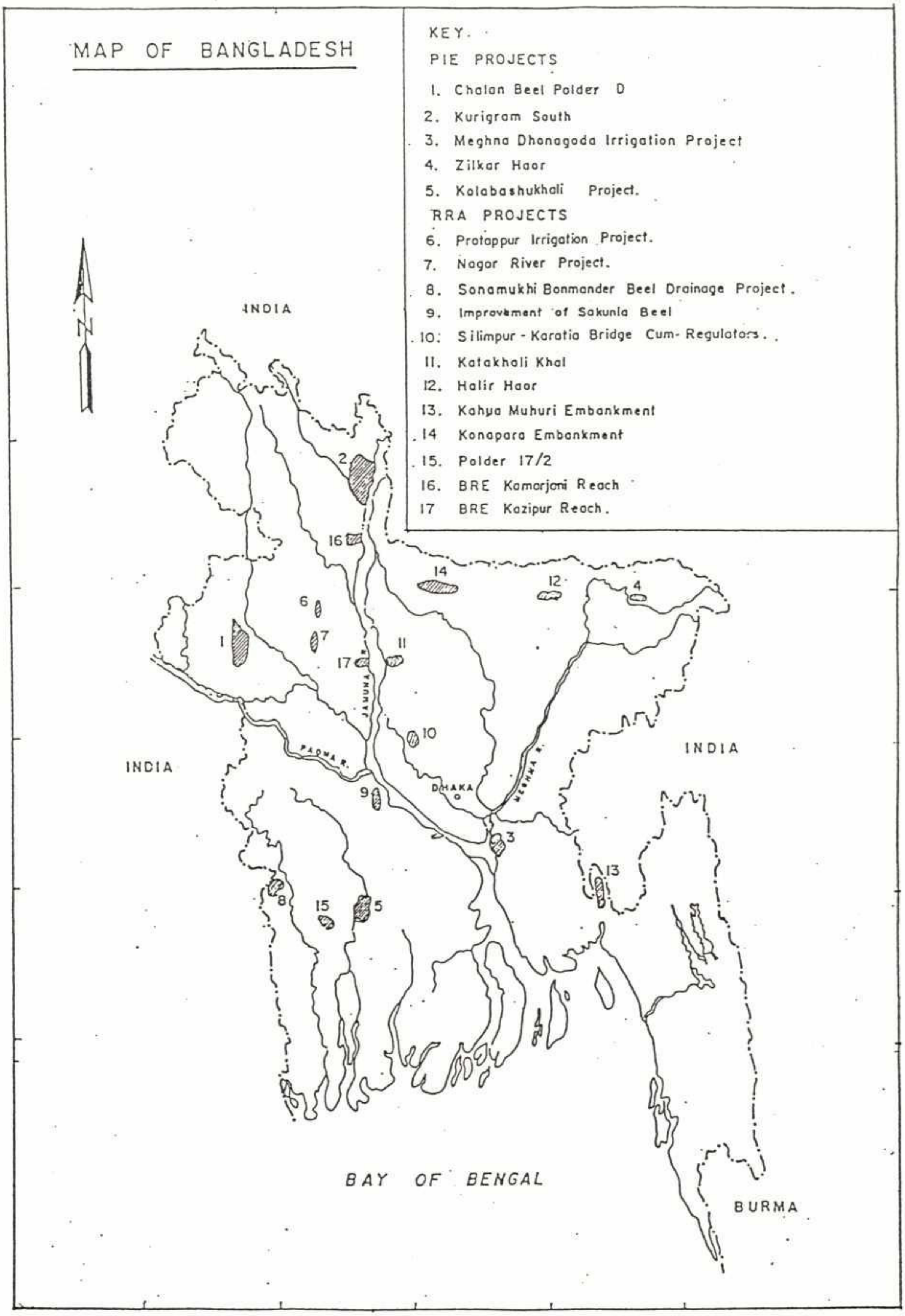
1.2.1 Location

Meghna-Dhonagoda Irrigation Project (MDIP) is situated in Matlab Upazila of Chandpur District in south-eastern Bangladesh (Figure 1.1), falling in the Flood Action Plan's South-East Region and in BWDB's Chandpur Operation and Maintenance (O&M) Circle. The Project has a gross area of 17,584 ha. and occupies the major portion of 14 out of the 22 Unions in Matlab Upazila. It is located on an island surrounded by the Meghna River on the north and west and the Dhonagoda, an anabranch of the Meghna, on the east and south (Figure 1.2). There are no large towns or administrative centres above Union level in the Project, though the Upazila town of Matlab lies immediately south of the Project across the Dhonagoda River.

1.2.2 Physical Characteristics

The Project area is low-lying, with general elevations ranging from about 7 to 12 feet above PWD datum. Rainfall averages 2300 mm. per year. Pre-Project, large areas flooded to a depth of 6-9 feet every year and almost all areas experienced some flooding, while soil moisture for agriculture was deficient in the rabi and early kharif seasons. Over most of the area either only a single aman paddy crop, or a mixed aus/aman crop followed by rabi crops of low water demand, was grown. The Project area is intersected by a network of fresh water but weakly tidal khals (natural channels). These provided the main means of access pre-Project but were little used for irrigation.

Figure 1.1 Location of Selected PIE and RRA Projects



Source: Consultants

Figure 1.2 Meghna-Dhonagoda Irrigation Project - Impacted Area

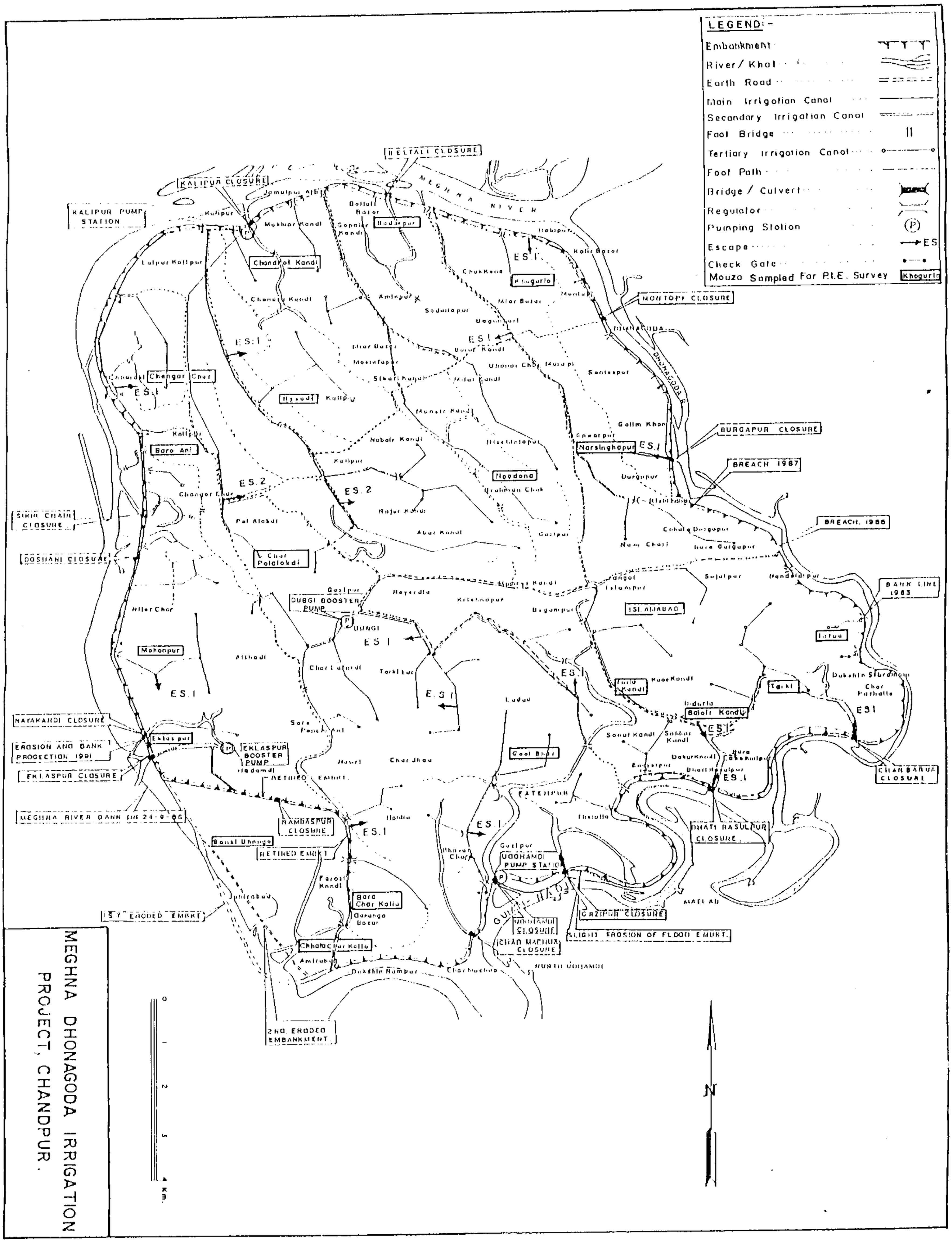
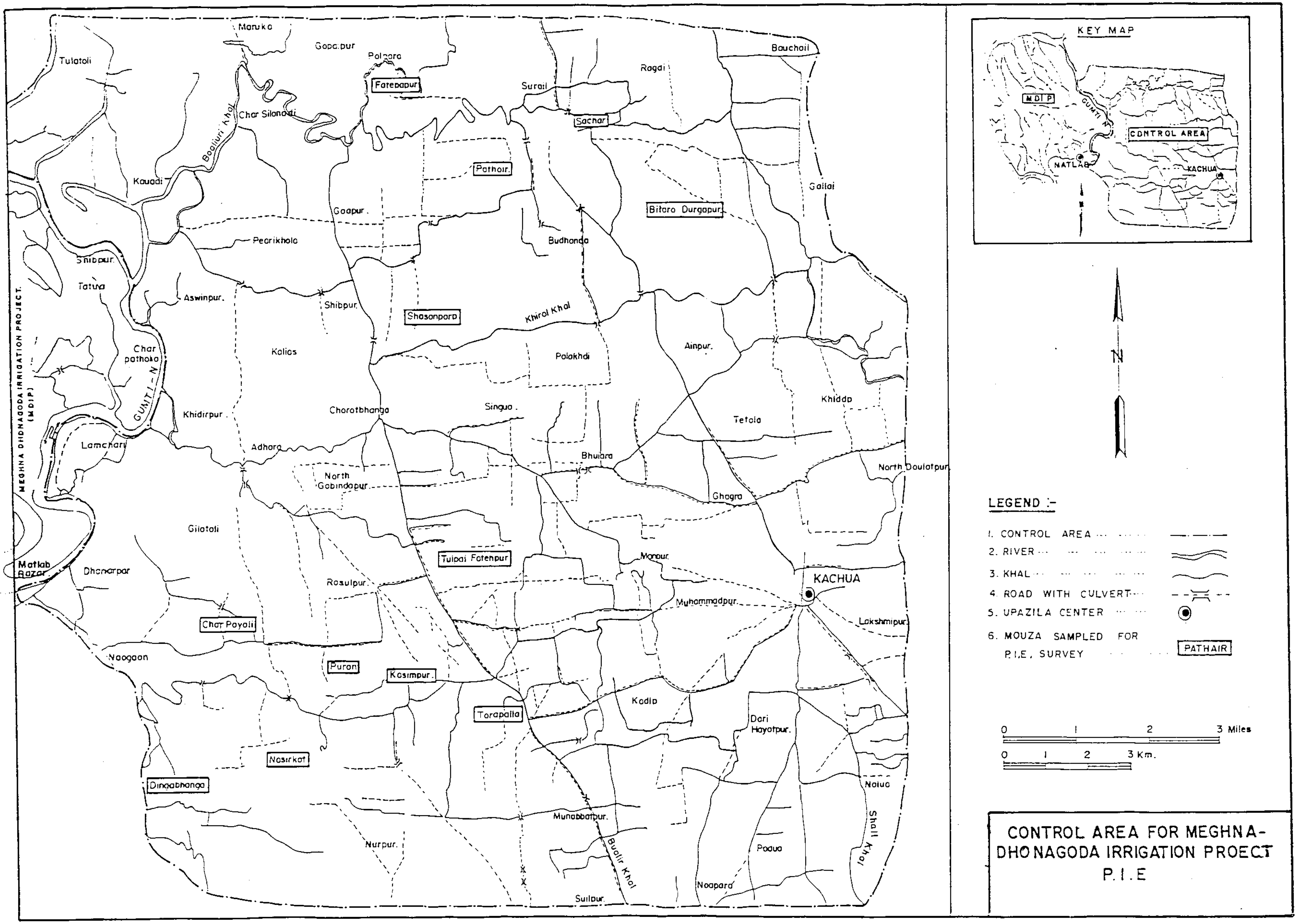


Figure 1.3 Meghna-Dhonagoda Irrigation Project - PIE Control Area



1.2.3 Outline of Project Design and Objectives

MDIP is a combined Flood Control, Drainage and Irrigation (FCD/I) project, and was selected for evaluation as representative of the class of large FCD/I projects. The main design features are a ring embankment around the perimeter for flood protection, and internal networks of irrigation canals to provide water during the dry season and drainage channels to remove excess water from rainfall in the monsoon. Evacuation of drainage water is by two pump stations, one at Kalipur at the northern and the other at Uddhamdi at the southern end of the Project. These also lift water from the Meghna and Dhonagoda rivers into the canals for dry-season irrigation. Water distribution within the Project is mainly by gravity flow, but there are two internal booster pump stations, at Dubgi and Eklaspur, to provide water to higher areas. The canal system commands a total of 14,367 ha., the balance of the gross area being excluded because it is too high to be commanded economically.

The objectives of the main embankment and drainage system design were to protect the Project interior from river flooding and drainage congestion respectively during the monsoon, thus improving agricultural conditions in the monsoon (with special reference to encouraging introduction of HYV aman) and increasing the security of the population, crops and livestock. The objective of irrigation development was to improve soil moisture in Rabi and early Kharif, again facilitating the introduction of HYV paddy varieties.

1.2.4 Project History

The Project was identified by BWDB and the Asian Development Bank in 1975. Feasibility studies were conducted with ADB funding in 1976-77, and the Project was appraised by ADB in 1977. Construction by BWDB commenced in 1978, and the embankment was closed in 1987, four years after the scheduled completion data of 1983. Breaches of the embankment on the eastern (Dhonagoda) side of the Project occurred in both 1987 and 1988, with deep and rapid flooding of the Project interior, major damage to the irrigation canal system and much sand deposition in the vicinity of the breaches. A rehabilitation programme is being implemented by BWDB, but at the time of the FAP 12 RRA in March 1991 over 3,000 ha. of the irrigable area remained without direct canal supply due to unrepaired flood damage.

1.3 METHODOLOGY

1.3.1 Previous Evaluations

In selecting projects for PIE study, FAP 12 deliberately excluded those for which a previous evaluation of good quality had been made, thereby avoiding unnecessary duplication of effort. In the case of MDIP, no previous post-evaluation had been made, and even the ADB PCR of 1990 did not attempt to recompute economic performance indicators. A longitudinal evaluation had however been proposed for the Project, and a baseline survey was conducted for this purpose by CIRDAP in 1986-87 as part of an intended evaluation of three FCD/I projects in the south-east (CIRDAP 1987).

The FAP 12 PIE did not re-use the CIRDAP survey villages, since these were not selected by probability sampling (see below) and also because shifting to a longitudinal basis for measuring project impacts would have been a departure from the control area approach adopted as standard for the PIEs (see below). Although some details of the CIRDAP data are not entirely clear (see, for example, Chapter 10 below) the study was in general of good quality and was consulted extensively by FAP 12, both during the RRA and as a cross-check on PIE findings for without-project conditions from the MDIP control area.

Part of MDIP was also included in the control area for the evaluation of the similar Chandpur Irrigation Project (CIP) situated south of Chandpur (Thompson 1990), while the International Centre for Diahorreal Disease Research, Bangladesh (ICDDR,B), which has a field station at Matlab, has conducted social and health studies in a number of riverine locations in the Project. The FAP 12 evaluation has drawn on these sources to supplement its own findings on the pre/without-project situation.

1.3.1 RRA and PIE Surveys

FAP 12's methodology for project evaluation has been described in detail in the FAP 12 Methodology Report (FAP12 1991a) and the experience with its application in practice has been reviewed in the FAP 12 Final Report (FAP12 1991b). Its main features are therefore only briefly summarised here.

FAP 12 has used two different but complementary approaches to project evaluation. These are Rapid Rural Appraisal (RRA) and Project Impact Evaluation (PIE). RRA is an informal survey technique intended to produce results more quickly than formal interview surveys, while avoiding biases in the data collected. It consists of selective direct observation and interviews conducted by a small team of well-qualified and experienced specialists who can reach informed judgements quickly in the field. Although some quantification of RRA results is possible, by its nature RRA is better at obtaining qualitative than quantitative data, and it cannot (in contrast to probability sample surveys) provide statistical verification of the size and extent of observed impacts.

The PIEs, in contrast, were formal questionnaire surveys using probability sampling for the core samples, and thus having the capability for collection of highly quantified data which would support statistical testing. The two approaches are however complementary. Each of the 5 PIEs was preceded by an RRA, which served as a reconnaissance of the area and which collected data on the condition and performance of the engineering structures and the operation and maintenance institutions of the project. In addition to the main RRAs of the PIE projects, which were conducted in March-April 1991, repeat visits were made in September-October 1991 to supplement the engineering and operation data with observations during the high water period.

1.3.2 PIE Survey Methodology

a) Measurement Approach

Measurement of project impacts in the PIEs was by the **control area** approach, in which observations in the impacted area of a project are compared with those from a non-project area (the control) which had similar conditions to the project area at the period before the project was implemented. The control area will have been subject to any general trends in operation since project completion, so that any differences between project and control should be attributable to the net influence of the project. PIE control areas were selected on the basis of similarity to the project areas in terms of pre-project flood depths and agricultural conditions, and subsequent analysis has shown that in general a high level of comparability was achieved.

b) Probability Samples

The core of the PIE surveys was two probability samples of households, one of cultivators (defined as any farm operator, regardless of type of land tenure) and the other of landless labour households. Probability sampling was adopted in order to confer the ability to test for statistically significant differences between the impacted and control areas. The sample design was two-stage, to minimise logistical problems in compiling sample frames, the first stage consisting of mouzas (revenue villages) and the second of households. Selection of the first stage was with probability proportional to size (PPS) and of the second stage by simple random sampling, the PPS/SRS design being self-weighting.

Sample size for each PIE was set at 120 cultivating and 48 labour households for the impacted area, and 60 cultivating and 24 labour households in the control area. The larger sample size for the impacted area was set in order to permit post-stratification between respondents inside the project (impacted/protected) and those outside but influenced by the project (impacted/unprotected). The cluster size of respondents taken from each first-stage unit was limited to 5 cultivator and 2 labour households, in order to minimise the adverse effect of intra-cluster correlation on precision. The expected mean sample size of 60 per stratum (impacted/protected, impacted/unprotected and control) was expected to permit estimation of crop yields (the key agricultural parameter) with 75 per cent confidence interval of 10 per cent of the mean. In practice, in most of the PIEs precision was somewhat better than this.

The first-stage sample frames were taken from the Small Areas Atlas of Bangladesh, which lists mouzas with their populations from the 1981 Census. Second-stage sample frames were compiled from the local taxation rolls maintained by the Union Parishads (the next administrative level above the mouzas) which include all household heads. The rolls were updated, and details of main and secondary occupation obtained, with the help of local informants immediately in advance of each PIE.

Female respondents were sampled from both cultivating and labour households in 50 per cent of the respondent clusters, providing a probability sample of 60 female respondents from cultivating and 24 from labour households in the impacted areas, and 30 from cultivating and 12 from labour households in the control areas.

c) Non-Probability Samples

For some categories of households, including fishermen, fish traders and operators of non-farm rural enterprises it was not logistically feasible to compile satisfactory sample frames for probability sampling. These groups were therefore the subject of questionnaire case-studies aimed at illustrating the project impacts, but without the ability for statistical generalisation. In each of the impacted and control areas a total of 15 fishermen, 5 fish traders and about 15 operators of rural enterprises (grain and input traders, artisans, transport operators, etc.) was interviewed. In addition, the female members of all the households in the non-probability samples were interviewed.

d) Field Procedures

The PIE survey programme was conducted between late May and early November 1991. Fieldwork for each PIE was executed in a period of approximately a month, the main enumeration effort taking about 3 weeks and being preceded by an advance party to compile sample frames and set up logistical arrangements. A team of 15 enumerators was employed (3 of whom were women who interviewed only the female respondents) working under 6 supervisors, who also compiled the sample frames under professional supervision and conducted post-survey questionnaire checking. The questionnaire was modular in design, to permit selective administration for activities (such livestock and fish pond ownership) not undertaken by all households. The questionnaire was pretested before the start of the PIEs, and was again modified slightly after the first PIE at Zilkar Haor.

e) Data Processing

Data entry was conducted with the dBase III+ package and the main tabulations were produced with SPSS. Secondary processing for calculation of standard errors was done with a combination of dBase and Lotus 1-2-3. The algorithms used to calculate standard errors from the PPS/SRS sample data are given in Annex P to the FAP 12 Draft Final Report.

1.3.3 The RRA and PIE Surveys of MDIP

The preliminary RRA of MDIP was conducted in March 1991 by a multidisciplinary team consisting of an agricultural economist (team leader), two agriculturalists, a civil engineer, a rural institutions specialist and an environmentalist. Subsequent visits were made by FAP 12 engineers to collect additional data on the Project's construction, rehabilitation and operating costs, and by two environmentalists to make a more intensive Preliminary Environmental Post-Evaluation (PEP).

The PIE of MDIP was conducted from early October to early November 1991, following the methodology described in Section 1.3.2 above. The control area selected for comparison with the Project area is on the mainland to the south-east of MDIP, falling in the eastern part of the mainland portion of Matlab Upazila, the northern part of Hajiganj Upazila, and in Kachua Upazila (see Figure 1.3). This area is closely comparable with the Project area in distribution of land area by pre-Project flood depth, and its agricultural characteristics are very similar to those recorded for the MDIP area pre-Project by the CIRDAP baseline survey (CIRDAP 1987).

In the impacted area a total of 120 cultivating and 48 labour households were sampled in 24 clusters, falling in 20 different mouzas, while 60 cultivating and 24 labour households, in 12 different mouzas, were sampled in the control area. The locations of sampled mouzas are shown in Figures 1.2 and 1.3.

1.4 ACKNOWLEDGEMENTS

FAP 12's staff spent extended periods in the MDIP area during 1991. In the course of their work they were courteously and cooperatively received everywhere, and this opportunity is taken to express the study team's thanks to all those concerned. Special thanks are due to the District Commissioner, Chandpur, and the officials of Chandpur District and of Matlab and Kachua Upazilas, to the Superintending Engineer and staff of the BWDB Chandpur O&M Circle, to the Chairmen and Members of the Union Parishads in the survey areas, and to the staff of the International Centre for Diahorreal Disease Research, Bangladesh. Last, but by no means least, FAP 12 wishes to thank the over 400 farmers, labourers, fishermen, fish traders and rural entrepreneurs, who with the women of their households gave their time and shared their experience with the study teams.

2 PLANNING, DESIGN AND CONSTRUCTION

2.1 THE PHYSICAL AND HYDROLOGICAL SETTING

2.1.1 Location and Physical Characteristics

MDIP is located on a river island surrounded by the Meghna to the north and west and by the Dhonagoda, an anabranch of the Meghna, to the east and south (see Figure 1.2). The Dhonagoda rejoins the Meghna at the south-west corner of the Project area. Both rivers are weakly tidal. The Project area is low-lying, with a general elevation ranging frpom about 7 to 12 feet (2.1-3.7 metres) above PWD datum. The area is geomorphologically recent, and the rivers have not had time to form the pronounced levees characteristic of other parts of Bangladesh. By the same token, the interior beels are few and small, the dominant landform being a series of longitudinal ridges and troughs trending broadly north-south. Several of the lower troughs, especially in the southern part of the Project area, contained extensive khals which were tidal in the pre-Project period.

2.1.2 Flood Characteristics of the Project Area

a) Flood Type and Seasonal Pattern

Hydrographs for the river gauging stations at Chandpur, Matlab Bazar and Satnal for 1985/86 are shown in Figure 2.1, and those for Chandpur and Satnal for 1987/88 and 1988/89 are shown in Figures 2.2 and 2.3. These represent the period just before closure of the embankment, and the two nationally devastating flood years of 1987 and 1988.

On the basis of the hydrographs, the hydrology of the area clearly falls into Flood Type M (monsoon flood on main river) in the classification adopted by FAP 12 (see FAP 12 Final Report, Volume 1, section 3.4.1), though during the non-monsoon half of the year tidal influence (Flood Type T) predominates. However, as can be seen from Figure 2.1.(1), the land elevation is such that tidal flooding is not important.

As can be seen from the 1985/86 hydrographs, the Pre-Project, large parts of the area flooded annually to a depth of 6-9 feet (1.8-2.7 metres) during the monsoon, and most areas experienced some flooding. The typical flooding pattern was:

- from late December to mid-March the lowest water levels, about 4 feet (1.2 metres) on average, prevailed;
- from early April to mid-May the river water levels started rising and entering the Project, the rise accelerating from mid-May onwards;
- from June to October, the Project area was deeply flooded, with the highest water level usually at some time during August (see Table 2.1(1) and 2.1(2));
- during November and December the water level fell rapidly.

FIGURE : 2·1 WATER LEVEL RECORD (I) (MDIP – 1985/86)

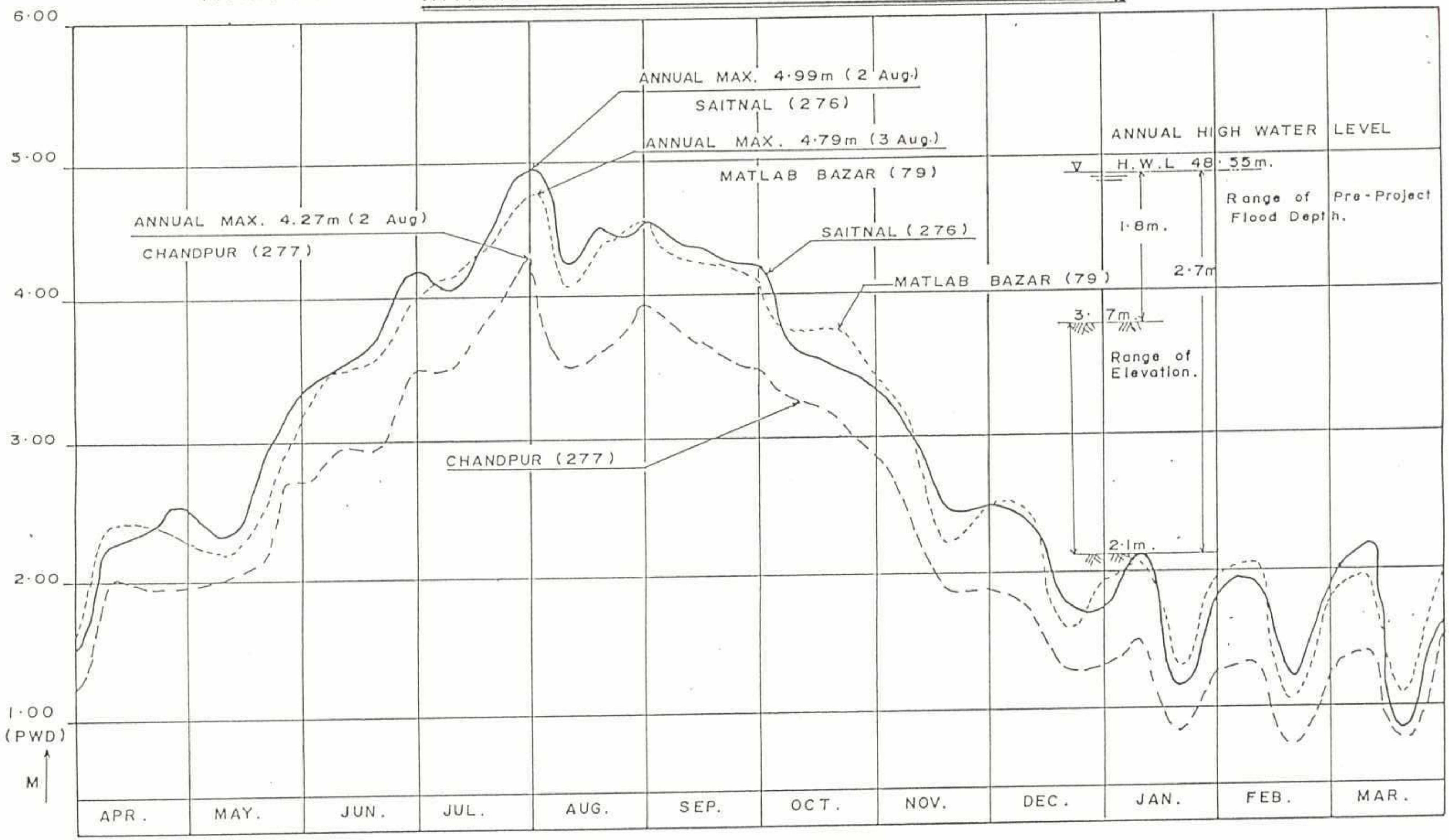


FIGURE : 2·2

WATER LEVEL RECORD (2) (MDIP – 1987/88)

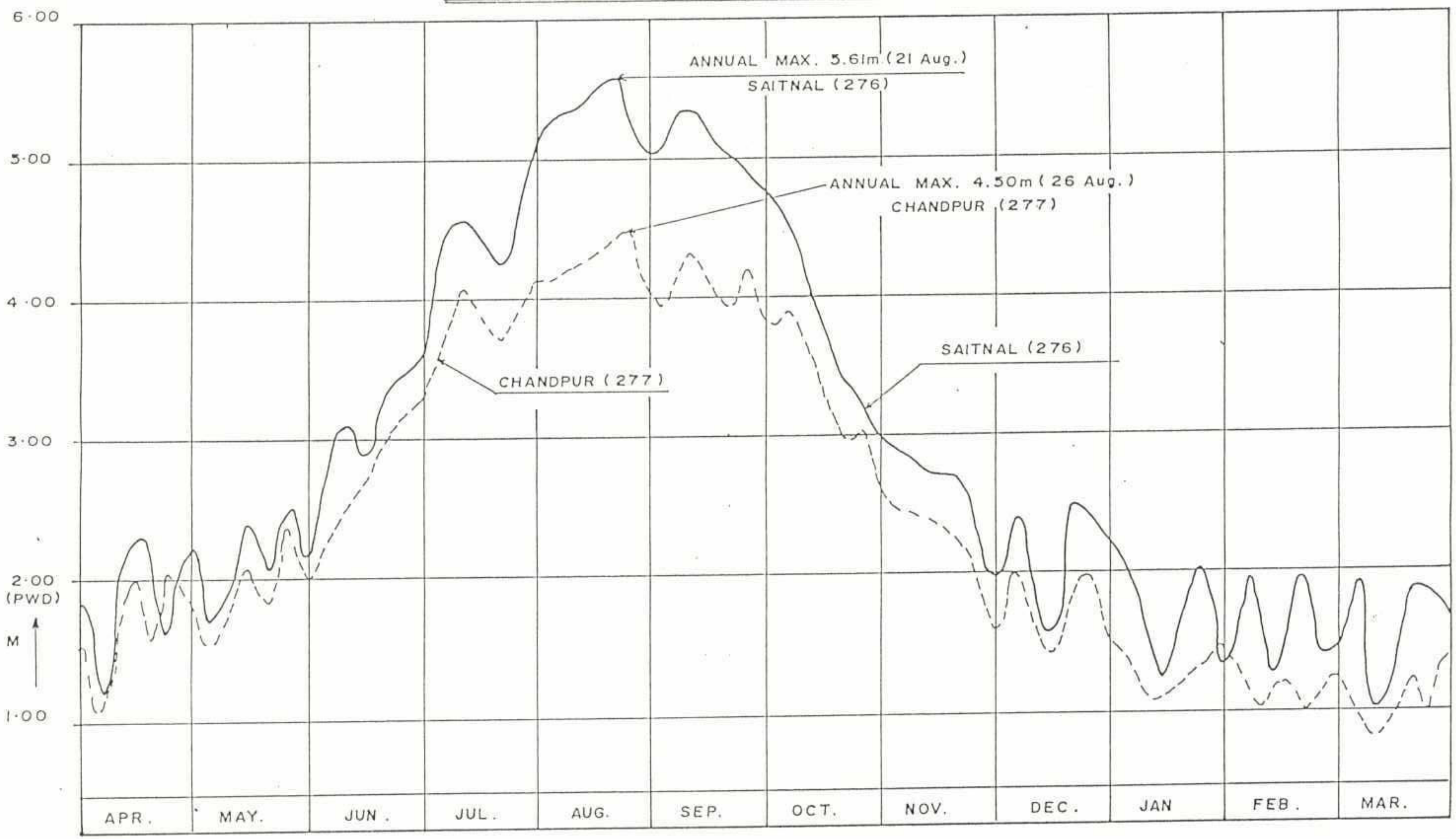
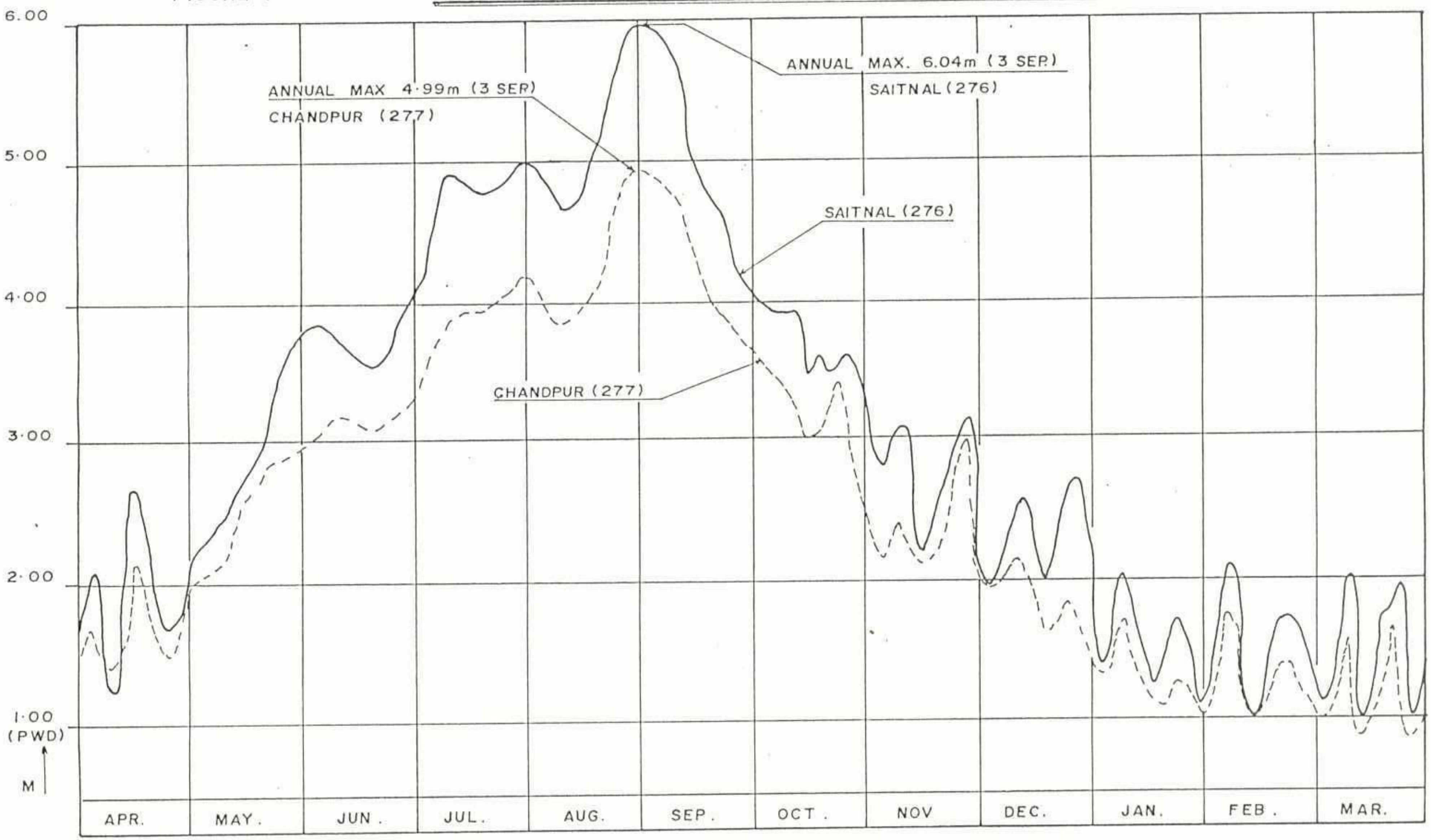


FIGURE : 2·3

WATER LEVEL RECORD (3) (MDIP - 1988/89)



b) Water Level Analysis

A preliminary water level analysis has been conducted employing the water level data from Satnal (station 276), Matlab Bazar (station 79) and Chandpur (station 277), most use being made of the Chandpur data for which there is the longest series (see Table 2.3). By Gumbel's formula, the 100-year high water level at Chandpur (277) is estimated to be 5.35 metres, which with the difference in elevation (1.11 metres) gives a level of 6.46 metres at Satnal at the northern end of MDIP.

The striking feature of Table 2.3 is that the nationally severe floods of 1987 and 1988 were events of quite high probability in the Lower Meghna area. The 1988 flood has an estimated return period of 19 years, and the 1987 flood a return period of 2 years.

2.1.3 Drainage

Due to the prevailing ridge-and trough topography the Project area is relatively free-draining, with few beels to retain water during the dry season. Drainage during the height of the monsoon was not a concern pre-Project, since the area was in any case subject to deep river flooding, to which the cropping pattern had been adapted. The rate of recession of flood water at the end of the monsoon (which was dependent on the rate of fall of river levels) was sometimes a constraint on the planting of rabi crops, while an early rise sometimes caused harvesting problems for rabi crops in April-May and of Aus paddy in July.

2.1.4 Irrigation

During the non-monsoon half-year the Project area was flood-free, and in fact experienced moisture deficit for paddy production on most land from January onwards. There was little development of irrigation pre-project; a relatively small number of LLPs was used to raise water from the tidal khals, and small areas were also irrigated by traditional manual lifting methods. Comparison with the PIE control area (see Chapter 3) shows that groundwater irrigation by DTW is possible in the area, but the depth of flooding in the monsoon (see above) would have made fixed pump installations vulnerable except on the highest land.

Table 2.1 Annual Water Level Records
River: Meghna, Station: Saitnal (276)
Unit: m/PWD

Year	Maximum	Date
1981	5.243	14th August
1982	4.816	3rd August
1983	4.260	21st September
1984	5.620	2nd August
1985	4.990	2nd August
1986	4.670	10th August
1987	5.580	22nd August
1988	6.040	3rd September
1989	4.690	22nd July

Source: BWDB

Table 2.2 **Annual Water Level Records**
River: Surma-Meghna, Station: Chandpur (277)
Unit: m/PWD

Year	Maximum	Date
1960	-	-
1961	-	-
1962	-	-
1963	-	-
1964	-	-
1965	4.80	25th August
1966	4.85	3rd September
1967	4.27	4th September
1968	4.64	29th July
1969	4.60	29th August
1970	4.66	8th August
1971	-	-
1972	4.42	7th August
1973	4.73	18th August
1974	4.96	14th August
1975	4.50	7th August
1976	4.16	27th August
1977	4.39	1st September
1978	4.24	22nd August
1979	4.35	8th August
1980	4.52	27th August
1981	4.38	9th August
1982	4.18	8th August
1983	4.44	20th September
1984	4.65	1st August
1985	4.27	2nd August
1986	3.82	7th August
1987	4.50	26th August
1988	4.99	2nd September
1989	4.29	23rd July

Source: BWDB

Table 2.3 Probability Analysis by Gumbel's Formula - Chandpur - (277)

Year	Annual Flood level (X_i)	X_i-x	$(X_i-x)^2$	$(X_i-x)^3$	Reduced Variate	Recurre. Interval	% Probability
1988	4.99	0.51	0.26	0.13	2.93	18.80	5.32
1974	4.96	0.48	0.23	0.11	2.79	16.35	6.12
1966	4.85	0.37	0.13	0.05	2.28	9.80	10.21
1965	4.80	0.32	0.10	0.03	2.05	7.76	12.88
1973	4.73	0.25	0.06	0.01	1.72	5.60	17.84
1970	4.66	0.18	0.03	0.01	1.40	4.05	24.72
1984	4.65	0.17	0.03	0.00	1.35	3.86	25.90
1968	4.64	0.16	0.02	0.00	1.30	3.69	27.13
1969	4.60	0.12	0.01	0.00	1.12	3.06	32.68
1980	4.52	0.04	0.00	0.00	0.75	2.11	47.43
1975	4.50	0.02	0.00	0.00	0.65	1.92	52.06
1987	4.50	0.02	0.00	0.00	0.65	1.92	52.06
1983	4.44	-0.04	0.00	0.00	0.37	1.45	68.83
1972	4.42	-0.06	0.00	0.00	0.28	1.32	75.55
1977	4.39	-0.09	0.01	0.00	0.14	1.15	86.87
1981	4.38	-0.10	0.01	0.00	0.09	1.10	91.01
1979	4.35	-0.13	0.02	0.00	-0.05	0.96	104.65
1989	4.29	-0.19	0.04	-0.01	-0.32	0.72	138.38
1967	4.27	-0.21	0.05	-0.01	-0.42	0.66	151.88
1985	4.27	-0.21	0.05	-0.01	-0.42	0.66	151.88
1978	4.24	-0.24	0.06	-0.01	-0.56	0.57	174.64
1982	4.18	-0.30	0.09	-0.03	-0.84	0.43	230.92
1976	4.16	-0.32	0.10	-0.03	-0.93	0.39	253.45
1986	3.82	-0.66	0.44	-0.29	-2.51	0.08	1233.92

Σx = 107.61, Variance = 1.75, Average (x) = 4.48, Standard Deviation = 0.28

Return period	Flood height
T (100)	5.35
T (50)	5.20
T (20)	5.00
T (10)	4.85
T (5)	4.71
T (2)	4.50
T (1)	4.36

Source: Consultants' estimates

2.2 OUTLINE OF PROJECT DESIGN AND OBJECTIVES

The overall objective of MDIP was to effect a transformation in the hydrology of the area favourable to introduction of HYV paddy in both the monsoon and dry seasons. The monsoon objective required both exclusion of the deep river flood (see above) and provision of drainage to prevent congestion of the high volume of rainfall, while the dry season objective required provision of irrigation facilities.

MDIP is therefore a combined Flood Control, Drainage and Irrigation (FCDI) project. The main design features are a ring embankment around the perimeter for flood protection, an internal network of gravity flow canals for dry season irrigation, and a network of drainage channels (mostly linked pre-existing khals) for drainage of excess rainwater in the monsoon. Evacuation of drainage water is by two main pump stations, one at Kalipur at the northern end of the project, and the other at Uddhamdi at the southern end (see Figure 1.2). The main pump stations are reversible and are also used to lift water into the irrigation canals in the dry season. The drainage volume is however much larger than that required for irrigation, and the pumps were sized to handle the monsoon drainage requirement. Part of the area cannot be commanded by gravity flow from the main pump stations, and there are therefore two booster pump stations, at Dubgi and Eklaspur, to command the higher areas. The canal system is designed to command a total of 14,367 ha., the remainder of the gross area being too high to command economically.

An original planning objective at MDIP was to avoid sacrificing the internal navigation access provided by the khals in achieving the project objectives in flood control. Navigation locks at the outfalls of the main khals were therefore planned. In addition to maintaining the pre-project water transport system, the project also had an objective of improving the land transport system by constructing or upgrading some *** km. of village roads.

2.3 PROJECT STRUCTURES

The structures planned and actually constructed to achieve MDIP 's objectives are summarised in Table 2.4.

The design 100-year high water level of the embankment was set at 6.7 m. above PWD datum, which agrees well with the 100-year flood for Satnal estimated by Gumbel's formula (see 2.1.2 above). The actual crest height of 7.6 m. PWD datum includes a freeboard of 0.9 m.. Comparison with the hydrographs in Figures 2.2 and 2.3 confirms that the embankment was in no danger of overtopping in 1987 or 1988.

As shown in the Table, there was significant variation between the structures originally planned and those actually built. The erosion problems which effected the embankment and resulted in it being retired to a shorter alignment are discussed below. Of the irrigation components, the third booster pump station envisaged for the eastern side of the Project was removed from the detailed design as not economically justified by the additional commanded area, but the length of canals constructed by BWDB was almost three times that originally planned, due to BWDB assuming responsibility for the tertiary network. As noted above, the original planning envisaged provision of navigation locks and of an improved road network, but in the event neither was constructed. The navigation locks were downgraded to transhipment points during detailed design, and even these were not actually constructed. None of the road network was built, although the planned number of bridges was constructed.

Neither the BWDB nor the ADB PCR give the underlying reasons for these changes, but it seems highly likely that they were forced by the serious cost over-run of the Project.

Table 2.4 Summary of Main Project Features

Items	No./Length (km)		No./Length(km) Damaged 1987 and 1988	No./Length (km)		Remarks
	As Planned	As Implemented		Repaired/ Modified	Need repair/ modification	
A. Flood Embankment	65 km.	60 km.	46.78 km.	46.78 km.	-	
B. Pumping Stations:						
i. Main	2 Nos.	2 Nos.	-	-	-	
ii. Booster	3 Nos.	2 Nos.	-	-	-	
C. Irrigation Canal						
i. Main & Secondary		97.5 km.				
ii. Tertiary		120.5 km.				
Total:	75 km.	218 km.	162.28 km.	74.70 km.	18.50 km	
D. Irrigation Structures:						
i. Regulator	69 Nos.	69 Nos.	-	-	-	
ii. Irrigation Conduit	14 Nos.	14 Nos.	2 Nos.	2 Nos.	-	
iii. Check Gate	42 Nos.	42 Nos.	-	-	-	
iv. Turn out	387 Nos.	387 Nos.	358 Nos.	358 Nos.	-	
v. Escape	17 Nos.	17 Nos.	1 No.	1 No.	-	
vi. Aqueduct	3 Nos.	3 Nos.	-	-	-	
E. Drainage Canal	160 km.	125.5 km.	38.25 km.	-	-	
F. Drainage Structures						
i. Drainage Conduit	39 Nos.	39 Nos.	7 Nos.	7 Nos.	-	
ii. Combined Structures	14 Nos.	14 Nos.	-	-	-	
iii. Water Control Strc.	9 Nos.	9 Nos.	-	-	-	
G. Bridges	72 Nos.	72 Nos.	6 Nos.	6 Nos.	-	20 new bridges constructed
H. Roads	70 km.	nil				
I. Navigation Locks	2 nos.	nil				

Sources: BWDB and ADB PCRs, RRA Survey

2.4 DESIGN AND CONSTRUCTION PROBLEMS

The construction of MDIP was affected by persistent problems, some of whichh reflect shortcomings in planning and design, while others relate to the standard of construction and the quality of its supervision. The components most affected were the main flood control embankment and the main pumphouses.

a) Embankments

The main embankment on the Meghna river side of the Project was in theory planned to remain secure in the face of 100 years of river bank erosion. In reality, it had to be retired twice (in 1981 and in 1986) in the Amirabad-Eklaspur area at the south-western corner of the Project, even before the Project was completed. The set-back of the embankment was clearly quite inadequate, but FAP 12 was not able to ascertain whether this was due to faulty estimation of the rate of erosion, or to political and social pressure to offer protection to as much land as possible. The ADB PCR notes that the design consultants may have faced political pressure on detailed design issues (ADB 1990, p.10).

The first MDIP Feasibility Report recommended a minimum embankment crest width of 20 ft. (6.1 m.) on the Meghna side and 17 ft. (5.2 m.) on the Dhonagoda side. During detailed design this was reduced to 14 ft. (4.3 m.), according to BWDB informants in order to reduce land acquisition costs. It seems likely that this reduction adversely affected embankment stability (a conclusion reached by BWDB's investigation after the 1988 floods). Embankment stability was reinforced over much of its length by siting the main irrigation canals immediately on the inner side of the embankment, thus reducing hydrostatic pressure at high outside water levels, but this was not possible on all stretches of the embankment and additional precautions (such as increasing the embankment width) were not taken in these stretches.

The reduction of the embankment width was particularly unfortunate in view of the known subsoil problems in the MDIP area. The Feasibility Study noted that soil moisture in the Project area varied directly with water level fluctuations in the bordering rivers, indicating high permeability and a danger that piping would develop through the embankment foundation.

Labour-intensive methods were used for all earthwork in MDIP, including the main embankment. From inspection during the RRA, it appeared that compaction was not satisfactory, leading to penetration by burrowing animals and danger of piping through the embankment.

b) Pumphouses

Both the main pumphouses, which are large structures, were affected by foundation problems stemming basically from failure to take account in design of the problems posed by the difficult subsoil conditions in the area. The foundation of one of the pumphouses required extensive and expensive additional piling during construction, while the other cracked after construction and required rehabilitation, also at high cost.

c) Irrigation System

Observations of the canal system during the RRA survey showed a number of defects in design and construction. In many cases local people have constructed unauthorised pipe turnouts from the irrigation canals, indicating that the turnouts originally provided were insufficient in number and/or inappropriately placed. Some turnout locations have been found to be useless due to borrow pits dug on the outlet side. Pipes used in turnouts are inadequate in size in many places and in some cases the beds of turnout pipes are inconsistent in level with the canal bed. Due to poor workmanship, water leakage has been found in some aqueducts and drainage conduits. In a few cases levelling of the structures both with respect to each other and with respect to the canal bed was not maintained. For example, the crest level of one escape was found to have a higher level than the check gate and regulator on the downstream side.

2.5 PERFORMANCE AND CONDITION OF PROJECT STRUCTURES

2.5.1 Performance in 1987 and 1988

During the 1987 flood a portion of the flood embankment on the Dhonagoda, near Durgapur on the eastern side of the Project, was breached, and another portion at Rishikandi near Durgapur was breached by the 1988 flood. From river gauging at Chandpur (see Table 2.3) on the Lower Meghna the 1988 flood was only about a 1-in-19 event, and the 1987 a 1-in-2 event, whereas the embankment crest level was designed for a 1-in-100 year event. This confirms the evidence of BWDB reports and local residents that the breaches were due to embankment and/or subsoil failure, not to overtopping. Both the 1987 and 1988 floods caused widespread damage to the recently completed irrigation system, and an area of several thousand acres inside the breaches was badly affected by sand carried by the resulting high-velocity flows.

2.5.2 Performance since 1988

Since 1988 two of the three major engineering components of the Project - the embankment and the pumping stations - have functioned effectively. The repaired embankment has successfully withstood the 1989, 1990 and 1991 floods, and on this evidence now seems adequate to withstand the normal yearly floods caused by the Meghna and Dhonagoda rivers in the Project area. There is still cause for serious concern, however, over the erosion threat to the main embankment. This remains severe both in the region of the 1987-1988 breaches on the eastern side of the Project, and in the south-western corner and on the western side, where continued erosion by the Meghna is likely. Extensive and expensive programmes are in hand for armouring the most vulnerable stretches on this side.

Discussion with BWDB staff on the operation of Uddhamdi and Eklaspur pumping stations gave no evidence of serious drainage congestion in the Project area, and this is strongly confirmed by FAP 12's analysis of flood depths and durations on cultivated land using PIE survey data (reported in detail in Chapter 3). This situation is possible because the two primary pumping stations were designed to satisfy major drainage requirements, and have so far operated without problems. The pumping stations have also been able to meet the dry-season water supply requirement, leading to dramatic increase in in irrigated cropping in the Boro and Aus seasons (see also Chapter 3).

The third main component - the irrigation canal system - remains extensively damaged, although a rehabilitation programme is gradually bringing it back into full operation. This has not in fact prevented the appearance of the expected dry-season agricultural benefits. The pump stations have been able to assure the required water supply, and a mixture of ad hoc operation of the damaged parts of the system and private initiative in providing low-lift pumps (see Chapter 4) has been able to deliver it to farmers' fields. In consequence irrigation is available almost throughout the intended command area (see Chapter 4), though at higher total cost than planned in the areas where LLPs must be used.

The as-built 14 ft crest width in most parts of the flood embankment seems to be adequate for road traffic although this width is hardly sufficient for passing of two standard vehicles. At present mini-taxi services have been well established from the ferry ghat opposite Matlab Bazar to Kalipur Bazar. Passenger road transport has been found quite attractive to local people, compared with the previous water transport system, due to reduced travel time. However, the road network in the Project interior remains rudimentary. Consequently, and in the absence also of the pre-Project internal water transport system, farmers are facing additional unit transport costs at the same time that their transportation requirements for both inputs and outputs have risen dramatically due to agricultural intensification.

2.5.3 Condition of Earthworks and Structures

Apart from the defects of construction and the damage caused by the 1987 and 1988 floods, the Project structures are in good condition; this is not unexpected in a project which has only been completed for 5 years. The condition of the earthworks, however, gives cause for concern, especially in the case of the irrigation canals. In most of the irrigation canals, dense aquatic vegetation exists within the waterway, which along with thick sediment on the canal bed, causes reduction in actual flow through the canal. Due to lack of proper compaction, randomly scattered rat holes, cattle grazing along the slope of irrigation canal dykes and local people using sides of these canals for bathing and washing clothes, severe damage is being caused to the interior sides of the irrigation canal dykes.

2.6 RECOMMENDATIONS

2.6.1 Development and Rehabilitation of MDIP

i. Strong protective measures must be taken up for protecting the danger prone portions of the flood embankment.

ii. The flood damaged portions of the irrigation and drainage system should be properly repaired/rehabilitated with a major emphasis on compaction of canal dykes and proper levelling of bed slopes.

iii. The internal communications as well as connection to the external communication nodes should be improved.

2.6.2 Recommendations for Future FCD/I Projects

i. Rigorous bank erosion studies must be conducted to determine safe locations for flood embankments on erosion-prone river reaches. Impact of flood water waves, and flow direction of flood water with respect to the flood embankment must be considered together with permanent slope protection works and cross bars at the time of detailed design;

ii. The subsoil permeability along flood embankments must be explored, and relevant protective measures must be taken.

iii. The major transportation facilities considered in the Feasibility Report should remain intact in detailed design and construction.

iv. More sophisticated methods of earth compaction must be practised for construction of all massive flood embankments, rather than labour intensive methods.

v. The irrigation and drainage network as indicated in the Feasibility studies should be implemented to achieve the original target of irrigable area.

3 HYDROLOGICAL IMPACTS

3.1 INTRODUCTION

The pre-Project hydrology in the MDIP area, and the Project's objectives for transforming the hydrological conditions within the Project, have been described in Chapter 2. Those objectives were to bring about major changes in the three key hydrological parameters of flood depth, flood duration and dry season water shortage. This Chapter describes the impact of the Project on these three parameters.

3.2 SOURCES OF DATA

The following reports and Project documents were reviewed in connection with the Project study.

- Report on the Meghna-Dhonagoda Irrigation Project (Feasibility Study), Volume I, Volume II, Chuo Kaihatsu Corporation (August 1977).
- Meghna-Dhonagoda Irrigation Project, Operation and Maintenance and Water Management Manual, Chuo Kaihatsu Corporation (June 1985).
- Project Proforma (PP) on Meghna-Dhonagoda Irrigation Project, BWDB (July 1988).
- Project Completion Report of the Meghna-Dhonagoda Irrigation Project ADB-PCR (January 1990).

Information relevant to the Project was also collected during the RRA survey and follow-up visits through discussions with BWDB officials and interviews with local people. The most important source of new quantified data, however, was the agricultural module of the PIE sample survey of agricultural households. This obtained details of pre- and post-Project flood\depth and duration, and of post-Project irrigation status, for all the plots of land operated by a random sample of 115 cultivators inside the Project and 60 in the control area. It is thus possible to compare both with/without and pre/post Project hydrological conditions.

3.3 ASSESSMENT OF HYDROLOGICAL IMPACTS

The Project impacts on hydrology have been assessed qualitatively in terms of impact on flood type within the Project and on the hydrology of the external areas, and quantitatively in terms of the changes in distribution of land area under different hydrological conditions as a result of the Project. An quantitative assessment has also been made of the hydrological comparability of the control area with pre-Project conditions in the protected area, as a guide to the validity of project-control area comparisons.

3.3.1 Impact on Flood Type

a) Impacts within the Project

As noted in Chapter 2, the pre-Project flood type in the MDIP area was an example of Flood Type M (Monsoon flood along main river) but combined with Flood Type T (Tidal flooding) (Flood Type: see FAP 12 Final Report, Volume I, sub-section 3.4.1). In the post-Project period, both the previous flood types have been completely eliminated from the Project area in a normal year (when the embankment remains intact). In the large majority of FCD projects studied by FAP 12, successful elimination of river flood types by construction of embankments carries a high risk of creating a situation of Flood Type L (local flooding due mainly to drainage congestion) which in extreme cases may be as damaging as the Type M or Type F floods prevented. This risk is almost unavoidable with gravity drainage systems, since the peak requirements for draining excess rainfall very frequently coincide with high river stages. The problem has been almost entirely avoided in MDIP through use of pumped drainage, although some reports were received of small localised areas of congestion. These are probably due to the incomplete rehabilitation of the internal drainage network following flood damage in 1987 and 1988.

b) External Impacts

Post-Project monsoon season hydrological conditions outside the Project remain typical of Flood Type M. The Lower Meghna is a very large river, and there has been no effect on its water levels from the Project. Equally important, there is no evidence of raised water levels in the adjacent areas on the left bank of the Dhonagoda, including the control area which lies inland from the Dhonagoda. MDIP's freedom from the widespread problem of public cuts is attributable to the absence of both internal drainage congestion and adverse external impacts. There is also no evidence so far that MDIP has had adverse effects on siltation, again probably because of the large flows in the adjacent rivers.

3.3.2 Impact on Flood Depth and Duration

a) Flood Depth

Project impact on flood depth in cultivated land is presented in Table 3.1 and Figure 3.1. The impact can be summarised as follows:

- the cultivated land subject to shallower depths of normal flooding (less than 30 cm.) increased tremendously from 0.09 ha. (0.1 per cent of the sample area) to 50.94 ha. (79.0 per cent), with a corresponding decrease in the area under the greater flood depths (more than 90 cm.) from 59.33 ha. (92 per cent) to 7.03 ha. (10.9 per cent) - a very positive impact in the impacted/protected area;

- in the control area, on the other hand, the cultivated land under every depth category of normal flooding is almost unchanged. There is a slight increase in the very low flood depth (over 180 cm.) by 1.20 ha. (4.5 per cent) with a corresponding decrease in the area under the flood depths of medium low and low (30 to 180 cm.). This seems not to be significant;

The pre/post and with/without Project comparisons are therefore unanimous in indicating that hydrological objectives in terms of flood depth have been achieved. Most of the land within the protected area is now suitable for HYV paddy cultivation in the monsoon season.

Table 3.1 Cultivated Land by Flood Depth (MDIP)

(Unit: ha)

Flood Depth	Impacted Area						Control Area		
	Protected Area			Unprotected Area					
	Before	Present	Increase	Before	Present	Increase	Before	Present	Increase
High (%)	0.09 (0.1)	41.54 (64.4)	41.45 (64.3)	- (-)	- (-)	- (-)	0.04 (0.2)	0.04 (0.2)	- (-)
Medium High (%)	- (-)	9.40 (14.6)	9.40 (14.6)	- (-)	- (-)	- (-)	0.32 (1.2)	0.32 (1.2)	- (-)
Medium Low (%)	5.04 (7.8)	6.51 (10.1)	1.47 (2.3)	- (-)	- (-)	- (-)	3.64 (13.7)	3.58 (13.5)	-0.06 (-0.2)
Low (%)	34.24 (53.1)	5.40 (8.4)	-28.84 (-44.7)	- (-)	- (-)	- (-)	15.75 (59.3)	14.61 (55.0)	-1.14 (-4.3)
Very Low (%)	25.09 (39.0)	1.63 (2.5)	-23.46 (-36.5)	- (-)	- (-)	- (-)	6.81 (25.6)	8.01 (30.1)	1.20 (4.5)
Total (%)	64.46 (100.0)	64.48 (100.0)	0.02 (-)	- (-)	- (-)	- (-)	26.56 (100.0)	26.56 (100.0)	- (-)

Flood Depth: High = Never flooded, Medium High = 0 - 30cm, Medium Low = 30 - 90cm
Low = 90 - 180cm, Very Low = over 180cm

Source: PIE Farm Household Survey

Table 3.2 Cultitvated Land by Duration of Inundation (MDIP)

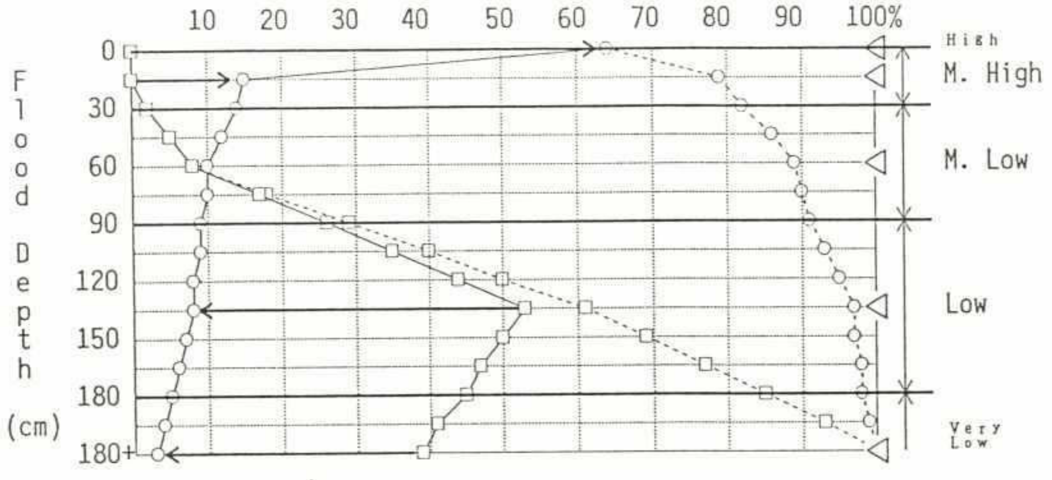
(Unit: ha)

Inundation Duaration (months)	Impacted Area						Control Area		
	Protected Area			Unprotected Area					
	Before	Present	Increase	Before	Present	Increase	Before	Present	Increase
0 (%)	- (-)	42.09 (65.3)	42.09 (65.3)	- (-)	- (-)	- (-)	0.04 (0.2)	0.03 (0.1)	-0.01 (-0.1)
0 - 1 (%)	0.80 (1.2)	2.68 (4.2)	1.88 (3.0)	- (-)	- (-)	- (-)	0.11 (0.4)	0.11 (0.4)	- (-)
1 - 2 (%)	1.76 (2.7)	2.48 (3.8)	0.72 (1.1)	- (-)	- (-)	- (-)	0.80 (3.0)	0.80 (3.0)	- (-)
2 - 3 (%)	4.63 (7.2)	4.31 (6.7)	-0.32 (-0.5)	- (-)	- (-)	- (-)	0.56 (2.1)	0.57 (2.2)	0.01 (0.1)
3 - 4 (%)	11.65 (18.1)	4.17 (6.5)	-7.48 (-11.6)	- (-)	- (-)	- (-)	1.91 (7.2)	2.44 (9.2)	0.53 (2.0)
4 - 5 (%)	31.28 (48.5)	4.38 (6.8)	-26.90 (-41.7)	- (-)	- (-)	- (-)	11.84 (44.6)	10.84 (40.8)	-1.00 (-3.8)
5 - 6 (%)	10.86 (16.9)	1.93 (3.0)	-8.93 (-13.9)	- (-)	- (-)	- (-)	10.08 (37.9)	10.57 (39.8)	0.49 (1.9)
6 and over (%)	3.48 (5.4)	2.42 (3.7)	-1.06 (-1.7)	- (-)	- (-)	- (-)	1.22 (4.6)	1.20 (4.5)	-0.02 (-0.1)
Total (%)	64.46 (100.0)	64.46 (100.0)	- (-)	- (-)	- (-)	- (-)	26.56 (100.0)	26.56 (100.0)	- (-)

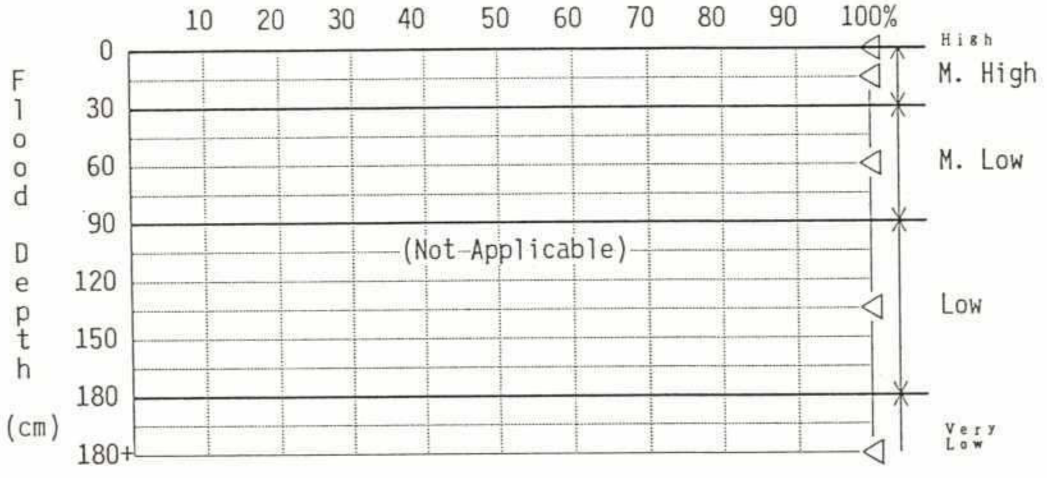
Source: PIE Farm Household Survey

Figure 3.1 Cultivated Land by Flood Depth (MDIP)

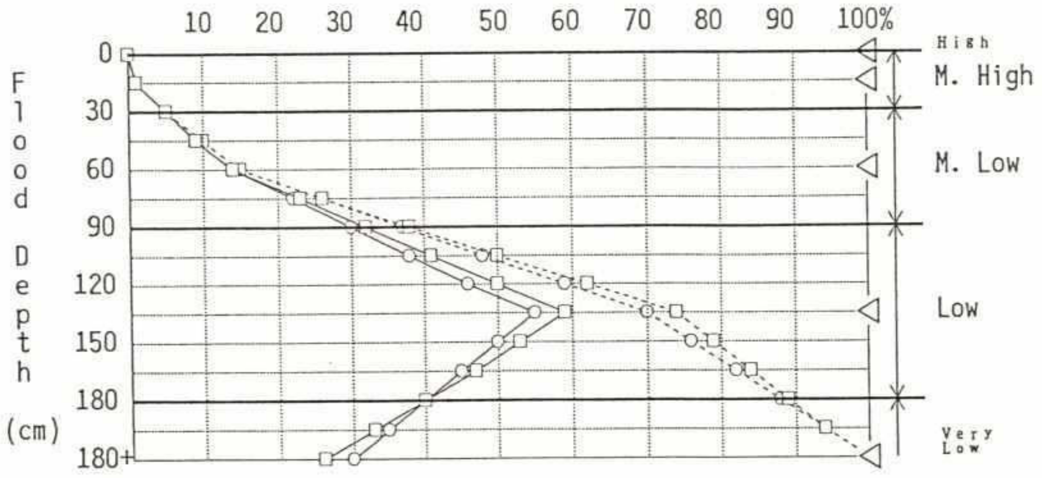
(1) Impacted Area - Protected



(2) Impacted Area - Unprotected



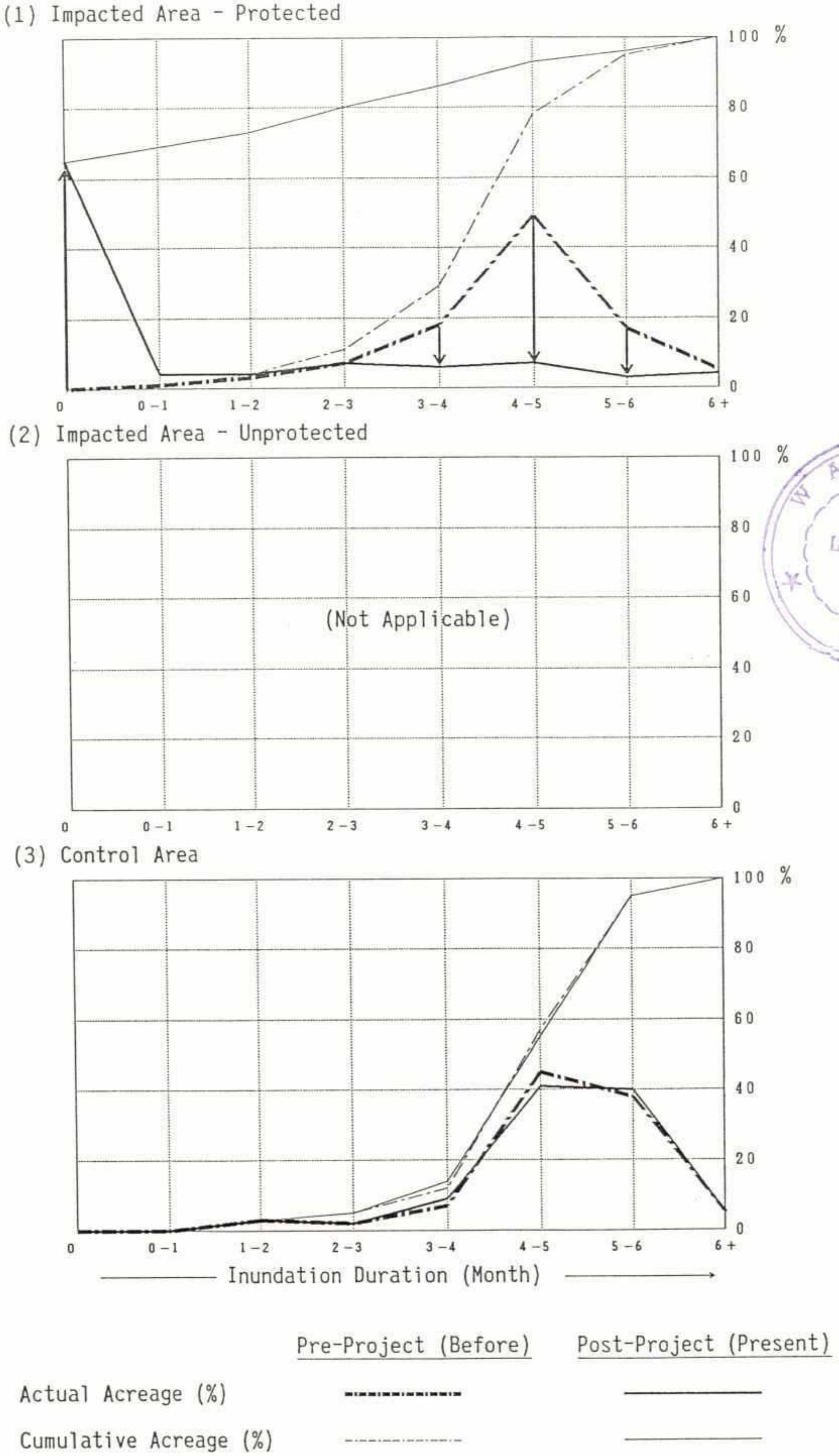
(3) Control Area



——— Actual Acreage (%) ··········· Cumulative Acreage (%)

□ Pre-Project, ○ Post-Project, ◁ Median of Range

Figure 3.2 Cultivated Land by Inundation Duration (MDIP)



b) Flood Duration

Table 3.2 and Figure 3.2 show that Project impact on duration of inundation has been almost as dramatic as that on flood depth. The cultivated lands subject to shorter inundation periods (less than two months) increased from 2.56 ha. (3.9 per cent of sample area) to 47.25 ha. (73.3 per cent), with a corresponding reduction in the area subject to an inundation period longer than two months - again a strong positive impact in the protected area. The control area shows very minor changes in the cultivated lands subject to various inundation periods that again seem not to be significant.

3.3.3 Impact on Irrigation

Tables 3.3 to 3.5 and Figure 3.3 give the post-project irrigation condition in the impacted and the control areas. In interpreting Figure 3.3, it should be observed that although the axes of the graphs are of equal length, this does not imply that the various land levels occupy equal proportions of the area.

The following impacts on irrigation can be summarised:

- in the impacted/protected area 59 per cent of the cultivated land is irrigated in the rabi season, compared with 24 per cent in the control area. Rabi season irrigation occupies nearly 90 per cent of the year-round irrigated area in both the protected and the control areas.

- in the rabi season, while some 64 per cent of the cultivated land subject to the three shallower flood depths (less than 90 cm.) is irrigated in the impacted/ protected area, only 28 per cent of the same land category is irrigated in the control area. Significantly, however, the percentages irrigated in the two highest land categories are greater in the control than in the protected area; this is probably due to the use of DTWs in the control area, which require a flood-free site. It is apparent that the gravity irrigation system has brought about substantial positive impact in the Project area, resulting in a substantial increase in the irrigated area, especially at lower land levels;

- in the impacted/protected area during the rabi season 60 per cent of the irrigated area is supplied by the BWDB canals, followed by LLPs (34 per cent), whereas in the control area LLPs predominate (50 per cent) followed by indigenous methods (28 per cent) and DTWs (21 per cent). Farmers in most of the Project area are presently irrigating their crops without paying any water charge, since the rates have not yet been set by BWDB; the exceptions are in the areas where the BWDB gravity canal system is awaiting rehabilitation, where farmers have to meet the cost of LLPs to lift water to their lands. The main source of LLPs irrigation water depends on khals and borrow-pits filled from BWDB canals.

The evidence is therefore that while the project has substantially increased irrigation, a significant area could have been irrigated without the project facilities. This would probably have been on a more sustainable basis than the present Project system, since impacted area farmers do not at present pay for canal water, while control area farmers get their water from LLPs and DTWs and have to pay its full cost). In addition, it is likely that in the areas where the canal system is operating, the lack of water charges encourages excessive use of water, resulting both in unnecessary pumping requirements and in a bias of the cropping system towards high water requirement crops, especially HYV Boro.

Table 3.3 Irrigated Area by Flood Depth and Crop Season (MDIP)

(Unit: ha)

Crop		Impacted Area												Control Area					
		Protected Area						Unprotected Area											
		H.	M.H.	M.L.	L.	V.L.	Total	H.	M.H.	M.L.	L.	V.L.	Total	H.	M.H.	M.L.	L.	V.L.	Total
Aus, T,HYV	Crp. A.	15.91	4.53	1.33	-	-	21.77	-	-	-	-	-	-	-	-	-	-	-	-
	Irr. A.	1.62	0.13	0.07	-	-	1.82	-	-	-	-	-	-	-	-	-	-	-	-
	(%)	(10.2)	(2.9)	(5.3)	-	-	(8.4)	-	-	-	-	-	-	-	-	-	-	-	-
Aus, B	Crp. A.	-	-	-	-	-	-	-	-	-	-	-	-	-	0.78	-	-	-	0.78
	Irr. A.	-	-	-	-	-	-	-	-	-	-	-	-	-	0.17	-	-	-	0.17
	(%)	-	-	-	-	-	-	-	-	-	-	-	-	-	(21.8)	-	-	-	(21.8)
Aus, Total	Crp. A.	15.91	4.53	1.33	-	-	21.77	-	-	-	-	-	-	-	0.78	-	-	-	0.78
	Irr. A.	1.62	0.13	0.07	-	-	1.82	-	-	-	-	-	-	-	0.17	-	-	-	0.17
	(%)	(10.2)	(2.9)	(5.3)	-	-	(8.4)	-	-	-	-	-	-	-	(21.8)	-	-	-	(21.8)
Aman, T,HYV	Crp. A.	27.52	7.19	5.47	-	-	40.18	-	-	-	-	-	-	-	0.12	-	-	-	0.12
	Irr. A.	3.01	-	0.23	-	-	3.24	-	-	-	-	-	-	-	0.12	-	-	-	0.12
	(%)	(10.9)	(-)	(4.2)	-	-	(8.1)	-	-	-	-	-	-	-	(100)	-	-	-	(100)
Boro, HYV	Crp. A.	23.53	7.01	4.25	0.49	1.12	36.40	-	-	-	-	-	-	-	-	0.46	3.49	1.34	5.29
	Irr. A.	23.12	7.01	4.25	0.44	0.69	35.51	-	-	-	-	-	-	-	-	0.40	3.49	1.28	5.17
	(%)	(98.3)	(100)	(100)	(89.8)	(61.6)	(97.6)	-	-	-	-	-	-	-	-	(87.0)	(100)	(95.5)	(97.7)
Wheat	Crp. A.	1.09	-	-	-	-	1.09	-	-	-	-	-	-	-	0.08	-	2.08	1.51	3.67
	Irr. A.	0.50	-	-	-	-	0.50	-	-	-	-	-	-	-	0.08	-	0.08	0.05	0.21
	(%)	(45.9)	-	-	-	-	(45.9)	-	-	-	-	-	-	-	(100)	-	(3.8)	(3.3)	(5.7)
Oilseeds	Crp. A.	3.00	0.46	-	-	-	3.46	-	-	-	-	-	-	-	-	-	-	-	-
	Irr. A.	0.36	0.06	-	-	-	0.42	-	-	-	-	-	-	-	-	-	-	-	-
	(%)	(12.0)	(13.0)	-	-	-	(12.1)	-	-	-	-	-	-	-	-	-	-	-	-
Pepper	Crp. A.	1.27	-	-	-	-	1.27	-	-	-	-	-	-	-	-	-	-	-	-
	Irr. A.	1.21	-	-	-	-	1.21	-	-	-	-	-	-	-	-	-	-	-	-
	(%)	(95.3)	-	-	-	-	(95.3)	-	-	-	-	-	-	-	-	-	-	-	-
Winter Vegetables	Crp. A.	0.10	-	-	-	-	0.10	-	-	-	-	-	-	0.04	0.09	0.15	-	-	0.28
	Irr. A.	0.10	-	-	-	-	0.10	-	-	-	-	-	-	0.04	0.09	0.05	-	-	0.18
	(%)	(100)	-	-	-	-	(100)	-	-	-	-	-	-	(100)	(100)	(33.3)	-	-	(64.3)
Potato	Crp. A.	-	0.07	-	-	-	0.07	-	-	-	-	-	-	-	-	0.74	1.75	-	2.49
	Irr. A.	-	0.07	-	-	-	0.07	-	-	-	-	-	-	-	-	0.44	0.24	-	0.68
	(%)	-	(100)	-	-	-	(100)	-	-	-	-	-	-	-	-	(59.5)	(13.7)	-	(27.3)
Sweet Potato	Crp. A.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	-	-	0.06
	Irr. A.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	-	0.02
	(%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(33.3)	-	-	(33.3)
Rabi/Boro, Total	Crp. A.	28.99	7.64	4.25	0.49	1.12	42.49	-	-	-	-	-	-	0.04	0.17	1.41	7.32	2.85	11.79
	Irr. A.	25.29	7.14	4.25	0.44	0.69	37.81	-	-	-	-	-	-	0.04	0.17	0.91	3.81	1.33	6.26
	(%)	(87.2)	(93.5)	(100)	(89.8)	(61.6)	(89.2)	-	-	-	-	-	-	(100)	(100)	(64.5)	(52.0)	(46.7)	(53.1)
Grand Total	Crp. A.	72.42	19.36	11.05	0.49	1.12	104.34	-	-	-	-	-	-	0.04	1.07	1.41	7.32	2.85	12.69
	Irr. A.	29.92	7.27	4.55	0.44	0.69	42.87	-	-	-	-	-	-	0.04	0.46	0.91	3.81	1.33	6.55
	(%)	(41.3)	(37.6)	(41.2)	(89.8)	(61.6)	(41.1)	-	-	-	-	-	-	(100)	(43.0)	(64.5)	(52.0)	(46.7)	(51.6)

Flood Depth: H. = High (never flooded), M.H. = Medium High (0 - 30 cm), M.L. = Medium Low (30 - 90 cm), L. = Low (90 - 180 cm), V.L. = Very Low (over 180 cm)

Note: Crp. A. = Cropped Area, Irr. A. = Irrigated Area

Source: PIE Farm Household Survey

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Table 3.4 Irrigated Area by Flood Depth and Means (MDIP)

(Unit: ha)

Season	Flood Depth	Impacted Area												Control Area					
		Protected Area						Unprotected Area											
		DTW	STW	LLP	Ind.	BWDB	Total	DTW	STW	LLP	Ind.	BWDB	Total	DTW	STW	LLP	Ind.	BWDB	Total
Aus	High	-	-	-	-	1.62	1.62	-	-	-	-	-	-	-	-	-	-	-	-
	M.H.	-	-	-	-	0.13	0.13	-	-	-	-	-	-	-	-	-	0.17	-	0.17
	M.L.	-	-	-	-	0.07	0.07	-	-	-	-	-	-	-	-	-	-	-	-
	Low	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V.L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	-	-	-	-	1.82	1.82	-	-	-	-	-	-	-	-	-	0.17	-	0.17
Aman	High	-	-	-	-	3.01	3.01	-	-	-	-	-	-	-	-	-	-	-	-
	M.H.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	-	0.12
	M.L.	-	-	-	-	0.23	0.23	-	-	-	-	-	-	-	-	-	-	-	-
	Low	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	V.L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	-	-	-	-	3.24	3.24	-	-	-	-	-	-	-	-	-	0.12	-	0.12
Rabi/Boro	High	-	-	7.74	1.41	16.14	25.29	-	-	-	-	-	-	-	-	-	0.04	-	0.04
	M.H.	-	0.25	2.54	0.07	4.28	7.14	-	-	-	-	-	-	-	-	-	0.17	-	0.17
	M.L.	-	-	1.99	-	2.26	4.25	-	-	-	-	-	-	-	-	0.12	0.79	-	0.91
	Low	-	-	0.37	0.04	0.03	0.44	-	-	-	-	-	-	0.78	0.08	2.28	0.67	-	3.81
	V.L.	0.30	-	0.34	-	0.05	0.69	-	-	-	-	-	-	0.53	-	0.75	0.05	-	1.33
	Total	0.30	0.25	12.98	1.52	22.76	37.81	-	-	-	-	-	-	1.31	0.08	3.15	1.72	-	6.26
Total	High	-	-	7.74	1.41	20.77	29.92	-	-	-	-	-	-	-	-	-	0.04	-	0.04
	M.H.	-	0.25	2.54	0.07	4.41	7.27	-	-	-	-	-	-	-	-	-	0.46	-	0.46
	M.L.	-	-	1.99	-	2.56	4.55	-	-	-	-	-	-	-	-	0.12	0.79	-	0.91
	Low	-	-	0.37	0.04	0.03	0.44	-	-	-	-	-	-	0.78	0.08	2.28	0.67	-	3.81
	V.L.	0.30	-	0.34	-	0.05	0.69	-	-	-	-	-	-	0.53	-	0.75	0.05	-	1.33
	Total	0.30	0.25	12.98	1.52	27.82	42.87	-	-	-	-	-	-	1.31	0.08	3.15	2.01	-	6.55

Irrigation Means: DTW = Deep Tube Well, STW = Shallow Tube Well, LLP = Low Lift Pump, Ind. = Indigenous Ones, BWDB = BWDB Canal

Flood Depth: High = Never flooded, M.H. = 0 - 30 cm, M.L. = 30 - 90 cm, L. = 90 - 180 cm, V.L. = over 180 cm

Source: PIE Farm Household Survey

Table 3.5 Irrigated Area by Means and Crop Season (MDIP)

(Unit: ha)

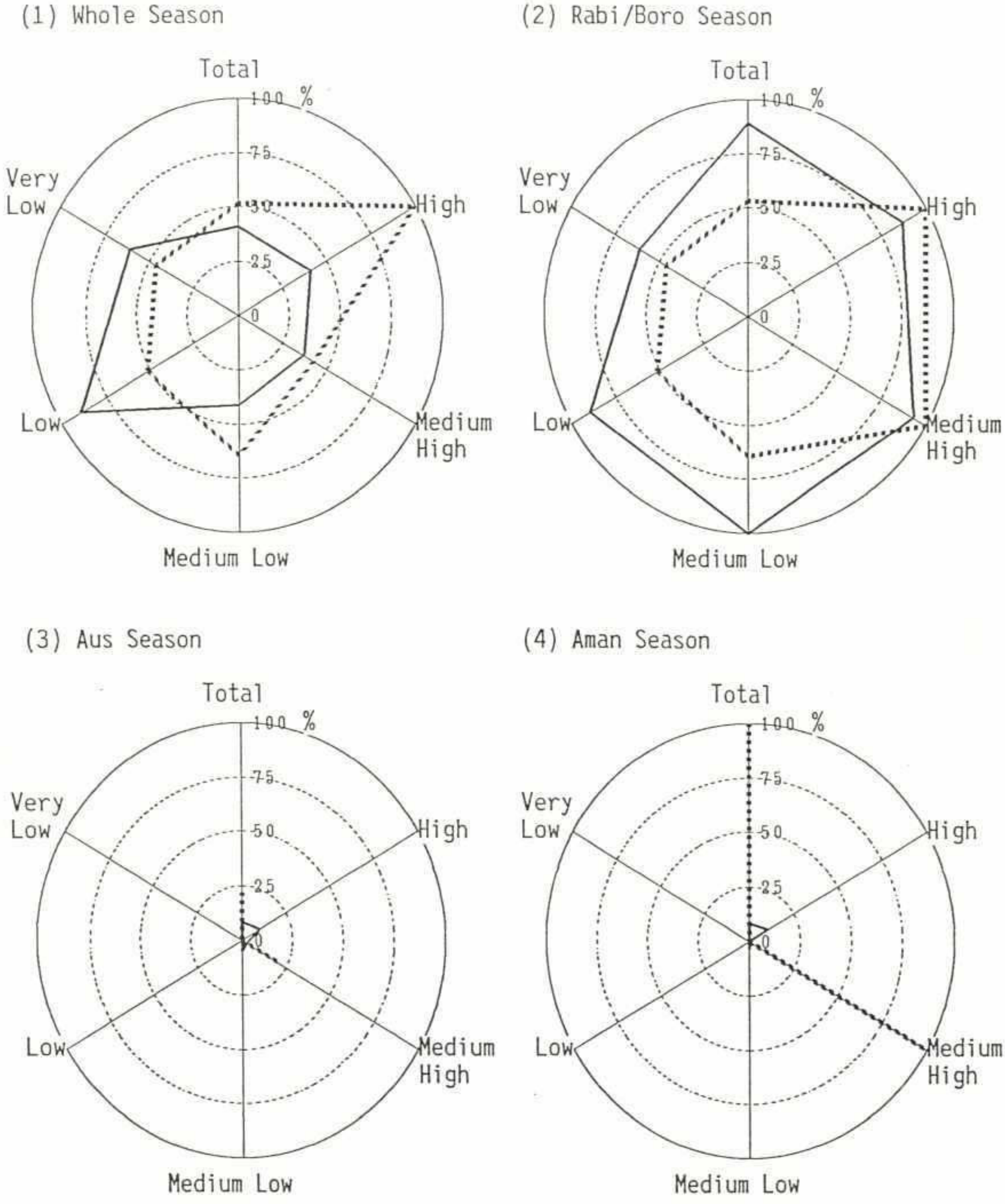
Crop		Impacted Area												Control Area					
		Protected Area						Unprotected Area											
		DTW	STW	LLP	Ind.	BWDB	Total	DTW	STW	LLP	Ind.	BWDB	Total	DTW	STW	LLP	Ind.	BWDB	Total
Aus, T, HYV	Irr. A.	-	-	-	-	1.82	1.82	-	-	-	-	-	-	-	-	-	-	-	-
	(%)	(-)	(-)	(-)	(-)	(100)	(100)	-	-	-	-	-	-	-	-	-	-	-	-
Aus, B	Irr. A.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.17	-	0.17
	(%)	-	-	-	-	-	-	-	-	-	-	-	-	(-)	(-)	(-)	(100)	(-)	(100)
Aus, Sub-total	Irr. A.	-	-	-	-	1.82	1.82	-	-	-	-	-	-	-	-	-	0.17	-	0.17
	(%)	(-)	(-)	(-)	(-)	(100)	(100)	-	-	-	-	-	-	(-)	(-)	(-)	(100)	(-)	(100)
Aman, T, HYV	Irr. A.	-	-	-	-	3.24	3.24	-	-	-	-	-	-	-	-	-	0.12	-	0.12
	(%)	(-)	(-)	(-)	(-)	(100)	(100)	-	-	-	-	-	-	(-)	(-)	(-)	(100)	(-)	(100)
Aman, Sub-total	Irr. A.	-	-	-	-	3.24	3.24	-	-	-	-	-	-	-	-	-	0.12	-	0.12
	(%)	(-)	(-)	(-)	(-)	(100)	(100)	-	-	-	-	-	-	(-)	(-)	(-)	(100)	(-)	(100)
Boro, HYV	Irr. A.	0.30	0.25	12.62	0.04	22.30	35.51	-	-	-	-	-	-	1.31	0.08	3.03	0.75	-	5.17
	(%)	(0.8)	(0.7)	(35.5)	(0.1)	(62.8)	(100)	-	-	-	-	-	-	(25.3)	(1.5)	(58.6)	(14.5)	(-)	(100)
Wheat	Irr. A.	-	-	0.30	0.20	-	0.50	-	-	-	-	-	-	-	-	-	0.21	-	0.21
	(%)	(-)	(-)	(60.0)	(40.0)	(-)	(100)	-	-	-	-	-	-	(-)	(-)	(-)	(100)	(-)	(100)
Oilseeds	Irr. A.	-	-	0.06	-	0.36	0.42	-	-	-	-	-	-	-	-	-	-	-	-
	(%)	(-)	(-)	(14.3)	(-)	(85.7)	(100)	-	-	-	-	-	-	-	-	-	-	-	-
Pepper	Irr. A.	-	-	-	1.21	-	1.21	-	-	-	-	-	-	-	-	-	-	-	-
	(%)	(-)	(-)	(-)	(100)	(-)	(100)	-	-	-	-	-	-	-	-	-	-	-	-
Winter Vegetables	Irr. A.	-	-	-	-	0.10	0.10	-	-	-	-	-	-	-	-	-	0.18	-	0.18
	(%)	(-)	(-)	(-)	(-)	(100)	(100)	-	-	-	-	-	-	(-)	(-)	(-)	(100)	(-)	(100)
Potato	Irr. A.	-	-	-	0.07	-	0.07	-	-	-	-	-	-	-	-	0.12	0.56	-	0.68
	(%)	(-)	(-)	(-)	(100)	(-)	(100)	-	-	-	-	-	-	(-)	(-)	(17.6)	(82.4)	(-)	(100)
Sweet Potato	Irr. A.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-	0.02
	(%)	-	-	-	-	-	-	-	-	-	-	-	-	(-)	(-)	(-)	(100)	(-)	(100)
Rabi/Boro, Sub-total	Irr. A.	0.30	0.25	12.98	1.52	22.76	37.81	-	-	-	-	-	-	1.31	0.08	3.15	1.72	-	6.26
	(%)	(0.8)	(0.7)	(34.3)	(4.0)	(60.2)	(100)	-	-	-	-	-	-	(20.9)	(1.3)	(50.3)	(27.5)	(-)	(100)
Total	Irr. A.	0.30	0.25	12.98	1.52	27.82	42.87	-	-	-	-	-	-	1.31	0.08	3.15	2.01	-	6.55
	(%)	(0.7)	(0.6)	(30.3)	(3.5)	(64.9)	(100)	-	-	-	-	-	-	(20.0)	(1.2)	(48.1)	(30.7)	(-)	(100)

Irrigation Mean: DTW = Deep Tube Well, STW = Shallow Tube Well, LLP = Low Lift Pump, Ind. = Indigenous Ones, BWDB = BWDB Canal

Flood Depth: High = Never flooded, M.H. = 0 - 30 cm, M.L. = 30 - 90 cm, L. = 90 - 180 cm, V.L. = over 180 cm

Source: PIE Farm Household Survey

Figure 3.3 Cropped Area under Irrigation by Flood Depth and Season (MDIP)



	Total Cropped Area (ha)				Legend
	Whole Sea.	Rabi/Boro	Aus	Aman	
Protected	104.34	42.49	21.77	40.18	————
Unprotected	n.a.	n.a.	n.a.	n.a.	
Control	12.69	11.79	0.78	0.12	....

3.3.4 Hydrological Comparability of the Control Area

In order to test the appropriateness of the selected control area, and its reflection of without-project conditions, correlation coefficients between the impacted and the control areas under pre-project conditions have been worked out from the view points of the flooding and drainage situations. The results are summarised below:

Flood Depth (n=5)	: R = 0.947
Inundation Duration (n=8)	: R = 0.856

Although the numbers of tested samples are rather small, these correlation coefficients give satisfactory justification for selection of the control area in the farm household survey.

3.4 CONCLUSIONS ON HYDROLOGICAL IMPACT

From the evidence discussed above, it is clear that MDIP has been highly successful in achieving its hydrological objectives in both the monsoon and dry seasons. As such it is technically outstanding amongst the FCD/I project studied by FAP 12. The main queries regarding this achievement relate to its sustainability, and to whether the high level of technical achievement is economically optimal.

The sustainability of both inundation- free conditions in the monsoon, and of irrigation in the dry season, depends on pumping, for which the entire cost is at present met from general Government revenue. Unless a significant part of these costs can be transferred to the beneficiaries, a situation can be foreseen in which BWDB would have to curtail this drain on its scarce resources, and the main hydrological impacts would then be lost.

The issue of economic optimality has already been raised in respect of the probable over-use of free irrigation water, but it also requires examination in the context of drainage. A priori, the monsoon pumping regime should be adjusted on the basis of the benefits from the marginal reduction in depth of inundation. Since the cropping pattern by inundation depth can now be ascertained with some confidence, and there have now been three monsoon seasons in which to calibrate the pumping requirement for a given reduction in water depth, there should be no insuperable problem in designing such a regime. A related issue is that of carry-over of water from the late monsoon period into the early rabi season. The internal khals in MDIP have a significant water storage capacity, and provided they are not drawn down by unnecessary drainage pumping at the end of the monsoon, the stored water would reduce the subsequent requirement for irrigation pumping.

4 OPERATION AND MAINTENANCE

4.1 PRE-PROJECT SITUATION

Prior to the MDIP there was no flood protection and very little locally managed irrigation in the Project area. There appear to have been no local initiatives to prevent flooding by bunds; instead, agriculture was adjusted to the normal range of monsoon flooding and homesteads were on higher land such as the ridges in between the lower troughs and depressions. There was limited private irrigation, for example by LLP from the large khals in the area. Hence, there was no widespread experience of public involvement in water management on which the project could have built.

4.2 INSTITUTIONAL FRAMEWORK

4.2.1 Overview

Because the MDIP is a complex engineering Project involving complete flood protection, pumped drainage and a complex irrigation system (Chapter 2), the operation and maintenance of this Project could have been anticipated to be technically relatively complex to manage. This in turn would require a high level of coordination between main system managers and local water users. For efficient management of the MDIP a special institutional structure was suggested in the PP and by the consultants in the O&M manual (Chou Kaihatsu, 1985). This aimed at:

- efficiency in O&M including collection of water rates; and
- close coordination of agricultural activities through farmers organizations within the project area.

The new organizational set up was to come into force on completion of the project and was to include a Project Director and his staff along with local organizations in the form of committees at various levels.

The institutional structure proposed provided for a Project Coordination Committee at the Project level, an Upazila Committee at Upazila level, Union Irrigation Associations at Union level, and at the lowest level the Turnout Irrigation Associations (TIAs). The TIAs were to be the primary unit of organisation for beneficiaries with irrigation facilities, and were to be formed at each turnout. The number of turnout committees was to be around 408 in the whole project area of MDIP.

The committees were to be responsible for implementation and coordination of operation (strategies, plans and programmes) within the service area of the system. Details of specific responsibilities are given in the following sections.

4.2.2 Project Coordination Committee

The Project Coordination Committee (PCC) was to be responsible for overall agricultural development, including water management, mobilization of resources, and input services. The PCC was to meet at least once a month. The composition of the committee was to those include heads of various departments posted at the project level who are directly related to agricultural development, input supplies and grass roots level institution building. The PCC was made broad-based in terms of institutions and departments represented, and was to function under the chairmanship of a BWDB Project Director at the rank of Superintending Engineer.

4.2.3 Upazila Committee

The Upazila Committee was to be responsible for coordination among Union Irrigation Associations and for mobilization of agricultural inputs and credit, and was to hold meetings once a month. Since all of MDIP falls within Matlab Upazila the rationale for having a separate Project level committee and an Upazila level committee is unclear. While separate project level coordination might be necessary in a project spanning several Upazilas (as in three of the other projects investigated by PIE under FAP 12) in the case of MDIP there appears to be no difference between the Project and Upazila levels, since the relevant departmental staff are those posted in Matlab Upazila. The implication is that the two separate committees were constituted merely as a matter of protocol so that the SE would liaise with District level officials.

4.2.4 Union Irrigation Associations

The intended objectives and functions of the Union Irrigation Associations were:

- identification of water management problems, relating to irrigation, drainage, and wastage of irrigation water, and their solution;
- guidance to the beneficiaries on construction and maintenance of farm ditches, field channels and drains;
- to receive and settle claims from among the beneficiaries; and
- holding regular meetings twice a month.

4.2.5 Turnout Irrigation Associations

The Turnout Irrigation Associations (TIA) were to be the fundamental units for water management in the Project comprising farmers irrigating from a common turnout. Their responsibilities were to be:

- equitable distribution of water;
- excavation and maintenance of field channels;
- arrangement of agricultural credit;
- arrangement of minor repairs;
- resolution of disputes;
- preparation and execution of water distribution schedules; and

- realisation of water charges.

4.2.6 Institutional experience

As will become apparent in discussing actual O&M in MDIP, this institutional framework exists largely on paper. No additional resources have been available to assist in organising farmers into cohesive irrigator groups, and there is consequently no sense of ownership of the Project infrastructure, while the intended system of liaison and joint involvement in management between BWDB and local government appears not to have developed.

4.3 OPERATION AND WATER MANAGEMENT

4.3.1 Technical assessment

Most of the operational problems during the first four years of this project's life stem from problems in the planning and construction phases of this project, rather than from negligence in post-completion operation. These planning and construction problems have been discussed in detail in Chapter 2, so the implications for operation, resources and expenditures are merely highlighted here. The damages to the Project system in 1987 and 1988, particularly the irrigation infrastructure, meant that irrigation benefits could not be achieved as soon as intended, while for the first two years not only were there no benefits to monsoon cropping, but conditions were actually worse than normal. While the irrigation system has been steadily rehabilitated, the problems of the early years have had a disproportionate impact on operation and particularly on resource mobilisation. Because the system could not operate as planned and farmers lost their crops, charges could not be made for irrigation, establishing a precedent for provision of free water. Yet, the sustainability of this pumped system, which is dependent on electric power, rests on the ability of the project authority (BWDB) to raise revenue from farmers, since otherwise it will be a continual drain on central government funds.

Discussion with BWDB staff on the operation of Uddhamdi and Eklaspur pumping stations gave no evidence of serious drainage congestion in the project area. This situation is possible because the two primary pumping stations were designed to satisfy major drainage requirements. A visit to MDIP in the second week of September 1991 further confirmed the adequacy and satisfactory operation of the two main pumping stations at Uddhamdi and Kalipur. At that time all four pumps at Kalipur pump house and five out of six pumps at Uddhamdi pump house were operating for drainage purposes, and there appeared to be minimal drainage congestion in the project. Additionally, due to implementation of the project, the agricultural lands have been protected from flooding since 1988. If this continues, the local economy may be more secure and further development may be induced.

4.3.2 Institutional aspects

Efficient functioning of a project as complex as MDIP needs detailed operational and maintenance guidelines. An operation and maintenance manual was provided by the design Consultants (Chuo Kaihatsu 1989), but this is not a practical guide to O&M, nor does it give guidance on how to establish operating rules based on system performance and agricultural development. During the RRA it was found that the operating committee structure described above has not been implemented, while BWDB officials stated that they are not in a position to implement the manual so long as the institutional framework is not fully implemented.

However, in places private initiatives have been successful in fielding a good number of low lift pumps to make good the deficiencies of the damaged BWDB canal system. In one example, a committee has been formed under the leadership of a local Member of the Union Parishad to operate four low lift pumps (LLPs). The parties in the operation are:

- the maintenance contractor who supplies 4 LLPs;
- the Irrigation contractor who ensures water delivery;
- the revenue collector who collects water charges;
- the general members who receive irrigation water; and
- the committee which coordinates operations and supports debt recovery.

The members pay Tk.1200 per kani (1 kani = 0.40 acres) per season. The charges cover the cost of hire of the pumps, fuel and lubricating oil and repairs plus some profit for the operation.

This initiative, and numerous others in the same area, shows two things very clearly: first, the people are interested in and capable of organizing themselves for water management; and second, the beneficiaries are willing to pay for the service they receive. These examples should guide BWDB in implementing the O&M structures envisaged in the Feasibility Study, the PP and the O&M Manual.

A considerable effort will be needed to establish farmer groups and active representative committees to enable beneficiary participation in the decision making process of running the Project. This will require staff skills which do not appear to be present in the Project at present. The linkage needs to be established between system performance and farmer contributions to costs, and hence a sharing of responsibility for operation and maintenance of the Project.

4.4 MAINTENANCE

4.4.1 Technical assessment

Erosion of the embankment and subsequent retirement has already been discussed for the construction period. However, this is a continuing threat and results in major expenditures which should not be considered as normal maintenance: for example the casting of concrete blocks for embankment protection near Eklaspur in 1991 was expensive, and it arises only five years after project completion because of inadequate set back for such an erosive river as the Lower Meghna. It appears that erosion rates were not revised according to experience during the feasibility study and construction phases, the only response being to simply react to embankment loss by retiring the alignment and rebuilding. Moreover, there is every chance of embankment protection continuing to be a drain on resources in future years (both at Eklaspur near the pumphouse at Uddhamdi, for example).

A number of factors have been implicated in the two embankment failures all of which relate to implementation inadequacies (including site investigations). This had the immediate effect of requiring high rehabilitation and repair expenditures, but also leaves a risk of similar events later in the Project life. For example, it is possible that inadequate compaction will result in continuing risks and maintenance problems, since weak points require greater vigilance in monitoring than is usually exerted in BWDB projects, and both the physical capacity and the ability to provide funds at short notice for emergency repairs.

The repaired embankment has successfully withstood the 1989, 1990, and 1991 flood seasons, and on this evidence seems adequate to withstand the normal yearly floods caused by the Meghna and Dhonagoda rivers in the project area. The embankment has been repaired where breached and eroded, although as noted earlier there are medium (even short) term risks of continued erosion. Also the pumps seem to be effective for drainage. However, many of the internal channels (the irrigation canals in particular) remain to be reconstructed.

A programme was started in 1988 to rehabilitate the flood damaged works and also to strengthen and protect the flood embankment. The programme, which is scheduled for completion in 1991 (at a cost of Tk 280.7 million) was reported to be 60 percent complete in June 1990. It is expected to complete 100 percent of the work in the scheduled time. During visits to some sample areas of the project it was observed, and also confirmed by the local people, that much of the repair/rehabilitation work on the irrigation canal systems is of poor quality.

4.4.2 Institutional and social assessment

As noted in Chapter 2, some portions of the damaged irrigation canal system have been repaired or by the local people on their own initiative. However, local initiative does not extend to routine maintenance of the system, parts of which already show signs of deterioration and reduced capacity.

So far formal repair and rehabilitation have been funded from external sources. With the failure of the project in the first two years, farmers could hardly be expected to pay for O&M, but they have now been benefiting from the project for over two years. In the Feasibility Study it was estimated that the annual O&M cost would be US $300 (about Tk 11400 at late 1991 exchange rates) per hectare, and it was anticipated that the farmers in the project area would have to pay water charges which would cover fully all operation and maintenance costs. In addition, it was envisaged that after a period of income growth, farmers would be able to make a contribution to development costs.

As shown in Chapter 5 (Table 5.8), a farmer who has been able, due to the Project, to move from growing a single crop of B Aman to growing one crop of HYV Boro and one crop of HYV T Aman, has an incremental financial net return of some Tk.38,000 per hectare, after costing all inputs (including family labour and owned draught animals) at market prices. With benefits of this magnitude, it appears not unreasonable for farmers to cover O&M costs of the order envisaged in the Feasibility Report.

Farmers were intended to commence paying water charges in the season during which they were first supplied with irrigation water. However, in practice even after two years of full operation of the project BWDB has not put the Irrigation Associations in action, nor have the water charges been fixed or levied. This should be done immediately, but action on this front seems destined to fail unless linked with re-excavation of channels, a management plan, and participation by farmers in developing that plan.

Furthermore, if Irrigation Associations had a formal status they would have access to credit at lower interest rates than on the private market, and credit is important given the much higher input costs of HYV paddy cultivation. Experience in CIP has shown that irrigator groups cannot work as fully fledged cooperatives, but a special arrangement with the banks (which might be represented in project management) could help to avoid small farmers' benefits being redistributed to moneylenders.

Operation, management, maintenance and revenue collection all depend on beneficiary participation and functioning of committees. However, due to the previous setbacks the concern of BWDB is almost exclusively focused on protecting the embankment, and little attention is being given to the people's involvement in project management. The BWDB hierarchy also seems to be isolated from the local administration. In particular, the Upazilla chairman complained that in spite of written requests, BWDB's Sub-Divisional Engineer, who is Secretary of the Upazilla Irrigation Committee, has failed to call meetings of the Committee.

4.5 O&M COSTS

Data on O&M costs are only available for MDIP for three financial years: 1988-89 to 1990-91. However, this was an unusual period, given the major damages to the Project from the 1987 and 1988 floods, and given that irrigation was not functioning near its target level until the last of these years.

Table 4.1 summarises the O&M costs reported in these three years. It is not possible to estimate from these data what the normal level of maintenance costs will be. Even the mechanical maintenance figures may be inflated by repairs to damaged gates, although considering the high value infrastructure involved in the Project, relatively high mechanical maintenance costs can be expected. It is also apparent that establishment costs are high, averaging Tk 1442 per net cultivated hectare in 1990-91 (these establishment costs include BWDB colony running costs such as electricity). It seems clear that there is great scope for reducing establishment costs, and that this will be necessary if there is to be any hope of realising O&M costs from farmers. Hopefully, once rehabilitation is completed the staff allocated can be substantially reduced.

MDIP inevitably has high electricity costs since the pumps are intended for both drainage and irrigation. The monthly breakdown of these costs provided by BWDB suggests that irrigation pumping runs from about October to June inclusive, since the two booster pump stations (which are used only for irrigation) are operated in these months. However, these booster pumps incur substantial electricity costs in the off season (36 per cent of on-season costs in 1990-91); moreover, off season costs increased by 6.6 times between 1989-90 and 1990-91 when the peak irrigation season costs increased by only 3.7 times for the same two pumps. Detailed monitoring and adjustment of the operation of the pumps in relation to target water levels and the functioning of the system is required as there is probably scope to reduce these costs while still serving farmer's needs (see also Section 3.4 above).

Table 4.1 O&M costs (Tk million actual financial costs) of MDIP 1988-89 to 1990-91

Financial year	Establishment		Electricity	Maintenance	
	Civil	Mech		Civil	Mech
1988-89	6.20	5.62	8.21		4.98
1989-90	8.50	5.69	6.85	202.90	3.66
1990-91	15.85	4.88	11.17		2.83

Note: civil maintenance refers to all flood damage repair works during the three years
1990-91 civil establishment includes electricity for BWDB buildings (presumably not pump houses)

Source: BWDB unpublished data, SE (MDIP), Chandpur, 21/10/91.

Overall the reported O&M costs amount to about Tk 2417 per net cultivated hectare in 1990-91 financial prices, which is very high. While there is room to reduce these costs, for example by reducing staff numbers once the system is rehabilitated, these figures make no allowance for routine civil maintenance - that is embankment, khal and canal maintenance and maintenance of civil structures. It is likely that these costs will be very substantial on average, and that this will more than outweigh any saving on other costs which can be achieved. Moreover, there is a high probability that continued non-routine works,such as embankment protection works, will be needed to protect the investment, and these costs have not been allowed for. It is essential that routine maintenance costs are estimated and programmed on the basis of the actual infrastructure and relevant maintenance experience, so that the financial implications of the Project are properly understood.

4.6 LESSONS

The organisational problems of MDIP reflect a more deep-seated problem of BWDB attitudes towards project development. BWDB follows a technical approach which emphasises the attainment of physical targets over the social aspects of development, and frequently appears to adopt a proprietary attitude towards projects which excludes the participation of other institutions. The social aspects however cannot be ignored, since long-term sustainability depends on involving the beneficiaries in the decision making process, especially as regards water distribution, fixing and collecting water rates, and settling disputes.

O&M has been handicapped by problems of project planning and implementation, which indicate that better pre-implementation studies are required. There is no liability on the bodies responsible for such failures to compensate those adversely affected, either permanently (loss of livelihood of fishermen and boatmen, for example) or periodically (people whose crops and homes are flooded) by avoidable embankment failures.

There are opportunities to lease out project infrastructure, particularly borrow-pits for fish cultivation, which would help to mitigate a major negative impact and could benefit the landless or ex-fishermen.

It is unlikely that water charges will be realised effectively when the provision of water and benefits have been so mixed, and farmers have come to expect water to be available free of charge. Agreement to pay fees needs to be achieved during intensive pre-completion (preferably pre-project) discussions accompanied by group formation, not tacked on after the project is built, which is the best that can now be hoped for at MDIP.

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5 AGRICULTURE

5.1 INTRODUCTION

The Meghna-Dhonagoda Irrigation Project (MDIP) is situated in Matlab Upazila of Chandpur District in south-eastern Bangladesh. It is a combined Flood Control, Drainage and Irrigation (FCD/I) project. The project has a gross area of about 17,600 ha. of which about 78 per cent is cultivated. The area is low, flat and alluvial delta, with elevation varying from 1.5 to 4.0 metres (Survey of Bangladesh datum) above mean sea level. There is very little land above 4 metres elevation. The higher areas are mostly artificially raised mounds on which homesteads are built. The rim of the area is slightly higher than the inside. Agricultural land is divided into innumerable small plots, heterogeneous in shape and size. All available lands are cultivated and there is almost no land that remains fallow for the whole year.

Pre-project, almost the entire area would go under 4-10 ft. of water for a period of 4-5 months (June-October). The water level in the Meghna and the Dhonagoda rivers starts rising from early April and the rate accelerates rapidly from mid May. Overflowing river waters would then start entering the project area threatening the Rabi crops harvest and Aus/Aman plantating. In November when the south-west monsoon is replaced by the north-east wind, the water level started decreasing at a rather rapid rate and left the project area dry till March. Moisture limitations, in the absence of any integrated irrigation system being developed before the project, limited Rabi cultivation during the period in the area. Boro/rabi crops were cultivated only in low lands utilizing residual soil moisture or by irrigating the land through indigenous methods (lifting water from ditches and khals manually).

The Project area being mainly low-lying with periods both of flooding and moisture deficit every year, there prevailed a situation of uncertainty in respect of land utilization and cropping during the pre-project period. Within each land type, there was little variation in cropping pattern. Paddy was the most important crop, but was restricted to about 50-60 per cent of the total annual cropped area. Local B. Aman was the major variety occupying about 45 per cent of the total cultivable land; followed by B. Aus + Aman mixed occupying little more than 30 per cent of the cultivable land. The other Kharif crop which had some significance was jute. Boro paddy cultivation was rather restricted due to moisture stress. It was cultivated only in 12 per cent of the total cultivable land (Feasibility Study, 1977, CIRDAP, 1987 and RRA, 1991).

Pre-project cropping intensity was estimated at 147 per cent (Feasibility Report, 1977), but the more detailed CIRDAP survey, undertaken 10 years later (in 1987), estimated it at 173 per cent. It is likely that in the interim there had been some growth of minor irrigation in the locality which had facilitated increased cropping intensity.

However, flooding every year, uncertainty of early monsoon rain, and lack of irrigation facilities all together depressed the overall yield of paddy crops. The weighted average yield of all types of paddy is stated by the PP to have been about 1.27 mt./ha. in the Project area under the pre-project situation, but comparison with both the CIRDAP baseline survey and with FAP 12 data for the without-project situation indicates that this may have been a serious underestimate. Yield rates of non-paddy crops (mostly rabi crops) were also low (CIRDAP, 1987).

5.2 PROJECT OBJECTIVES AND TARGETS

With the back-drop of the gloomy agricultural scenario presented above, MDIP was undertaken with multipurpose objectives which included flood control, irrigation and drainage to attain agricultural development. The aim was to boost agricultural production in the shortest possible time. On full completion the Project was expected to:

- prevent monsoon flood and reduce drainage congestion to intensify monsoon crop cultivation;
- provide year-round irrigation to an area of about 14370 ha.;
- facilitate extensive cultivation of Boro (specially HYV Boro) and Rabi crops during the dry season;
- introduce high yielding varieties of paddy and thus increase production;
- contribute to the country about 42,106 metric tones of additional paddy annually;
- increase cropping intensity from 147 per cent to 193 per cent;
- provide additional employment opportunities of about 6.3 million man-days annually;
- increase farmers' income by about 140 per cent;
- achieve an estimated net incremental benefit of Tk. 219.82 million per annum from agriculture.
  (See ADB, 1977 and Revised/Recast P.P, 1988).

5.3 PROJECT IMPACTS ON AGRICULTURE

In order to create a favourable environment for increasing crop (mainly paddy) production through using high yielding cultivars as well as increasing cropping intensities, MDIP was constructed to alleviate the impact of two major constraints on agriculture, namely flooding and moisture deficit. The present section of this study evaluates the successes (also failures) of the Project in agriculture. The decisive major indicators are: change in cropped area, cropping pattern, extent of HYV paddy cultivation, cropping intensity, crop yield rates, crop production and output, use of crop inputs, and net return from agriculture.

To assess project impacts a 'control' area (comparable to the without project situation) was selected from outside but adjacent to the project area, to compare with project situations. The same structured questionnaire was conducted both in the impacted and the control areas and the results compared to arrive at "with and without project" assessments.

5.3.1 Crops, Cropping Pattern and Cropping Intensity

a) Crop Areas

There are two ways in which an FCD/I project like MDIP might change cropped areas: by bringing previously uncultivated areas under cultivation (impact on net cultivated area), and/or by changing the seasons in which land is cultivated (impact on gross cropped area and cropping intensity).

In MDIP, overall there has not been an increase in net cultivated area since all the cultivable land in the project area was already cultivated in at least one season before FCD/I was provided. The Project has, however, very successfully changed the incidence of seasonal cropping. Land cultivation in both the Aus season and the Boro season has increased significantly in the impacted area due to the Project. Aman cropping has not, however, been decreased. The Project thus has effectively led to intensified cultivation in the impacted area as it now protects crops from flood damages. During the Kharif-I (Aus and Jute cropping) season, moisture deficits prevailed on higher land in the early part of the season (especially for paddy) while in the later part of the season crops on lower land were threatened by rising flood water. The Project pumping stations broke both these constraints, by providing irrigation during the early part of the season and by preventing inundation at the end. Farmers have fully exploited the opportunity this has provided. The extended cultivated lands are mostly low and medium low land classes. The RRA shows more than 150 per cent increase in land cultivation for Aus paddy crops in the impacted area compared to the pre-project situation. The PIE data are in great agreement with the RRA findings. Compared to the control area the impacted area cultivates more than four times more land for Aus paddy (most of which is T. HYV and B. HYV), and three times more land if jute is included (Table 5.1).

The Project has not changed the Aman season cropping intensity. The area of land under Aman cultivation has effectively remained the same compared either to the pre-project situation (RRA) or with the control area (Table 5.1). Nevertheless, Aman remains the most important crop season both for the impacted and the control areas. The project has, however, successfully impacted the cropping pattern and yield rates in the season in the impacted area (see sub-sections 5.3.1 (b) and 5.4 below).

Although expansion of Boro does not always imply an increase in winter cropping intensity, this has been the case with the MDIP area. The project now makes gravity irrigation available to most of the targeted area (10500 ha. against a targeted area of 14370 ha., estimated during the RRA). Water is therefore no longer a constraint for dry season cropping. People now cultivate most of the cultivable very low lands (69 per cent), medium low lands (65 per cent), medium high lands (75 per cent), and even high lands (57 per cent) for HYV Boro paddy in the impacted area while in the control area farmers cultivate less than 20 per cent of the cultivable lands (over all elevation levels) for paddy in the season (Table 5.1). The result is that the farmers in the impacted area cultivate about 11 times more land for Boro compared to the pre-project situation (RRA), and more than three times higher compared with the control (Table 5.1). These positive changes are attributable particularly to the irrigation component of the MDIP.

Overall, Rabi/Boro crops are cultivated in about 69 per cent of cultivable land both in the impacted and in the control areas. Although there is no difference in the percentage of land cultivated in the season, what is important to stress is Project impact on crop choices (impact on cropping pattern). The impacted area produces more productive and more profitable HYV Boro in 85 per cent of the cultivated land in the season (excluding sugarcane) while the control area uses about 71 per cent of the cultivated land for less productive Rabi crops including wheat and potato (Table 5.1). This suggests that the Project's objective of facilitating extensive cultivation of Boro, specially HYV Boro, has been greatly achieved.

Table 5.1 Crops and Crop Areas: Percentage Distribution of Cultivable Land by Levels

Crops	Impacted						Control					
	HL	MH	ML	LL	VL	All levels	HL	MH	ML	LL	VL	All levels
Aus Season												
B. Aus LV	7.5	-	22.4	-	-	7.1	-	53.1	1.1	0.6	0.8	1.3
T. Aus LV	1.0	3.6	2.0	-	-	1.4	-	-	-	-	-	-
B. Aus HYV	13.4	8.3	16.0	3.7	-	11.8	-	-	-	-	-	-
T. Aus HYV	38.3	48.2	20.4	-	-	33.8	-	-	-	-	-	-
B. Aus+Aman mixed	-	1.3	1.2	43.7	-	4.0	-	-	9.2	17.4	3.6	11.9
Jute	3.8	3.3	2.3	3.0	20.2	3.9	100.0	-	5.3	7.7	6.6	7.1
Sub-total: Aus season	**64.0**	**64.7**	**64.3**	**50.4**	**20.2**	**62.0**	**100.0**	**53.1**	**15.6**	**25.7**	**11.0**	**20.3**
Aman Season												
B. Aman LV	0.7	-	1.1	6.9	24.5	1.8	-	-	55.9	51.5	79.4	59.8
T. Aman LV	7.2	6.1	0.9	-	-	5.6	-	-	1.4	5.2	-	3.1
T. Aman HYV	66.3	76.5	84.0	5.0	-	61.9	-	37.5	-	6.2	-	3.8
B. Aus+Aman mixed	-	1.3	1.2	43.7	-	4.0	-	-	9.2	17.4	3.6	11.9
Sub-total: Aman Season	**74.2**	**83.9**	**87.2**	**55.6**	**24.5**	**73.3**	**0.0**	**37.5**	**66.5**	**80.3**	**83.0**	**78.6**
Boro/Rabi Season												
Boro LV	-	-	-	4.6	-	0.4	-	-	-	-	-	-
Boro HYV	56.7	74.6	65.3	9.1	68.7	56.5	-	-	12.9	23.9	16.7	19.9
Wheat	2.6	-	-	3.7	-	2.0	-	25.0	19.0	14.2	18.9	16.4
Potato	0.1	0.7	-	-	-	0.2	-	-	20.7	12.0	5.7	11.1
Oilseeds	7.2	4.9	-	9.6	12.9	6.5	-	-	-	5.6	5.5	4.7
Others	4.2	-	0.6	1.9	4.9	3.1	100.0	28.1	16.8	16.1	16.0	16.4
Sub-total: Boro/Rabi Season	**70.8**	**80.2**	**65.9**	**28.9**	**86.5**	**68.7**	**100.0**	**53.1**	**69.4**	**71.8**	**62.8**	**68.5**
Perennial												
Sugarcane	3.4	-	-	-	-	2.2	-	-	-	-	-	-
Total Cultivable Land (ha.)	**41.51**	**9.40**	**6.51**	**5.40**	**1.63**	**64.45**	**0.04**	**0.32**	**3.58**	**14.61**	**8.01**	**26.56**
Total Cropped Land (ha.)	89.68	21.50	14.16	7.12	2.14	134.60	0.08	0.46	5.42	25.95	12.56	44.47
Cropping Intensity (%)	216	229	218	132	131	209	200	144	151	178	157	167

Source: FAP 12 PIE Household Survey

Note: HL = High Land (flood free), MH = Medium High Land (flooding up to 1'), ML = Medium Low Land (flooding 1'-3'), LL = Low Land (flooding 3'-6'), VL = Very Low Land (flooding 6'+)

b) Cropping Pattern

The Meghna-Dhonagoda Irrigation Project has very favourably affected extensive cultivation of paddy at the expense mainly of jute (in Kharif-I), and wheat, potato, pulses and other rabi crops (in the Boro/Rabi season). The dominance of paddy in the cropping pattern is clear from the fact that paddy occupies more than 90 per cent of the annual gross cropped land against only about 67 per cent in the control area (Table 5.2). The RRA reports over 89 per cent of land under paddy (over all seasons and all crops), post-project, compared to only 49 per cent under the pre-project situation. This extension in paddy cultivation has occurred mainly in Boro/Rabi and Kharif-I, the previous moisture deficit seasons, mainly due to the irrigation component of the Project. Irrigation now facilitates timely land preparation for Aus and supplies required water for Boro crops. Alleviation of flood damages to Aus crops at harvest time in the impacted area (excluding the areas of severe breaches due to erosion) due to the embankment and the provision of pumped drainage, has also facilitated extension of Aus paddy cultivation through reduction of previous seasonal fallow land.

Table 5.2 Cropping Pattern
(% of Gross Cropped Land)

Crops	Impacted	Control	Pre-project[1]
B. Aus LV	3.4	0.8	0.4
B. Aus HYV	5.6	-	-
T. Aus LV	0.7	-	-
T. Aus HYV	16.2	-	-
Jute	1.9	4.2	12.1
B. Aus/Aman mixed	3.8	14.2	30.3
B. Aman LV	0.9	35.7	44.8
T. Aman LV	2.7	1.8	-
T. Aman HYV	29.6	2.3	-
Boro LV	0.2	-	4.8
Boro HYV	27.0	11.9	7.6
Wheat	1.0	9.8	-
Potato	0.2	6.6	-
Other Rabi Crops	5.8	12.7	-
Sugarcane	1.0	-	-
Total (%)	100.0	100.0	100.0
Gross Cropped area (ha.)	134.60	44.47	n.a.

Source: FAP - 12 PIE Household Survey
Note: [1]See Feasibility Study, Vol. 1, 1977

In addition to strengthening the dominance of paddy in the cropping pattern, MDIP has also been successful in inducing varietal changes within the paddy cropping pattern, particularly from local to HYV varieties and from broadcast to transplanted varieties. The irrigation component of MDIP seems to have strengthened the dominance of HYVs even within the newly evolved paddy cropping patterns in every season - monsoon or Boro. The availability of ample irrigation facilities, effectively with no cost, and reduction in flood losses due to the Project have significantly promoted the cultivation of T. HYV Aus, B HYV Aus, T HYV Aman, and HYV Boro in the project impacted area. Aus crops - broadcast or transplanted, local or HYV - are basically new introductions in the impacted area. These crops are almost non-existent in the control area (see Table 5.2). Farmers have now started cultivating these high yielding crops instead of the lower-yield, lower-cost B. Aman and mixed B. Aus/Aman, because of the Project. Among the Aman crops T HYV Aman is the most prominent crop in the impacted area while local B Aman is the most important one in the control area. This suggests that the project has been successful in reducing flood losses effectively. The Aman season had traditionally been a deep flood season.

Overall MDIP has led to a significant shift to T. HYV Aus and marginally to B HYV Aus from the traditional mixed B. Aus/Aman, local B. Aus, Boro LV and jute; to T. HYV Aman from local B Aman; and to HYV Boro from LV Boro, wheat and few other Rabi crops. In general, the increased and/or newly introduced crops involve more production costs (and therefore more risk) compared to the displaced ones, but the prevailing more stable crop environment due to the Project now encourages the farmers of the impacted area to grow these costlier varieties because they bring higher yields and higher returns. However, keeping aside the question of financial benefits from the changed cropping patterns, the comparative gains (or losses) in terms of their nutritional contents (both for humans and livestock) remain to be assessed.

c) HYV Paddy Concentration

One of the main objectives of MDIP was to introduce high yielding varieties of paddy over all seasons, particularly in the Boro season, and thus increase production. The present survey indicates that this objective has been achieved with great success. In the MDIP impacted area reduced variation in monsoon conditions and protection from flood damages have greatly encouraged the farmers to adopt HYV Aus (both transplanted and broadcast) and to extend T HYV Aman Cultivation. Boro HYV cultivation has been extended mostly because irrigation water is now available due to the project. However, all the HYV paddy crops are produced mostly in high, medium high and medium low classes of lands. HYV Boro is produced also in the very low land class (Table 5.1). Overall, HYVs in the impacted area occupy 78.50 per cent of cropped land, and 87.12 percent of land cultivated for all types of paddy over all seasons against only 14.19 per cent and 21.26 per cent respectively in the control area (Table-5.3).

Table 5.3 HYV Paddy Concentration

Crops	% of Cultivated land for paddy		% of gross cropped land	
	Impacted	Control	Impacted	Control
B. Aus HYV	6.3	-	5.6	-
T. Aus HYV	18.0	-	16.2	-
T. Aman HYV	32.9	3.5	29.7	2.3
Boro HYV	30.0	17.8	27.0	11.9
All HYVs (%)	87.2	21.3	78.5	14.2
Total Land (ha.)	121.29	29.68	134.60	44.47

Source: FAP - 12 PIE Household Survey

d) Cropping Intensity

It has already been mentioned that the irrigation component of MDIP has successfully broken the soil moisture constraint in the Boro and Aus seasons. As a result, paddy intensity has increased significantly (about 80 percentage points higher than the control area). This has however been partly offset by reduced areas of non-paddy crops resulting in an annual intensity of 209 per cent in the impacted area against 167 per cent in the control area (Table 5.1). The intensity has increased mainly in the high, medium high and medium low land classes, part of which remained fallow either in Aus or in Boro season or in both before the project was implemented, presumably due to moisture stress. Overall the Project has been successful in achieving the targeted annual cropping intensity of 193 per cent (in fact 16 per cent more than the target).

5.3.2 Crop Yields

Increases in average yield following flood protection with irrigation arise mainly from three factors: a switch to transplanted varieties and/or to HYVs, increased use of crop production inputs given lower perceived risk of crop failure, and reduced annual or periodical losses due to flood. In MDIP all these have been identified as significant. Farmers in the impacted area have changed the pre-project cropping pattern almost completely and have now replaced the local varieties by HYVs in most cases (see sub-section 5.3.1 (b)). Input use, particularly the use of chemical fertilizer, has increased significantly, especially in the case of HYV crops and local T. Aman (see sub-section 5.3.4). All these factors together have raised paddy yield considerably. The project impacted area now harvests 4.37 mt./ha., on weighted average over all seasons, against only 2.52 mt./ha. in the control area. The yields of T. Aman LV and T. HYV Aman are double or even more than double for a given land level inside the project compared with the control, which is consistent with the Project's providing greater security from fluctuations in water levels during an approximately normal year. Better harvests in the case of Aus as well as Aman within the project area also reflect the benefits of controlled drainage.

In general the transplanted paddy varieties and the HYVs compared to the broadcast or local varieties yield double or in some cases three times more per hectare at a given level of land (Table 5.4). Thus the higher weighted mean paddy yields (4.37 mt./ha.) compared to either the pre-project situation (1.27 mt./ha., estimated in PP) or the control area (2.52 mt./ha.) is because of farmers' switching over to more productive types of paddy as the hydrological conditions changed sufficiently to permit this in the project area due to the MDIP.

The impact of the project is not clear in case of non-paddy crops, except that many of them have been either totally or greatly displaced by paddy. This is so mostly because the comparative net return from paddy is higher if a safe yield is assured. So, the yield difference, positive or negative, of whatever non-paddy crops are still produced is of little significance in the context of the total project impact assessment. However, in terms of yields per hectare the project area has a slightly higher advantage in the case of certain spices (e.g. Chilli), oilseeds and jute) over the control area. In the case of potato, including sweet potato, and winter vegetables, the control area gets a better yield compared with the impacted area. They produce these crops in medium low to very low lands which retain moisture even in the dry season. In the impacted area, conversely, these classes of lands are used mostly for paddy, particularly Boro paddy in the dry season, as ample irrigation water is now available due to the project.

Table 5.4 **Crops and Crop Yield Per Hectare by Land Levels**
(Metric Tonnes)

Crops	Impacted						Control					
	HL	MH	ML	LL	VL	All levels Av.Yield	HL	MH	ML	LL	VL	All levels Av.Yield
Paddy Crops												
B. Aus, LV	1.95	-	2.38	-	-	2.08	-	2.19	2.05	0.92	3.07	2.04
B. Aus, HYV	3.50	4.09	3.47	4.61	-	3.59	-	-	-	-	-	-
T. Aus, LV	2.80	3.04	3.46	-	-	2.99	-	-	-	-	-	-
T. Aus, HYV	4.25	3.84	5.24	-	-	4.22	-	-	-	-	-	-
B. Aus/Aman, Mixed	-	3.07	2.05	0.92	-	1.71	-	-	1.69	1.04	1.43	1.14
B. Aman, LV	1.23	-	1.54	1.68	2.58	1.87	-	-	2.47	2.04	1.92	2.04
T. Aman, LV	3.35	3.00	4.30	-	-	3.31	-	-	1.54	1.27	-	1.29
T. Aman, HYV	4.47	4.31	4.60	6.08	-	4.66	-	3.07	-	2.76	-	2.80
Boro LV	-	-	-	3.15	-	3.15	-	-	-	-	-	-
Boro HYV	5.10	5.25	4.45	6.27	4.03	5.04	-	-	5.60	4.14	4.98	4.47
All Paddy (weighted av.)	**4.38**	**4.44**	**4.13**	**1.81**	**3.65**	**4.37**	**1.54**	**2.55**	**2.74**	**2.16**	**2.39**	**2.52**
Non-paddy Crops												
Jute	1.36	1.21	1.45	1.38	0.68	1.26	-	-	0.93	0.68	2.10	1.02
Wheat	2.04	-	-	1.47	-	1.96	-	0.17	2.35	1.77	2.22	1.98
Potato	7.90	10.85	-	-	-	9.52	-	-	17.03	17.57	17.23	17.38
Sweet Potato	11.93	-	-	-	-	11.93	-	-	15.37	-	-	15.37
Pulses	-	-	-	-	-	-	-	-	1.04	0.98	0.74	0.90
Oilseeds	0.74	0.49	-	1.01	0.65	0.74	-	-	-	0.39	0.67	0.49
Chilli	1.39	-	0.07	0.22	0.23	1.21	-	-	0.93	0.47	0.36	0.58
Other Spices	-	-	-	-	-	-	-	-	-	0.46	-	0.46
Winter vegetables	1.47	-	-	-	-	1.47	0.51	16.76	13.44	3.62	7.28	7.98
Fruits	-	-	-	-	-	-	-	-	-	15.37	-	15.37
Sugarcane	32.80	-	-	-	-	32.80	-	-	-	-	-	-
Others	1.09	-	-	-	-	1.09	-	23.04	-	0.58	0.29	4.92

Source: FAP - 12 PIE Household Survey

5.3.3 Crop Production and Output

As indicated earlier paddy is by far the most important crop in the cropping pattern of the MDIP impacted area. Cultivation of diversified crops is not practised, presumably because of extensive adoption of high yielding varieties of paddy crops - Aus, Aman and Boro alike. The major indicator of the Project impact on production is therefore the change in paddy output. Compared to the control area the impacted area produces over 73 per cent more paddy per hectare per year, on average. This higher rate of production is the result of decreased flood losses and varietal changes in favour of HYVs, within the paddy cropping pattern which the project has made possible. Production and yield differences of paddy crops are shown in Table 5.5. The table shows that the major difference in output is made by all the Aus crops (excluding local B. Aus), and T. Aman (both LV and HYV), and HYV Boro. This demonstrates the success of the irrigation component of the Project (in Aus and Boro seasons) and its flood protection and controlled drainage facilities (particularly for Aman crops).

Table 5.5 Paddy Crops and Output

Paddy	Impacted			Control			Yield difference/ha.	
	Cultivated land (ha.)	Total output (mt.)	Yield/ha. (mt.)	Cultivated land (ha.)	Total output (mt.)	Yield/ha. (mt.)	mt.	%
B. Aus LV	4.58	9.53	2.08	0.35	0.71	2.04	+0.04	+1.96
B. Aus HYV	7.59	27.25	3.59	-	-	-	-	-
T. Aus LV	0.88	2.63	2.99	-	-	-	-	-
T. Aus HYV	21.77	91.87	4.22	-	-	-	-	-
B. Aus/Aman mixed[1]	2.40	4.10	1.71	3.16	3.60	1.14	+0.57	+50.00
B. Aman LV	1.15	2.15	1.87	15.88	32.40	2.04	-0.17	-8.33
T. Aman LV	3.63	12.02	3.31	0.81	1.05	1.29	+2.02	+156.59
T. Aman HYV	39.91	185.98	4.66	1.02	2.87	2.80	+1.86	+66.43
Boro LV	0.25	0.79	3.15	-	-	-	-	-
Boro HYV	36.39	183.41	5.04	5.29	23.65	4.47	+0.57	+12.75
All	118.55	519.73	4.37	26.51	64.28	2.52	+1.85	+73.41

Source: FAP 12 PIE Household Survey
Note: [1]For yield rate estimate the land under the crop is considered for either of the seasons.

Output changes are also influenced by intensity changes. In MDIP there has been a significant change in cropping intensity due to the project (see sub-section 5.3.1(d)). Overall the 'with' and 'without' project estimates show an increase of 74310 mt. of paddy per annum due to the project, which is almost double the additional quantity targeted at the inception of the Project (42106 mt./yr.).

Table 5.6 Paddy Output: With and Without Project Estimates

	Output (mt.)
With Project	113109
Without Project	38799
Difference	74310
% Change	191

Note: The estimates are made extrapolating per hectare annual paddy yields with benefited annual paddy cropped land due to the project.

5.3.4 Crop Production Inputs

It has already been seen that the MDIP has achieved considerable success in protecting crops from flood damage and making irrigation water available at an appropriate time to most of the project benefited areas. As a result, the farmers in most cases have increasingly adopted the high yielding varieties of paddy which in general require more production inputs compared to local varieties. The farmers in the Project area spend about Tk. 700 more per hectare, on a weighted average, for paddy production, than their counterparts in the control area. Most of the farmers in the impacted area get irrigation water from MDIP free. If a standard irrigation water cost were included this difference would become much higher.

The impacted area farmers use about 122 per cent more chemical fertilizers, about 13 per cent more human labour and about 39 per cent more animal labour than the control area farmers (Table 5.7). HYV paddy varieties grown in both areas (HYV T. Aman and HYV Boro) receive similar levels of inputs, but some local varieties show evidence of input intensification in the impacted area, especially in fertilizer use (B. Aus LV and T. Aman LV). The inference is that control area farmers confine HYV cultivation to areas where their high investment is safe, while growing local varieties in the riskier areas with input rates adjusted accordingly. It follows that FCD measures can produce some impact on intensification even where there is not widespread adoption of HYVs (in agreement with other FAP 12 studies, e.g. the PIE of Kolabashukhali Project).

The average irrigation cost in the case of Boro HYV (the only irrigated crop produced in the control area) is about 2.5 times more (Tk. 2400/ha.) in the control area than in the impacted area. This is because BWDB does not make any charge for water supply by its pump houses, and the impacted area farmers exploit this benefit to the full. Control area farmers, however, have to pay for water from LLPs and DTWs.

5.3.5 Value of Crop Output and Net Return

The annual aggregate net output value of paddy crops, including the value of by-products, is more than 6 times higher in the project area than in the control area. The cost and return ratio is 1:3.63 in the impacted area against only 1:1.45 in the control area. The impacted area, however, uses more inputs, particularly modern inputs such as chemical fertilizers and pesticides (see Table 5.7), and is therefore expected to reap higher output value. However, the proportionate increase in output value is much higher than the increase in input costs (the incremental cost and return ratio being 1:28), indicating that the farmers in the impacted area now enjoy greater security (against flood losses) and their present cropping pattern, with increasing importance on adoption of HYV technology, utilizes inputs more productively.

Overall, the difference in net return to all crops, paddy or non-paddy, is positive (ranging from Tk. 600/ha. in wheat to Tk. 11500/ha. in T. HYV. Aman) in the impacted area, excepting potato, sweet potato and winter vegetables, in the case of which the control area has an absolute advantage. Nevertheless, the impacted area farmers were not found to incur financial losses in any of these crops although these are now very minor crops in the area and people have, in general, replaced them by more productive Boro paddy crops, wherever possible.

Table 5.7 Crop Production Input Use per Hectare

Crops	Impacted								Control							
	Seeds/ seedlings (Tk.)	Human labour (m-d)[1]	Animal labour (p-d)[2]	Chemical Fertilizer (kg.)	Manure (md)	Pesticide (kg.)	Irrigation water (Tk.)	Total input cost (Tk.)	Seeds/ seedlings (Tk.)	Human labour (m-d)[1]	Animal labour (p-d)[2]	Chemical Fertilizer (kg.)	Manure (md)	Pesticide (kg.)	Irrigation water (Tk.)	Total input cost (Tk.)
Paddy Crops																
B. Aus LV	647	64	22	271	-	-	-	6526	813	107	17	129	-	-	-	6959
B. Aus HYV	818	93	14	184	-	3	-	6761	-	-	-	-	-	-	-	-
T. Aus LV	519	118	20	212	-	1	-	7941	-	-	-	-	-	-	-	-
T. Aus HYV	772	117	18	411	2	4	4	9344	-	-	-	-	-	-	-	-
B. Aus/Aman mixed	564	67	23	40	3	-	-	4900	594	59	17	74	19	1	-	3866
B. Aman LV	754	114	19	71	6	3	-	7294	808	90	12	71	6	-	-	5508
T. Aman LV	1128	112	8	238	-	3	-	7334	726	157	21	148	-	-	-	7076
T. Aman, HYV	704	112	18	408	1	4	34	9063	482	104	19	426	-	-	-	8155
Boro, LV	823	79	15	39	-	-	-	3803	-	-	-	-	-	-	-	-
Boro, HYV	702	124	15	488	2	5	1623	11238	743	138	15	492	9	5	4023	14165
All Paddy Crops	**732**	**115**	**18**	**381**	**2**	**4**	**510**	**8491**	**753**	**102**	**13**	**172**	**8**	**1**	**803**	**7807**
Non-paddy Crops																
Jute	382	121	23	246	2	2	-	8394	393	103	12	238	14	2	-	6569
Wheat	1299	87	15	257	-	-	463	7673	1413	99	15	355	10	-	-	8424
Potato	6693	124	31	506	-	-	-	19382	9793	166	19	1461	12	8	84	26119
Other Rabi Crops	850	125	15	275	6	-	-	6328	825	53	17	362	-	3	-	4812
Sugarcane	5293	198	12	385	-	2	-	17885	-	-	-	-	-	-	-	-

Source: FAP - 12 PIE Household Survey
Note: [1]m-d man-days, [2]p-d pair-days

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In the case of per hectare return to individual crops, the difference is highest in T. Aman, (both HYV and LV), followed by HYV Boro. In the case of T. HYV Aus and B. HYV Aus, the project area has an absolute advantage over the control area. From agriculture as a whole the impacted area enjoys about Tk. 16,800 more in net returns per hectare of cultivated land at 1990-91 local prices.

Mention should be made that in estimating the output values the same prices have been used for both the impacted and the control areas, to avoid possible distortion of the comparison. Family labour and family animal labour have been costed at the local market rates. The lower return in the control area demonstrates that such labour is poorly rewarded compared to its counterpart in the impacted area. The returns (benefits) shown above for the impacted area would however go down slightly if the farmers there had to pay at a standard rate for irrigation water. This would not however change the trend of conclusions arrived at.

5.3.6 Concluding Remarks

a) Project Successes

MDIP has resulted in a very large growth in paddy output, estimated at some 75000 mt. annually (Table 5.6), which has transformed the area from rice deficit to rice surplus. Mean yield over all types of paddy is about 4.4 mt./ha., which is about 2 mt. higher compared with 2.5 mt./ha. in the control area, and about 3 mt. higher compared with Feasibility Report estimates (1.27 mt./ha.). The cropping intensity for paddy is also about 80 per cent higher than in the control area. The overall cropping intensity is over 40 per cent higher than in the control area (209 per cent against 167 per cent), and over 60 per cent higher than the pre-project situation (209 per cent against 147 per cent). The yield increase is associated with the replacement of B. Aman and Aus/Aman by HYV Aman, and of Boro LV by Boro HYV. The gains in intensity have taken place largely in the Aus season, with introduction of an HYV Aus crop; in an interesting indigenous farming system development, some farmers are sowing HYV Aus broadcast to minimise time and cost requirements. The Project area is at present almost a paddy monoculture (paddy occupies more than 90 per cent of the annual cultivated land), which accurately reflects the financial returns to production of paddy and non-paddy crops when water is free, as it is to the majority of the MDIP farmers.

The Project successes may, however, be summarised as follows:

- change in cultivated area : +205 per cent in Aus; no effective change in Aman or Boro seasons;
- change in cropping pattern : introduction of B. HYV Aus and T. HYV Aus; significant shift to T. HYV Aus from B. Aus LV, and to HYV Aman from B. Aman and Aus/Aman mixed; and to Boro HYV from Boro LV and wheat;
- change in cropping intensity : +ve; 167 per cent to 209 per cent (annual), compared with control; +ve; 147 per cent to 209 per cent (annual) compared with pre-project intensity;

Table 5.8 Per Hectare Cost of Production, Yield and Net Return

Crops	Impacted area					Control area					Differences in net returns (Imp.-Cont.) (Tk. '00)
	Crop Yield (mt.)	By-products (mt.)	Total cost (Tk. '00)	Gross Return (Tk. '00)	Net Return (Tk.'00)	Crop Yield (mt.)	By-products (mt.)	Total cost (Tk. '00)	Gross Return (Tk. '00)	Net Return (Tk.'00)	
Paddy Crops											
B. Aus LV	2.08	4.16	65	160	95	2.04	4.08	70	157	87	+8
B. Aus HYV	3.59	3.59	68	137	53	-	-	-	-	-	-
T. Aus LV	2.99	5.98	79	238	159	-	-	-	-	-	-
T. Aus HYV	4.22	4.22	93	304	211	-	-	-	-	-	-
B. Aus/Aman mixed	1.71	3.42	49	127	78	1.14	2.28	39	84	45	+33
B. Aman LV	1.87	3.74	73	138	65	2.04	4.08	55	152	97	-32
T. Aman LV	3.31	6.62	73	239	166	1.29	2.58	71	93	22	+144
T. Aman HYV	4.66	4.66	91	311	220	2.80	2.80	82	187	105	+115
Boro LV	3.15	6.30	38	234	196	-	-	-	-	-	-
Boro HYV	5.04	5.04	112	369	257	4.47	4.47	142	327	185	+72
All paddy (weighted Av.)	4.37	4.74	85	309	224	2.52	3.85	78	113	35	+189
Non-paddy Crops											
Jute	1.26	2.52	84	145	61	1.02	2.04	66	102	36	+25
Wheat	1.96	-	77	105	28	1.98	-	84	106	22	+6
Potato	9.52	-	194	255	61	17.38	-	261	373	112	-51
Sweet Potato	11.93	-	103	256	153	15.37	-	164	330	166	-13
Pulses	-	-	-	-	-	0.90	-	24	72	48	-
Oilseeds	0.74	-	53	79	26	0.49	-	64	53	(-)11	+37
Chilli	1.21	-	89	156	67	0.58	-	108	75	(-)33	+100
Other Spices	-	-	-	-	-	0.46	-	37	49	12	-
Winter vegetables	1.47	-	58	126	68	7.98	-	107	684	577	-509
Fruits	-	-	-	-	-	15.37	-	100	165	65	-
Sugarcane	32.80	-	179	615	-	-	-	-	-	-	-
Others	1.09	-	63	161	436	4.92	-	48	725	677	-579
Net Return from non-paddy crops/ha.	-	-	-	-	98	-	-	-	-	63	+35
Net Return from Agri./ha.	-	-	-	-	213	-	-	-	-	45	+168

Source: FAP - 12 PIE Household Survey

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- change in paddy yield : +ve; 2.52 to 4.37 mt./ha. (all paddy) compared with control (+73 per cent); +ve; 1.27 to 4.37 mt./ha. compared with pre-project yield (+244 per cent);

- change in paddy output (incremental output) : +74310 mt. (annual) i.e. 192 per cent compared to 'without' project situation; +76 per cent above the target;

- change in input use : +122 per cent chemical fertilizers; +13 per cent Human Labour; +39 per cent Animal Labour; +300 per cent pesticides;

- change in value of output : +173 per cent in paddy; +56 per cent in all non-paddy crops.

b) Negative Findings

- Farmers in most of the Project area irrigate their crops without paying any water charge. The exceptions are the areas where the BWDB gravity canal system is awaiting rehabilitation. In such areas farmers have to meet the cost of LLPs to lift water to their fields. In the areas where the canal system is operating, the availability of free water encourages its excessive use, resulting both in unnecessary pumping requirements and in a bias of the cropping system towards high water requirement crops.

- In the pre-project situation, jute was cultivated on a considerable area of cropped land; but post-project the area has decreased tremendously. Since the embankment prevents the seasonal flood, the retting facilities required for jute production have been lost.

- The agricultural support services are very weak in the Project area although the Agriculture Department's extension staff have been supplemented by a small number of BWDB extension staff. Problems in addressing the day-to-day technical disorders in the Project area have been observed as serious deterrents during the present survey.

c) Recommendations

- The irrigation canal network should be fully rehabilitated so that it reaches the entire command area specified in the Project design and provides year-round irrigation to the Project targeted area.

- An irrigation water charge, at a minimal but standard rate, should be introduced to minimize Government subsidy for O&M.

- Extension services should be strengthened further and the farmers should be given guidance in use of correct fertilizer mixes so that indiscriminate use of fertilizers, especially the micro-nutrients (Zinc, Sulphur etc.) does not affect soil health.

6. LIVESTOCK

6.1 INTRODUCTION

Most of the households in the Project area belong to the farming community, and livestock plays an important role in the existing farming system. Animals are kept primarily as a supporting activity to crop production and secondarily as a source of animal protein (milk, meat, eggs) and cash income for the farm households. Most farm households keeps a small number of livestock as scavenging animals. Cattle, chickens and ducks are the most important animals in the project area. A few goats and sheep are kept by some households, but buffaloes and horses are not kept in the area. According to the Census of Agriculture and Livestock 1983-84, in Chandpur District about 47 per cent of all households possessed cattle, 30 per cent had goats and sheep and 81 per cent had chickens and ducks.

Economically, cattle are the most important livestock in the project area, and are kept primarily for draught purposes. Bullocks are kept mainly for draught power while cows are kept for milk and calves. The small and marginal farm households have been increasingly using cows for draught purposes. However, during the peak seasons for land preparation, cows are used as draught animals to overcome draught power shortages by all types of farm households.

The Project had no specific objectives related to livestock development. However, it could have been expected that the Project would have a positive impact on crop production (primarily paddy production) through increasing cultivable area, changing cropping patterns and increasing cropping intensity, which would lead to reduction of fallow land and grazing area for livestock on one hand and increased requirement for draught animals on the other hand. It is anticipated that any change in the availability of feeds would lead to change in the production costs of livestock and livestock products. FCD/I project planners in general have rarely considered project impacts on the inputs and outputs of livestock, particularly draught power requirements, and how to meet the increased demand on draught power for timely land preparation.

The project could not have been expected to have direct impacts on livestock production parameters, but it should have been expected to have some effects on livestock feed resources and disease occurrence, which would influence livestock production in the area. The impacts of the project would be expected in the following areas:

- incidence of livestock owning households and livestock holding size;
- livestock feed resources;
- draught power availability and demand;
- livestock outputs,
- livestock health and incidence of diseases.

In this Chapter an attempt will be made to estimate the impacts of the Project on the above mentioned areas using the PIE data and RRA results.

6.2 DISTRIBUTION OF SAMPLE HOUSEHOLDS

Livestock production data were collected from 252 sample households (combined total from the protected and control areas). Out of the 252 sample households, 168 households were from the protected area and 84 households from the control area. The sample households include 72 landless, 159 marginal and small, and 21 medium and large farm households. The number of bovine, ovine and poultry holding households and their distribution are shown in Table 6.1.

Table 6.1 : Distribution of PIE Sample Households Owning Livestock

	Protected Area	Control Area	Total Sample
Landless Households	48	24	72
Owning Bovine	6	2	8
Owning Ovine	9	3	12
Owning Poultry	22	13	35
Marginal and Small Farm HH	107	52	159
Owning Bovine	72	26	98
Owning Ovine	20	16	36
Owning Poultry	97	49	146
Medium and Large Farm HH	13	8	21
Owning Bovine	13	8	21
Owning Ovine	2	3	5
Owning Poultry	13	8	21
All types of HH	168	84	252

Source : PIE Household Survey.

6.3 IMPACT ON LIVESTOCK HOLDING

6.3.1 Change in the Number of Livestock Owning Households

The impact of the project on the number of livestock owning households was analysed by comparing the Household Survey data from the protected and control areas; the results are presented in Table 6.2. The PIE results confirm the RRA findings that cattle are the most important type of animal in the Project area. No buffaloes were recorded in the sample households. The number of households owning cattle was higher in the protected area than in the control area. The PIE results give a clear indication that the number of cattle holding households increases with the increasing farm size both in the protected and control area (Table 6.3). About 13 per cent of landless households and 67 per cent of marginal and small farm households possessed cattle in the protected area. In contrast, 100 per cent of medium and large farm household in the protected area possessed cattle. The increased number of cattle holding households with increasing farm size may be due to higher demand for draught animals for land preparation. Moreover, medium and large farm households have greater financial ability and more feed resources to procure and maintain a larger number of cattle.

Table 6.2 : Percentage of Households Owning Livestock by Type

Species	Protected Area	Control Area
Bovines	54	43
Cattle	54	43
Buffaloes	0	0
Ovines (Goats & Sheep)	18	26
Poultry	79	83
Chickens	78	80
Ducks	34	64

Source : PIE Household Survey.

Table 6.3 : Percentage of Households Owning Bovines by Farm size

Farm Size	Protected Area	Control Area
Landless Households	13	8
Marginal & Small Farm Households[1]	67	50
Medium & Large Farm Household[2]	100	100

Note: [1] Households having operated land between 0.01 and 2.50 acres.
[2] Households having operated land of 2.51 acres and above.

Source : PIE Household Survey.

PIE results indicate that goats and sheep are not very important in the project area. Only 18 per cent of the households in the protected area and 26 per cent in the control area possessed goats and sheep (Table 6.2). The PIE results further indicate that the number of goats and sheep per owning household increases with increasing farm size (Table 6.4).

About 80 per cent of the total household kept poultry both in the protected and control areas (Table 6.2). Chicken is the predominant species of poultry in the area. But only 34 per cent of the total households in the protected area and 64 per cent in the control area kept ducks. The smaller number of duck owning households in the protected area may be due to fewer number of water bodies and inadequate availability of natural duck feeds in the protected area after the project.

Table 6.4 : Percentage of Households Owning Ovines, by Farm Size

Farm Size	Protected Area	Control Area
Landless Households	19	13
Marginal & Small Farm Households[1]	19	31
Medium & Large Farm Households[2]	15	38

Note: [1] Households having operated land between 0.01 and 2.50 acres.
[2] Households having operated land of 2.51 acres and above.

Source : PIE Household Survey .

The PIE results indicate that the number of poultry owning households increases with increasing farm size in both the protected and control areas (Table 6.5). Only about 50 per cent of landless households possessed poultry. In contrast, around 90 per cent of marginal and small farm households and 100 per cent of medium and large farm households have poultry. There is little difference in the number of poultry owning household between the protected and control areas.

Table 6.5 : Percentage of Households Owning Poultry, by Farm Size

Farm Size	Protected Area	Control Area
Landless households	47	54
Marginal & Small Farm Households[1]	91	94
Medium & Large Farm Households[2]	100	100

Note: [1] Households having operated land between 0.01 and 2.50 acres.
[2] Households having operated land of 2.51 acres and above.

Source : PIE Household Survey .

6.3.2 Change in the Size of Livestock Holding

The average size of livestock holding per household in the project area is quite small, but most of the farm households and a small number of non - farm households keep a few livestock as scavenging animals.

The PIE results confirm the RRA finding that bovines are the most important type of livestock to the farming community because of draught power supply. Land preparation, and thereby crop production as a whole, is highly dependent on animal draught power. The average size of bovine holding per household is quite small, only 1.4 head per household in the protected area and 0.9 head in the control area (Table 6.6). In other words the average size of cattle holding per household in the protected area was 55 per cent higher than the control area. However, the average owning household possessed more than two head of cattle both in the protected and control areas, indicating that the cattle owning farmers could make up a plough team for cultivating their land.

Table 6.6 : Number of Livestock per Household in the Protected and Control Areas.

Species	Protected Area	Control Area
Bovines	1.4	0.9
Cattle	1.4	0.9
Buffaloes	0	0
Ovines (Goats & Sheep)	0.3	0.5
Poultry	6.9	7.4
Chickens	5.3	5.2
Ducks	1.6	2.2

Source : PIE Household Survey.

Table 6.7 : Number of Livestock per Owning Household in the Protected and Control Areas.

Species	Protected Area	Control Area
Bovines	2.6	2.1
Cattle	2.6	2.1
Buffaloes	0	0
Ovines (Goats & Sheep)	1.4	1.9
Poultry	8.8	8.9
Chickens	6.9	6.5
Ducks	4.6	3.5

Source : PIE Household Survey .

The PIE results clearly indicate that the size of bovine holding per household increases with increasing farm size (Table 6.8 and 6.9). The landless households possessed only 0.2 head of cattle per household or 1.67 head per owning household in the protected area. Marginal and small farm households possessed 1.73 head of cattle per household or 2.57 head per owning household, and medium and large household had 3.31 head per household and per owning household. The results indicate that medium and large farm households keep more cattle for cultivation of their land. Moreover, they probably have more financial and feed resources for procurement and maintenance of bovine animals.

Table 6.8 : Number of Bovines per Household by Farm Size.

Farm size	Protected Area	Control Area
Landless households	0.2	0.8
Marginal & Small Farm Households[1]	1.7	0.9
Medium & Large Farm Households[2]	3.3	3.0

Note: [1] Households having operated land between 0.01 and 2.50 acres.
[2] Households having operated land of 2.51 acres and above.

Source : PIE Household Survey .

Table 6.9 : Number of Bovines per Owning Household by Farm Size.

Farm Size	Protected Area	Control Area
Landless Households	1.7	1.0
Marginal & Small Farm Households[1]	2.6	1.9
Medium & Large Farm Households[2]	3.3	3.0

Note: [1] Households having operated land between 0.01 and 2.50 acres.
[2] Households having operated land of 2.51 acres and above.

Source : PIE Household Survey.

The results of the Household Survey on the size of ovine (goat and sheep) holdings in the protected and control areas are presented in the Table 6.6 and 6.7. The average size of ovine holding was 0.3 head per household or 1.4 head per owning household in the protected area and 0.5 head per household or 1.9 head per owning household in the control area. This indicates that the protected area has slightly smaller number of ovine animals per household than the control area. The PIE results further indicate that the size of ovine holding does not increase with increasing farm size either in the protected or control area (Table 6.10 and 6.11).

Table 6.10 : Number of Ovines per Household by Farm Size.

Farm Size	Protected Area	Control Area
Landless Households	0.29	0.17
Marginal & Small Farm Households[1]	0.26	0.65
Medium & Large Farm Households[2]	0.15	0.50

Note: [1] Households having operated land between 0.01 and 2.50 acres.
[2] Households having operated land of 2.51 acres and above.

Source : PIE Household Survey.

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Table 6.11 : Number of Ovines per Owning Household by Farm Size.

Farm Size	Protected Area	Control Area
Landless Households	1.6	1.3
Marginal & Small Farm Households[1]	1.4	2.1
Medium & Large Farm Households[2]	1.0	1.3

Note: [1] Households having operated land between 0.01 and 2.50 acres.
[2] Households having operated land of 2.51 acres and above.

Source : PIE Household Survey.

Poultry is another important type of livestock in the project area. The household survey results on poultry are shown in Table 6.6 and 6.7. The average number of poultry per household was slightly lower in the protected area than the control area. However, chickens are the predominant species of poultry in both the protected and control areas. There is no significant difference in the size of chicken holding between the protected and control areas, but the average household possesses fewer ducks in the protected area than in the control area.

The PIE results show that the size of poultry holding per household increases with increasing farm size (Table 6.12 and 6.13). The landless households had only 2.5 birds per household in the protected area and 3.2 birds in the control area. In contrast, medium and large farm households possessed 14 birds per household in the protected area and 12 birds in the control area. There is a similar trend in the number of poultry per owning household. The larger number of poultry owned by medium and large farm households both in the protected and control areas may be due to greater availability of fallen grains and other poultry feeds in the household.

Table 6.12 : Number of Poultry per Household by Farm Size.

Farm Size	Protected Area	Control Area
Landless households	2.5	12.0
Marginal & Small Farm Households[1]	8.0	8.6
Medium & Large Farm Households[2]	14.3	12.0

Note: [1] Households having operated land between 0.01 and 2.50 acres.
[2] Households having operated land of 2.51 acres and above.

Source : PIE Household Survey.

Table 6.13 : Number of Poultry per Owning Household by Farm Size.

Farm Size	Protected Area	Control Area
Landless Households	5.5	5.9
Marginal & Small Farm Households[1]	8.8	9.2
Medium + Large Farm Households[2]	14.3	12.0

Note: [1] Households having operated land between 0.01 and 2.50 acres.
[2] Households having operated land of 2.51 acres and above.

Source : PIE Household Survey.

6.4. IMPACT ON DRAUGHT POWER

6.4.1 Draught Power Requirement

It has been shown (Chapter 5) that improved drainage and irrigation facilities due to the project have led to changes in the cropping pattern and cropping intensity, and have thereby caused changes in cropped area in different cropping seasons. The change in cropped area in different seasons, due to the Project, is in turn expected to cause change in draught power requirements for land preparation.

The PIE results indicate that the average operated land area per household was higher in the protected area than the control area (Table 6.14). Of the three cropping seasons, the cropped area was the highest in Aman and lowest in Aus, in both the protected and control areas. In the protected area the utilization of land was more intensive and almost evenly distributed between the three seasons, viz. 65 per cent of total operated land was used in the Aus season, 77 per cent in Aman and 71 per cent in the Boro season. In the control area, only 20 per cent of the total operated land was used in the Aus season, 78 per cent in the Aman season and 73 per cent in the Boro season. Thus, increased cropped area will demand more draught power for cultivation of land in the protected area in the Aus season.

Table 6.14 : Operated and Cropped Areas per Household by Cropping Season (acres).

Operated land/HH (acres)	Protected Area	Control Area
Total operated area	0.94	0.79
Cropped Area in:		
- Aus Season	0.61	0.16
- Aman Season	0.72	0.63
- Boro Season	0.67	0.58
- All seasons	2.00	1.37

Source : PIE Household Survey.

6.4.2 Change in Draught Animal Availability

Supply of draught power to the farm household is the major contribution of bovine animals in the area. As already shown in sections 6.3.1 and 6.3.2, the number of bovine owning households and the size of bovine holding vary with farm size and between the protected and control areas. Bullocks and bulls are the most important animals for draught power, but small and marginal farmers are now increasingly using cows for draught purpose.

The average number of bovine animals per household and herd composition in the protected and control areas are shown in Table 6.15. The total number of bovine animals per household was around 60 per cent higher in the protected area than in the control area. The herd composition of bovine animals also varied between the protected and control areas. There was only 27 per cent of bullocks/bulls and 37 per cent of cows in the total bovine herd in the protected area as against 34 per cent of bullocks/bulls and 36 per cent of cows in the control area. The higher percentage of bullocks/bulls in the control area is largely due to lower numbers of young stock; a possible cause is that control area farmers, whose cropping is much less productive than that of the protected area (see Chapter 5), are under greater financial pressure to sell off their young stock.

In order to compare draught power availability per household in the protected and control areas, all bovine animals were converted into draught animal units (DAU) using the following conversion factor.

DAU = 1 x (Bullocks+Bulls) + 0.5 x Cows + 2 x Buffaloes.

Available DAU per household in the protected and control areas are presented in Table 6.16. The results indicate that the number of DAU per household was higher (0.64 DAU per household) in the protected area than in the control area (0.46 DAU per household). Although bullocks/bulls constitute only 27 per cent of the total bovine animals in the protected area, they contribute about 60 per cent of the total DAU, while cows contribute only 40 per cent of the total DAU per household. In the control area, however, the contribution of bullocks/bulls was 65 per cent and that of cows was 35 per cent. No buffaloes were present in the sample households. The results give further confirmation that there was a higher number of DAU per acre of operated land in the protected area than the control area.

Table 6.15 : Composition of Bovine Holding in the Protected and Control Areas.

No. of Animal/HH	Protected Area		Control Area	
	No.	%	No.	%
Bullock+Bull/HH	0.38	27	0.30	34
Cows/HH	0.53	37	0.32	36
Calves/HH	0.51	36	0.27	30
Buffaloes/HH	0		0	
Total Bovine/HH	1.42	100	0.89	100

Note: HH = household

Source : PIE Household Survey .

Table 6.16 : Availability of Draught Animal Units (DAU) per Household in the Protected and Control Areas.

Draught Animal/HH	Protected Area	Control Area
Bullocks+Bulls/HH	0.38	0.30
Cows/HH	0.53	0.32
Buffaloes/HH	0	0
DAU/HH	0.64	0.46
DAU/Acre Operated Land	0.68	0.58

Source : PIE Household Survey .

6.4.3 Draught Power Demand and Supply

Demand for draught power is dependent on the area of operated land per household as well as cropped area in different seasons, while supply of draught power is dependent on the size of livestock holding per household. As already shown in Table 6.14 the operated land area per household varies with the cropping season and with the farm size. Average operated land per pair of DAU in different crop seasons and for medium and large farm households is shown in Table 6.17. It can be seen from the Table that the average operated area per pair of DAU for medium and large farm households was higher (4.66 acres per DAU) in the protected area than in the control area (3.58 acres/DAU). The cropped area per pair of DAU in Aman season and for medium and large farm households was more than two acres both in the protected and control areas. It is assumed that at best only two acres of land can be cultivated by a pair of DAU in the Aman season within a 30 day time limit (the typical period available for Aman land preparation). This indicates that there is an overall shortage of draught animal power both in the protected and control areas, a conclusion in agreement with the RRA finding that power tillers are increasingly used in the protected area.

Table 6.17 : Draught Power Requirement and Supply in Aman Season for Medium and Large Farm Households.

Area per Pair of DAU (acres)	**Protected Area**	**Control Area**
DAU/HH (No.)	0.64	0.46
Operated land/Pair DAU	2.94	3.46
Operated land/Pair DAU for M&L Farms	4.66	3.58
Cropped land/Pair DAU in Aman Season	2.24	2.73
Cropped land/Pair DAU in Aman Season for M&L Farms	3.46	2.72

Source : PIE Household Survey .

Table 6.18 : Days Required for Land Preparation, by Farm Size and Season, with Available Draught Power Supply

Farm Size	Days Required					
	Protected Area			Control Area		
	Aus	Aman	Boro	Aus	Aman	Boro
Marginal & Small	26	30	26	9	42	35
Medium & Large	44	52	54	13	41	44
All Farms	29	34	31	10	41	38

Source : PIE Household Survey.

The time requirement for cultivation of operated land with the available DAU by different categories of farm households in different cropping seasons is shown in Table 6.18. The PIE results indicate that the time requirement for cultivation by medium and large households in the Aman and Boro seasons was more than 30 days both in the protected and control areas. This indicates that there was shortage of draught power both in the protected and control area. However, the shortage of draught power was more severe in the Aman season and particularly for the medium and large farm households.

From the above discussion it can be concluded that there is a shortage of draught animal power both in the protected and control areas. There are some indications that the Project has aggravated the draught power situation through increasing draught power requirement. However, the shortage of draught animal power is being partly overcome through the use of power tillers.

6.5 IMPACTS ON LIVESTOCK FEEDS

It is expected that the Project would have some impact on livestock feed resources, particularly on fallow land and grazing area, and thereby on availability of a green feedstuffs. It is anticipated that with the increased production of paddy there would be a concomitant increase in availability of paddy straw and rice bran for the bovine animals. RRA results indicate that the seasonal grazing area in the Boro and Aus seasons has been reduced due to conversion of fallow land into crop fields. The RRA results provide further indication that the paddy straw production has increased in the Project area mainly due to increased production of Boro and Aus crops, but the palatability and digestibility of straw have declined due to cultivation of HYVs rather than local varieties.

In order to assess the status of livestock feeds in the project area, the household survey data on bovine feeds were analysed and the results are presented in Table 6.19. In the protected area more than 50 per cent of the total households or about 100 per cent of bovine owning households provide some green feedstuffs, dry roughage and concentrate feeds to their bovine animals. In the control area similar percentage of households provide green and dry feeds to their animals, but a smaller percentage of households provide

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concentrate feeds to their cattle. The trend is in agreement with other evidence for the greater wealth of the protected area and its investment in livestock (see 6.4.2 above).

Table 6.19: Feed Types Provided for Bovine Animals in Last 12 months
(% households providing)

Areas	Type of Feeds Bought		
	Green Feedstuff (% HH)	Dry Roughage (% HH)	Concentrate feed (% HH)
Protected	59	55	51
Control	50	46	35

Source : PIE Household Survey.

Table 6.20 shows the amount of money spent per household for feeding their bovine animals in the survey year (1990-91). The results indicate that the largest proportion of money was spent for dry roughage both in the protected and control areas. Among concentrate feeds, spending on oil cakes per household was higher in the protected area than the control area. The total amount of money spent per household for feeding bovine animals was much smaller in the control area than the protected area, both in absolute terms and in relation to herd size and composition. This is again likely to be due to the greater wealth of the households in the protected area

Table 6.20: Amount Spent per Household for Feeding their Animals in Last 12 Months (1990-91).

Areas	Type of Feeds Fed					
	Green Feed		Dry Feed		Concentrate Feed	
	Amount/HH (Tk)	Amount/ Spending HH (Tk)	Amount/HH (Tk)	Amount/ Spending HH (Tk)	Amount/HH (Tk)	Amount/ Spending HH (Tk)
Protected	242	410	592	1069	379	749
Control	145	289	284	611	141	409

Source : PIE Household Survey.

6.6 IMPACTS ON LIVESTOCK HEALTH

The RRA results show that there has been a general deterioration of cattle health over time, mainly due to shortage of feeds, seasonal fluctuation of feed supply and seasonal overwork of the animals. However, it was not clear from the RRA whether this was a project impact or due to exogenous trends (especially rising human population pressure).

The PIE results indicate that around 30 per cent of all households used veterinary facilities for treating or vaccinating their animals during the survey year (1990-91) (Table 6.21), but there is little difference in the number of households using veterinary facilities between the protected and control areas. The amount of money spent per household and per using household for veterinary treatment is smaller in the protected area than the control area possibly reflecting the better nutrition (and consequently better health) of cattle in the protected area.

The small number of households using veterinary facilities and the small expenditure per household for animal treatment and vaccination indicate that the farmers are not fully aware of the usefulness of veterinary facilities for protecting their animals.

Table 6.21 Percentage of Household Using Veterinary Facilities and Amount Spent

	Protected Area	Control Area
% HH Used Vet. Treatment	33	27
Amount Spent/HH for Treatment (Tk.)	26	37
Amount Spent/Using HH for Treatment (Tk.)	78	125

Source: PIE Household Survey.

6.7 HOUSEHOLD INCOME FROM LIVESTOCK

Average income per household from sale of live animals and livestock products is shown in Table 6.22. Average sale proceeds per household from live animals was higher (Tk.1019) in the protected area than in the control area (Tk.772). Around 60 per cent of the total proceeds from sale of live animals comes from cattle and 35 per cent from poultry, in both the protected and control areas. Less than 5 per cent of the total sale proceeds comes from sheep and goats.

Average sale proceeds from livestock products were significantly higher in the protected area than the control area. Milk contributed the lion's share of the sale proceeds in the protected area. Eggs and cowdung were other important components of the sale proceeds both in the protected and control areas. The total sale proceeds per household from livestock sources were around 72 per cent higher in the protected area than in the control area.

The net income per household from sales of livestock and livestock products is shown in Table 6.23; this does not include the value of draught power services. Although the gross income per household was higher in the protected area than in the control area by 72 per cent, the net income per household was higher by 35 per cent only. This is mainly due to the higher production cost of the animals in the protected area. The results indicate that livestock production under the present form of management is not very profitable in either the project or control area.

Table 6.22 **Average Household Income from Sale Proceeds of Live Animals and Livestock Products (in TK.).**

Sources	Protected Area	Control Area
Sale Proceeds from Live Animals	1,019	772
Bovine /HH	599	479
Ovine /HH	31	31
Poultry /HH	389	262
Sale Proceeds from Livestock Products	1,018	415
Milk/HH	694	118
Meat/HH	0	7
Eggs/HH	155	155
Others/HH	169	135
Total Sale Proceeds/HH	2,037	1,187

Source : PIE Household Survey

Table 6.23: Net Income/Household from Livestock Sources.

Item	Protected Area	Control Area
Gross Household Income from Livestock	2037	1187
Cost of Feeds and Treatment/HH	1239	604
Net Income/HH	789	583

Source : PIE Household Survey.

6.8 SUMMARY

A comparison of the status of livestock production between the protected and control areas indicates that there is a considerable positive impact of the project on livestock. In the protected area the proportion of households owning bovine animals is higher, the average holding size is substantially higher, and as a result the availability of draught power per household is higher. Nevertheless, there is an overall shortage of draught power both in the protected and control areas, and the shortage was more severe in the protected area in all seasons and particularly for medium and large farm households. However, farmers overcome their draught power shortage through the use of power tillers.

The project is believed to have had a negative impact on green feedstuff availability in the protected area by reducing seasonal fallow and grazing land, but the production of dry roughage (paddy straw) and rice bran has increased with the increased production of paddy. The spending for bovine feeds was much higher in the protected area than the control area, reflecting greater wealth due to higher crop output.

The percentage of households owning goats and sheep, and average holding size, is substantially lower in the protected area than in the control area. The proportion of duck owning households and average holding size were also lower in the protected area although the chicken population was more or less the same in both the areas.

Average income from sale proceeds of live animals and livestock products was higher by 72 per cent in the protected area than in the control area, but the net income per household was only 35 per cent higher in the protected area. This is mainly due to the higher expenditure on feeding and maintenance of cattle in the protected area. The results indicate that livestock production under the present form of management is not very profitable in either the project or the control area.

6.9 RECOMMENDATIONS

The following measures could be taken to overcome the adverse effect of the project on given feed resources and to improve livestock production in the area.

a) A programme could be undertaken to cultivate high biomass yielding forage crops such as Napier and Para grass on the slopes of the embankment, road sides and on homestead boundaries. This would not only produce green fodder but would also reduce soil erosion. Para grass, which is tolerant of wet conditions, could be cultivated on the lower part of the embankment slopes and on the borrow pits.

b) Paddy straw, which is the main feedstuff for cattle in Bangladesh, is low in both digestibility and nutrient content. However, urea treatment of straw improves both nitrogen content and digestibility of straw. A large scale extension programme should be undertaken to popularize urea treatment of straw for improving cattle nutrition in the Project area.

c) A programme for introduction of urea-molasses blocks for feeding cattle with the straw ration should be undertaken. Urea molasses blocks are a good source of energy and nitrogen for rumen micro-organisms which in fact digest fibrous feeds, while the rumen micro-organisms themselves are a good source of protein for the ruminant. Thus, feeding urea molasses blocks as supplemental feed for cattle on straw based rations will not only improve digestibility and palatability of straw but also improve total nutrient intake.

d) The extension programme of the Department of Livestock Services should be extended and strengthened in the area under the FCD/I Project. Provision should be made to provide routine vaccination and mass anthelmintic doses in the Project area to protect animals against prevalent infectious and parasitic diseases.

e) As a long term measure, during selection of HYV paddy some consideration should be given to straw quality because straw of some HYVs has higher digestibility than that of others. This will help to improve straw quality along with the increase in rice production.

7 FISHERIES

7.1 CAPTURE FISHERIES

The CIRDAP benchmark survey report, conducted in 1986, provided information on the number and areas of different water bodies, types of fishing and fish output within MDIP for the pre-project period. There was hardly any information about the number of professional and part time fishermen within the project. The total number of fishermen now has been estimated (Appendix J of FAP 12 Final Report), at about 3000 in the project area and 1000 in the control area. Out of these, 18 fishermen from the impacted area and 16 from the control area were interviewed during the PIE study. The results of this study are discussed below.

The average daily catch and fishing days per year per fisherman are shown in Tables 7.1 and 7.2.

Table 7.1 Average Capture Fish Catch per Fishermen per Day (Kg.)

Items	Impacted Area	Control Area
Now	2.7	2.3
Before Project	4.4	3.5

Source: FAP 12 PIE Survey

Table 7.2 Average Number of Fishing Days per Fishermen per Year

Items	Peak Period	Lean Period	Total
Impacted Area			
Now	126	150	276
Before Project	118	134	252
Control Area			
Now	122	133	255
Before Project	119	126	245

Source: FAP 12 PIE Survey

The sharp difference of present average catch from that pre-project indicates rapid decline of fish production in both protected and control areas. This decline in fish catch is larger in the impacted area than in the control area. The average daily catch has declined by about 39 per cent in the impacted area and 34 per cent in the control area. These findings agree broadly with those of the RRA where it was reported that the fish catch has declined by at least 50 per cent after project implementation. A 75 per cent loss of fish catch in the interior water bodies was also been quoted to the RRA team. It is not clear from the PIE data that the decline is highly specific to the Project area, though since the Project and control areas are close it may nevertheless be a Project impact.

The average number of fishing days per fishermen per year has increased slightly between now and the pre-project situation, in both impacted and control areas (Table 7.2). The average fishing days per year are relatively high in this project as a result of the timing and duration of flood and the scope for fishing in different types of water body. The peak fishing season extends from April to November in the impacted and from August to November in the control area, and the lean fishing season varies from December to March and from December to July in the Impacted and control areas respectively.

Fish catches by average quantity and value, and by main species groups as reported by the fishermen are presented in Table 7.3.

Table 7.3 Average Catch per Fisherman During 1990/91
(Quantity in kg. and value in Tk.)

Species	Impacted area		Control area	
	Quantity	Value	Quantity	Value
Major carps	47	3228	42	1622
Catfish	52	2537	45	1314
Snake-heads	-	-	65	1466
Hilsa	195	6783	16	662
Tilapia	1	33	6	156
Minor carps	-	-	10	308
Live fish	15	737	91	3592
Shrimp	68	2418	42	3623
Other species	302	4903	307	4985
Total capture fish	680	20639	624	17729
Pond fish (mainly carps)	-	-	353	11841
Overall Total	680	20639	977	29570

Source: FAP - 12 PIE Survey

The above table shows a higher average annual catch of capture fisheries in the impacted area than that of the control area, and the data are consistent with the average catch per day per fisherman (Table 7.1). However, the overall total average annual catch is higher in the control area than in the impacted area. These differences in both average daily catch and annual catch between impacted and control areas may be associated with the relative differences of productivity in various water bodies and differences in the efficiency of gears used by the fishermen.

In the present study an attempt has been made to compare the present fish catch of the fishermen with their pre-project catches, though there is a danger that the fishermen may not exactly recall their pre-project fish catches and values. From the reports of the fishermen, the extent of changes in catch are shown in Tables 7.4 and 7.5.

Table 7.4 Comparison of 1990/91 and Pre-project Catches
(No. of fishermen responding)

Extent of change	Impacted	Control
Increased more than 25 %	-	-
Increased more than 25 %	-	1
Catch about the same	-	1
Decreased up to 25 %	7	10
Decreased more than 25 %	10	4
Total no. of respondents	17	16

Source: FAP - 12 PIE Survey

From Table 7.4 it is seen that almost all of the respondents from both impacted and control areas said there was a reduction of fish production after project implementation. The extent of reduction is higher in the impacted area where about 59 per cent of the respondents said there was more than 25 per cent decrease in contrast to 25 per cent of fishermen in the control area. The distribution of the reduction between the major species (Table 7.5) provides further confirmation of the sharp decline in the project area. The decline is stronger in the Project than in the control for the major carps, catfish and hilsa. These results support the earlier findings and the finding of the RRA study about the decline of capture fisheries production (Table 7.5). In the PIE study, as shown in Table 7.5, no fishermen has commented about the extent of change in shrimp production, although it was reported to the RRA team that the shrimp and prawn fishery have been almost wiped out due to the project. This calls for further investigation.

Table 7.5 Changes in Species Composition in the Catch
(No. of fishermen responding)

Species	Area	Increased		No change	Decreased	
		25% plus	Up to 25%		Up to 25%	25% plus
Major carps	Impacted	-	-	-	1	9
	Control	-	-	1	4	-
Catfish	Impacted	-	-	-	1	9
	Control	-	-	1	1	3
Hilsa	Impacted	-	-	-	3	4
	Control	-	-	-	-	1
Life fish	Impacted	-	-	-	1	2
	Control	-	-	1	2	3
Minor carp	Impacted	-	-	-	-	-
	Control	-	-	-	-	4
Snake head	Impacted	-	-	-	-	-
	Control	-	-	-	-	-
Shrimp	Impacted	-	-	-	-	-
	Control	-	-	-	-	-
Other Species	Impacted	-	-	1	2	10
	Control	-	-	-	2	9

Source: FAP - 12 PIE Survey

The main causes of the decline in capture fish stock and catches as reported by the fishermen are presented in Table 7.6.

Table 7.6 Fishermen's Views on Causes of Project Impact
(Number of fishermen responding)

Cause of Impact	Impacted area	Control area
Fish access blocked by embankment	10	1
Drying of water bodies	4	1
Decrease in fishing area	7	1
Use of current nets	-	7
Fish disease	-	8
Excess capture of immature fish	-	2
Less fish	1	-
Gods will	1	-

Source: FAP - 12 PIE Survey

Table 7.6 shows that the majority of fishermen in the impacted area (56 per cent) are of the opinion that blockage of migratory routes is the main reason for reduction of catch and fish stock in the impacted area. The next most important reasons as stated by the fishermen are decrease in fishing area and drying of water bodies. These findings are quite similar to the findings of the RRA which found that the obvious cause for decline is the prevention of fish migration into the previously flooded areas by the embankment and loss of spawning areas in the shallow and slow-moving flood waters. Amongst the 5 PIE projects this project has most effectively controlled the annual flooding and thereby resulted in a sharp reduction in the areas of regularly inundated plains. Moreover irrigation and drainage channels have greatly reduced the beels areas, rendering a vast area of water bodies seasonally if, not permanently, dry. In the control area the most important causes as claimed by the fishermen are fish disease (50 per cent) and use of current nets (44 per cent).

Table 7.7 Fishermen's Income and Expenditure, 1990/91 (Tk.)

Items	Impacted area	Control area
Average catch (kg.) from Table 7.3	680.0	978.0
Fish kept for home consumption (kg.)	41.0	54.0
Quantity sold (kg.)	639.0	924.0
Mean value (weighted average) Tk./kg.	30.4	30.2
Gross income	19426.0	27905.0
Boat costs-upkeep and depreciation	1597.0	912.0
Fishing gear repairs and replacements	1445.0	3327.0
Licences, leases, other costs	506.0	5400.0
Total costs	3548.0	9639.0
Net income	15878.0	18266.0

Source: FAP - 12 PIE Survey

Table 7.7 shows the differences in costs and incomes between the fishermen of impacted and control areas. The reasons for these differences are possibly due to variations in prices of fish, types of gear and water bodies used for fishing and in modes of payment made for the catch of fish from ponds and other water bodies. Though pond fish culture has been increasing in the project area due to protection of ponds from annual flooding, catching fish from ponds is not an important activity in the impacted area, compared to a good catch in the control area (Table 7.3).

The involvement of family members in fishing was investigated during the PIE survey as shown in Table 7.8.

Table 7.8 Involvement of Family Members in Fisheries Work
(% of fisheries related work contributed by family members)

Items	Impacted area	Control area
Men		
Fish catching	22	27
Boat and gear repairing	46	44
Fish processing	-	-
Fish trading	18	20
Wives and Children		
Fish catching	1	-
Boat and gear repairing	12	9
Fish processing	-	-
Fish trading	1	-
Total percentage	100	100

Source: FAP - 12 PIE Survey

It is evident from the above table that the male members of a fishing family are mostly involved in fishing and boat and gear repairing. They also do almost all the fish trading. Other family members hardly participate in any fisheries activities except in repairing gear and other equipment. The non involvement of fishermen and their family members in fish processing, indicates that they sell out the whole catch in fresh condition. This also indicates high demand for fresh fish.

The involvement of fishermen in fish trading may be due to the decrease in their catch. In the RRA study the fishermen reported a severe impact of the project on their income and further stated that it had compelled them to adopt other occupations such as wood cutters, carpenters and daily labourers. Such information is not available from the PIE survey.

7.2 FISH FARMING

The PP for this project (in common with that for most other FCD/I projects) does not contain any fisheries objectives projects, with the exception of provision of funds to train two additional staff of the Department of Fisheries in fish culture. The PP contains no information on culture, ownership status, and distribution of ponds in the project area. This information needed to prepare a future development programme for fish culture. For the present survey, 5 pond owners were interviewed from the impacted and 5 from the control areas. The sample size is small, so that the data obtained should be taken as indicative rather than definitive. However, data obtained from the PIE survey on pond number, size, ownership status and reasons for excavation are shown in Tables 7.9 and 7.10.

Table 7.9 Numbers of Ponds and Ownership Status

Items	Impacted area	Control area
No. of pond-owners interviewed	5.00	5.00
No. of ponds involved	5.00	5.00
Area of ponds owned (ha.)	0.93	1.48
Average pond size (ha.)	0.20	0.30
Single owner ponds (no.)	1.00	-
Jointly owned ponds (no.)	4.00	5.00
Estimated total pond area (ha.)	404.00	539.00

Source: FAP - 12 PIE Survey

Table 7.10 Reasons for Pond Excavation and Use
(No. of pond owner responding)

Items	Impacted area	Control area
Ponds excavated		
- for fish culture	1	-
- for house construction	1	-
- for other purpose	-	-
Pond utilization		
- for fish culture only	-	-
- also for household use	5	5
- also for livestock	1	1
- also for irrigation	-	2
Total no. of respondents	5	5

Source: FAP - 12 PIE Survey

The average pond size recorded in the PIE study is almost the same as the official figure on local pond size (between 0.1 to 0.2 ha. as reported by DOF) which is about the national average. Among the ponds surveyed, 80 per cent of the ponds in the impacted area and 100 per cent of the ponds in the control area are jointly owned. This is one of the most important constraints on bringing them under improved fish culture. In the present study almost all the ponds were found to be used by the pond owners for both fish culture and household purposes. The pattern of use of ponds by the pond owners is almost the same in both the areas. Efficient multi-use of ponds needs careful management and congenial environmental conditions.

Table 7.11 Pond Owners' Assessment of Flooding Risks
(Nos. of respondents)

Items	Impacted area	Control area
Ponds subject to flooding before	4	4
Ponds still subject to flooding	-	3
Total respondents	5	5

Source: FAP - 12 PIE Survey

Almost all the respondents in the impacted area stated that their ponds are not inundated now though they used to be overtopped by flood water every year while, almost all the ponds in the control area are still flooded as before (Table 7.11). This confirms that the project has effectively protected the impacted area from annual flooding. This improved condition may have enhanced the culture fisheries within the project area as noted during the RRA. A number of ponds, khals and borrow-pits were observed to be used for fish culture and the project seems to have scored some success in developing these types of water bodies for fish culture by the local people. However, the beneficiaries are mostly the local land owners, and not the displaced fishermen and landless labourers who were envisaged as the primary target in the Feasibility Report.

The average productivity of fish ponds in the MDIP area was assessed and the results are shown in Table 7.12.

Table 7.12 Average Productivity of Fish Ponds (kg./ha.)

Items	Impacted area	Control area
Carps	1263	1209
Catfish	10	-
Tilapia	80	-
Shrimp	-	-
Other species	39	-
Total	1392	1209

Source: FAP - 12 PIE Survey

The average fish production per hectare (1392 kg.) in the impacted area is close to the current national average production of about 1400 kg./ha. and relatively higher (15 per cent) than the production (1209 kg./ha.) in the control area (Table 7.12). The pre project production would have been under 1000 Kg./ha.. Most of the pond owners interviewed in the protected area claimed that an increase has been achieved in pond fish production (Table 7.13), whereas opinion was equally divided between increase and no change in production in the control area. The increase in pond fish production within the project area may be associated with the encouraging responses concerning the adoption of improved pond fish culture methods by drying (100 per cent), and re-excavating (60 per cent) ponds (FAP 12 Final Report, Appendix Table J.17) and by using chemical fertilizer (100 per cent) and feed (80 per cent) as reported by the respondents (Appendix Table J.19). The effective protection of ponds from annual flooding may have given an incentive to the owners to adopt improved fish farming methods. The relatively improved DOF extension activities may have also contributed to the increased pond fish production within the project. 60 per cent of the respondents claim an improvement in DOF extension activities in the project area as compared to 20 per cent in the control area (Table 7.14). This conforms with the findings of the RRA. Pond fish production has also increased significantly in the control area which may be associated with increased awareness of fish culture, availability of quality fish seeds and adoption of improved technology. About 60 per cent of pond owners reported they have used both fertilizers and feed. The opinions of pond owners about the trends in pond fish production are presented in Table 7.13.

Table 7.13 Trends in Farmed Fish Production
(Nos. of respondents)

Extent of change	Impacted area	Control area
Increased more than 25%	2	2
Increased up to 25%	2	-
Not changed	-	2
Decreased up to 25%	-	-
Decreased more than 25%	-	-
Total respondents	5	5

Source: FAP - 12 PIE Survey

The responses of the pond owners regarding the effectiveness of extension services of DOF are shown in Table 7.14.

Table 7.14 The Effectiveness of DOF Aquaculture Extension Work.
(Nos. of respondents)

Items	Impacted area	Control area
Extension effort has improved	3	1
Remains about the same	-	-
Extension is worse now	2	1
Total respondents	5	5

Source: FAP - 12 PIE Survey

The profitability of pond fish culture is now increasing due to the decrease in capture fish stock which has greatly enhanced the demand for and price of fish. Better availability of quality fish seeds, improved technology and better yields are also contributing factors for increased profitability of pond fish culture. The average fish pond profitability estimated from the data of the respondents is presented in the Table 7.15.

Table 7.15 Average Fish Pond Profitability
('000 Tk./ha.)

Items	Impacted area	Control area
No. of respondents	5.0	5.0
Average sales income	55.5	47.3
Average costs for stocking, feeding and harvesting ponds	18.8	13.2
Average net income	36.7	34.1

Source: FAP - 12 PIE Survey

The net income differs little between impacted and control areas (Table 7.15) which may be due to adoption of improved fish culture methods in both the areas.

7.3 FISH MARKETING

To assess the extent of project impacts on fish trading, 4 fish traders were selected from the impacted area and 4 from the control area for interview during the PIE survey. The DOF fisheries statistics contain very little information on fish traders, their activities and problems. In the PIE fishermen were found to take part in fish trading almost equally to their normal fishing profession. This confirms the finding of the RRA. The consequent reduction in catch compels them to take up fish trading and other professions on a part-time basis after project implementation. The number of traders per market has, however, been found to be more or less static (FAP 12 Final Reports Appendix Table J.27). The possible reason may be the replacement of traders, who gave up their profession due to the reduction in quantity of fish, by fishermen adopting fish trading.

In the impacted area the quantity of fish handled by a trader per day per hat has decreased by about 41 per cent as compared to 24 per cent in control area. The quantity of fish traded per trader during the peak season also shows a decline by about 41 per cent in the impacted and 28 per cent in the control areas. Similar declines both in quantity of fish handled per day and per season during the lean period have also been recorded. About 100 per cent of traders in the impacted area and 50 per cent from the control area reported a decrease in fish production (FAP 12 Final Report Appendix Table J.30). They also confirmed the change in abundance of fish species as stated by the fishermen. Most of the traders stated that drying up of water bodies, fish disease in the production area, blocking of fish migation into and out of the project and use of illegal nets are the main factors affecting fish production and species composition. Some of the respondents reported an increase in pond fish culture and re-stocking of carps in beels and khals. However, the increased quantities of cultivated fish are far less than the losses from the capture fishery.

Change in abundance and variations in species in the project and control areas as reported by the traders are shown in Table 7.16.

Table 7.16 Changes in Abundance of Fish Species/Groups
(Nos. of respondents reporting)

Fish Species/Groups	Impacted area	Control area
Decreased		
Major carps	2	1
Boal/Pabda	-	-
Baim	1	-
Hilsa	-	-
Chital/Fali	-	-
Shing/Magur/Koi (Live fish)	3	1
Snake-head	2	-
Minor carp	1	-
Shrimp	2	-
Other species	-	-
Increased		
Major carps	-	1
Small fish	-	1

Source: FAP - 12 PIE Survey

The results from the above table support the reports of the fishermen in many cases excepting that the traders reported a decrease in shrimp which is a major concern in the project area after its implementation. Though the traders reported a decrease in major carps in impacted and control areas, a few of them also reported an increase in the control area which might be due to introduction of relatively improved fish culture. The current buying and selling prices of fishes have been compared with the prices from other sources and are tabulated in Appendix J of the FAP 12 Final Report.

7.4 CONCLUSIONS

The project has effectively prevented the annual flooding and greatly reduced flood levels and inundated areas. The embankment has blocked the migration of fish into and out of the project area and subsequent reductions in flood levels and other water areas have greatly altered the fish habitats, affecting the spawning of many fishes. Thus the project has had a substantial effect on capture fisheries. This has compelled many fishermen to adopt other professions on a part time basis in addition to their normal fishing profession.The turnover of the fish traders has declined sharply due to decrease in fish production.

On the other hand the project has provided a good opportunity for pond fish culture and restocking of water bodies within the project with quality fish seeds due to their protection from annual flooding. Unfortunately, little attempt has been made by the DOF extension officials to develop these water bodies for stocking fish. Where these water bodies have been developed for fish culture, only local landowners are found to have benefited instead of the displaced fishermen and landless labourers who were targeted in the Feasibility Report.

Though it is not possible to regain all the fishery losses due to the project, an attempt could be made to mitigate the losses through introduction of improved fish culture methods both in ponds and in other perennial and seasonal water bodies. For this purpose extension activities within the project area would have to be intensified by DOF extension staff or by NGOs.

The overall estimated outcome of the project interms of fish production losses and gain is illustrated in Table 7.17.

Table 7.17 Meghna-Dhonagoda Irrigation Project Fishery Losses and Gains

1. Area Data	
Gross area	17584 ha. (14367 ha. net)
Estimated flood land area was	13000 ha.
Area of flood land now drained	9000 ha. to 13000 ha.
Area of remaining flood land	4000 ha. to 0 ha.
Area of beels, was about 180 ha., but now all drained, i.e. loss	180 ha. - 180 ha.
Area of internal khals (Feasibility + UFO estimates)	430 ha. to 580 ha.
Area of external rivers (shared) $\frac{30\ km. \times 0.5\ (Meghna) + 30 \times 0.2}{2}$	1000 ha. to 1500 ha.
2. Fishery Losses	
a) Floodplain fully drained @ 37 kg./ha.	333 mt. to 481 mt.
b) Floodplain still flooded @ 20 kg./ha.	80 mt. to 0 mt.
c) Beels drained @ 400 kg./ha.	72 mt. to 72 mt.
d) Internal khals @ 15 kg./ha.	6 mt. to 9 mt.
e) External rivers @ 15 kg./ha.	15 mt. to 22 mt.
	506 mt. to 584 mt.
3. Culture Fishery Gains	
Area of ponds (UFO estimates)	330 ha.
Area of ponds (DOF area data)	400 ha.
Average productivity now	1400 kg./ha.
Average productivity before	1000 kg./ha.
Therefore Gain, @ 400 kg./ha.	132 mt. to 160 mt.
4. Net Loss	
Low	High
374 mt.	424 mt.

Source : Consultants, estimates

8 IMPACT ON NON-FARM ECONOMIC ACTIVITIES

8.1 INTRODUCTION

Non-farm activities are considered by FAP 12 to be essentially the small and rural industrial activities. In dealing with such activities, we have not considered activities under fishing, livestock and forestry - the subsectors which fall in agriculture in the broader sense of the term. We have, however, included trading activities (e.g. dealing in rice and agricultural inputs), shop keeping and transport businesses (e.g. rickshaw, rickshaw van, boat).

Agricultural growth is expected to give rise to growth in non-farm activities. Since the projects studied by FAP 12 have in most cases had some positive impacts on agricultural output, it is expected that there would be some linkage effects with non-farm activities. However, since these effects are mostly indirect interventions and given that there always exist many variables influencing the changes, there are serious problems in segregating the impacts attributable fully or directly to the projects.

During the RRAs first hand information was gained about the trends of change, through direct observation and interviews with informed sources, while during the PIEs short case studies were conducted in each of the PIE areas in order to substantiate the findings obtained during the RRAs and to provide further insights into aspects of change. The PIE case studies were conducted in both impacted and control areas. Because of the purposive nature of sampling, we have refrained from doing statistical analyses and tests.

During the case studies the key aspects investigated were level (number of units) of activities, seasonality, employment (annual person days worked), production, income and demand. Given that there is a wide range (more than 60) of non-farm activities, selection of the limited number of sample respondents posed problems. However, respondents were selected from all the major activities and thus the sample is believed to be representative of the non-farm economy as a whole.

Additionally, given that non-farm activities widely vary in capital intensity, scale, and employment, and given that the sample was small and the survey was brief, it has not been possible, in many cases, to perform comparisons between enterprise types. In view of this, the information provided in some of the tables is indicative and provides only a general picture of the present state of non-farm activities in the study area. Annual return figures, however, have been standardised in the form of return to family labour and management. This approach avoids the problems of imputing a wage rate for family labour, much of which is part-time and remunerated at levels well below the market wage.

The present case study on Meghna Dhonagoda was conducted in both the impacted and the control areas. In all, we have interviewed 33 enterprises, of which 15 were in the impacted area and 18 in the control area. Table 8.1 shows the distribution of enterprises by type and by age. It should be mentioned that we purposively selected relatively long established enterprises, in order to obtain information on the situation during the pre-project period and thereby enable comparison of this with the post-project situation. As can be seen from the table, all of the enterprises in the impacted areas and all but one in the control areas were established at a time before the project was implemented. The average age of the enterprises is about 15 years for the impacted areas and 17 years for the control areas. The table reveals a considerable age variation between the enterprises. On the average, the enterprises of rice milling, pottery, handloom weaving, blacksmithing, and rice trading are relatively older than other types.

Table 8.1 Sample Enterprises by Type and by Age

Activities	No. of units established							
	Impacted				Control			
	Before	After	Total	Avg. age	Before	After	Total	Avg. age
Rice milling	2	-	2	17	2	-	2	20
Wood & bamboo works	2	-	2	18	-	-	-	-
Saw mill	-	-	-	-	1	-	1	7
Furniture making	-	-	-	-	1	-	1	4
Handloom weaving	-	-	-	-	1	-	1	51
Ice cream factory	1	-	1	7	-	-	-	-
Pottery	-	-	-	-	1	-	1	30
Net Making	1	-	1	5	-	-	-	-
Cobbler	1	-	1	19	-	-	-	-
Blacksmithing	1	-	1	17	2	-	2	12
Goldsmithing	1	-	1	8	-	-	-	-
Tailoring	1	-	1	8	1	-	1	9
Carpentry	-	-	-	-	1	-	1	10
Rickshaw repairing	-	-	-	-	1	-	1	16
Stationery/Grocery	2	-	2	13	1	-	1	7
Rice trading	1	-	1	24	2	-	2	23
Rickshaw/Van transport	1	-	1	9	2	-	2	24
Boatmen	1	-	1	13	1	1	2	6
All	15	-	15	14	17	1	18	17

Source : PIE Case Studies of MDIP, October 1991

8.2 OVERALL PROJECT IMPACT

Based on the findings of the RRA of MDIP and on the case studies during the PIE, an attempt has been made to scale the degree of impact of the project on the various non-farm activities. In scaling the impacts, changes in key variables such as level of activity (number of units in operation), seasonality, employment (annual person days worked), production, income and demand for products have been taken into account. The scale of impacts (positive or negative) is as follows:

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0	- nil or negligible impact
1	- minor impact
2	- moderate impact
3	- major impact

The scale of "overall impact" is as follows:

0 - < 5	- nil or negligible impact
5 - <10	- minor impact
10 - <15	- moderate impact
15 +	- major impact

The scale of impact (positive or negative) the Project Meghna Dghonagoda has made on ten selected major non-farm activities is assessed as follows:

Rice milling	- +3	Ag. input marketing	- +2
Wood, cane & Bamboo products	- +1	Rice Trading	- +2
Furniture and carpentry	- 0	Rickshaw/Van	- +2
Blacksmithing	- +2	Water transport	- -1
Light engineering workshop	- +2	Earth work	- +3
Overall impact	- +16		

Thus the Project is assessed as having major positive impact on non-farm activities.

8.3 LEVEL OF ACTIVITIES

As in most of the other study areas, the Meghna Dhonagoda Project supports a wide variety of non-farm activities based mainly on local resources and skills, but almost all the activities are carried out at a cottage scale of activity. The most important activities include rice milling, wood and bamboo products, handloom weaving, blacksmithing, trading, transport and earth work.

8.3.1 Rice and Oil Milling

As is expected, increase in paddy intensity in the project area has given rise to increased rice milling. More remarkably, increase in irrigational equipment has eventually increased the number of small rice hullers which are usually powered by STW engines and run in off-seasons. In view of this, the growth of rice mills is not attributable fully or directly to the project. In addition to that, with the widespread increase in rice milling, the traditional method of rice husking by dheky has sharply declined. As in most other FCD/I projects, the Project areas of Meghna Dhonagoda also have shown a decline in oil presses, particularly the manually operated ones, presumably because of the decline in oilseed production in the Project area as a result of the expansion of more profitable HYV Boro cultivation encouraged by the Project.

8.3.2 Output and Input Trading

Trading activities in general have considerably increased. More particularly, rice trading has experienced a remarkable increase. Increased use of agriculture inputs such as fertilizer, seeds and pesticides has also resulted in increase in the number of traders dealing in such items.

8.3.3 Agriculture Tools and Wood Works

Saw mills appear not to have shown any growth. However, the activity of producing agriculture tools and implements, made of wood and bamboo, in the form of containers, winnower, hoes, yokes, ploughs appears to have shown a moderate growth. The number of blacksmiths producing metal agricultural implements has experienced a modest growth. The number of light engineering workshops appears to have shown an increase, probably associated with the widespread use of LLPs in the parts of the impacted area where the BWDB canal system is non-operational.

8.3.4 Transportation

The embankment has improved conditions for road transport, but the internal road network, originally planned as part of the Project, was dropped during the actual construction and thus the condition of the internal road network has been a significant constraint on development. Thus, unlike in other projects, the number of low-cost transport operations like rickshaws and rickshaw vans has not registered a significant increase in the project area. Over and above this, the Project has severely impeded boat transport, and the number of boatmen inside the Project has fallen substantially.

Apart from RRA and case study findings, some additional information on the growth of non-farm activities are available from the community survey conducted during the PIE. Table 8.2, based on such information, depicts the growth of a few non-farm activities in the project and control areas. As can be seen from the table, the relative increase in the number of rice mills and agricultural input traders has been higher in the impacted area, compared to the control area. There has been some growth in the number of light engineering units in the impacted area (increased to 6 from 2), against zero growth in the control area. Oil press units have registered a negative growth in the impacted area whereas the growth is positive in the control area.

Table 8.2 : Growth of Selected Non-farm Activities

Activities	No. of units					
	Impacted (20 Mouzas)			Control (12 Mouzas)		
	Before	After	Change %	Before	After	Change %
Rice Mill	18	87	+383	24	34	+42
Oil Press	2	1	-50	1	3	+200
Saw Mill	1	1	Nil	1	2	+100
Light Engg. Workshop	2	6	+200	1	1	Nil
Ag. Input marketing	8	29	+263	6	16	+167

Source : Community Survey.

8.4 SEASONALITY OF PRODUCTION

All the sample activities in the impacted areas, and all but rice milling, pottery and water transport in the control area, are run for twelve months a year. Few of the activities (the exceptions being rice mills in the impacted area, and rice mills and pottery in the control area) has shown any change in their duration of work at present, compared to that in the pre-project period. This is true for both impacted and control areas (Table 8.3 and 8.4).

Table 8.3 Period of Operation of Activities by Peak and Lean Season - Impacted Area

Activities	Period of Operation (months)					
	Peak Period		Lean Period		Total	
	Before	After	Before	After	Before	After
Rice milling	4.0	7.0	6.0	5.0	10.0	12.0
Wood & bamboo works	3.0	3.0	9.0	9.0	12.0	12.0
Saw mill						
Handloom weaving						
Ice cream factory	5.0	5.0	7.0	7.0	12.0	12.0
Pottery						
Net Making	3.0	3.0	9.0	9.0	12.0	12.0
Cobbler	3.0	3.0	9.0	9.0	12.0	12.0
Blacksmithing	3.0	3.0	9.0	9.0	12.0	12.0
Goldsmithing	2.0	2.0	10.0	10.0	12.0	12.0
Tailoring	6.0	6.0	6.0	6.0	12.0	12.0
Carpentry						
Rickshaw repairing						
Stationery/Grocery	5.0	5.0	7.0	7.0	12.0	12.0
Rice trading	4.0	3.0	8.0	9.0	12.0	12.0
Rickshaw/Van transport	7.0	7.0	5.0	5.0	12.0	12.0
Boatmen	5.0	2.0	7.0	10.0	12.0	12.0

Source : PIE Case Study.

8.5 EMPLOYMENT

The major non-farm economic impacts include raising of employment opportunities in rice milling in the impacted areas, part of which is definitely a result of the project's success in paddy production. The employment opportunities created in small rice hullers, however, as mentioned earlier, is not attributable fully or directly to the project. As elsewhere, the traditional method of rice husking by dheky has been in sharp decline with the establishment of more and more rice mills. As a result, some disadvantaged women (and even some landless males) have been displaced in the rural areas. In the recent past, however, rice processing by "kutials" (traders) has come into practice on a large scale. The whole process of soaking, boiling and drying is mostly done by women, particularly the distressed women, and finally husking is done by rice mills. The activity of rice trading has thus largely been able

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to provide employment to the displaced women, previously employed in traditional methods of husking.

Large-scale but relatively short term employment opportunities have been created during construction and excavation, and some additional employment has been created for unskilled labourers in earthworks done for repair and maintenance of the embankment and in rehabilitation of the canal system. However, given that the network of internal roads, as originally designed, has not been developed the employment impact of earthworks has been somewhat less than it could have been. Like most other FCD/I projects, the project has limited the navigational facilities and, in consequence, shortened the working periods of boatmen, and perhaps also of fishermen.

Table 8.4 Period of Operation of Activities by Peak and Lean Season - Control Area

Activities	Period of Operation (months)					
	Peak Period		Lean Period		Total	
	Before	After	Before	After	Before	After
Rice milling	4.5	4.0	5.0	5.0	9.5	9.0
Wood & bamboo works						
Saw mill	4.0	4.0	8.0	8.0	12.0	12.0
Furniture making	7.0	7.0	5.0	5.0	12.0	12.0
Handloom weaving	8.0	9.0	4.0	3.0	12.0	12.0
Ice cream factory						
Pottery	4.0	4.0	6.0	6.0	10.0	10.0
Net Making						
Cobbler						
Blacksmithing	5.0	5.0	7.0	7.0	12.0	12.0
Goldsmithing						
Tailoring	6.0	6.0	6.0	6.0	12.0	12.0
Carpentry	6.0	6.0	6.0	6.0	12.0	12.0
Rickshaw repairing	5.0	5.0	7.0	7.0	12.0	12.0
Stationery/Grocery	2.0	2.0	10.0	10.0	12.0	12.0
Rice trading	4.5	4.5	7.5	7.5	12.0	12.0
Rickshaw/Van transport	5.0	5.0	7.0	7.0	12.0	12.0
Boatmen	4.5	4.5	6.0	6.0	10.5	10.5

Source : PIE Case Study.

Table 8.5 and 8.6 give some information on the trend of changes in annual working days for selected non-farm activities. As can be seen from the tables, some of the activities in the impacted area have shown some increase in working days, compared to the pre-project situation; the activities are rice mills (+20 per cent), wood and bamboo products (+62 per cent) and rickshaw transport (+10 per cent). The activities having negative change in working days are grocery (-2 per cent), rice trading (-15 per cent) and boatmen (-18 per cent). The working days for all other activities appear to have shown no change. In the control areas, the working days during post-project period appear to have fallen in case of rice mills (-6 per cent) and tailoring (-29 per cent) while most other activities have shown some increase.

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Table 8.5 Working Days of Activities by Season - Impacted Area

Activities	Days of operation during						
	Peak Period		Lean Period		Total		Change (%)
	Before	After	Before	After	Before	After	
Rice milling	110	198	140	102	250	300	+20
Wood & bamboo works	75	83	135	158	210	341	+62
Saw mill							
Handloom weaving							
Ice cream factory	130	130	105	105	235	235	Nil
Pottery							
Net Making	90	90	135	135	225	225	Nil
Cobbler	90	90	225	225	315	315	Nil
Blacksmithing	60	75	108	135	168	210	+20
Goldsmithing	50	50	150	150	200	200	Nil
Tailoring	180	180	180	180	360	360	Nil
Carpentry							
Rickshaw repairing							
Stationery/Grocery	150	144	195	195	345	339	-2
Rice trading	73	78	170	208	243	286	+15
Rickshaw/Van transport	175	189	110	125	285	314	+10
Boatmen	150	60	105	150	255	210	-18

Source : PIE Case Studies, October, 1991.

Table 8.6 Days of Operation of Activities by Season - Control Area

Activities	Days of operation during						
	Peak Period		Lean Period		Total		Change(%)
	Before	After	Before	After	Before	After	
Rice milling	135	120	108	108	243	228	-6
Wood & bamboo works							-
Saw mill	120	120	160	200	280	320	+14
Furniture making	210	210	60	60	270	270	nil
Handloom weaving	216	252	60	45	276	297	+8
Ice cream factory							
Pottery	100	100	60	72	160	172	+8
Net Making							
Cobbler							
Blacksmithing	116	135	140	166	256	301	+18
Goldsmithing							
Tailoring	180	180	144	150	324	230	-29
Carpentry	162	162	72	72	234	234	nil
Rickshaw repairing	125	125	140	152	165	177	7
Stationery/Grocery	60	60	200	200	260	260	nil
Rice trading	133	130	103	135	236	265	+12
Rickshaw/Van transport	138	143	131	153	269	296	+10
Boatmen	150	150	180	140	330	290	-12

Source : PIE Case Studies, October, 1991

In common with other PIE study areas, the enterprises in the MDIP area, by and large, are family based. This is evidenced from Table 8.7. As can also be seen from the table, most of the enterprises, both in impacted and control areas are of one to two employment size group.

Table 8.7 Average Employment Per Enterprise (no. of persons employed)

Activities	Average employment					
	Impacted			Control		
	Family	Hired	Total	Family	Hired	Total
Rice milling	1.5	1.0	2.5	1.0	1.5	2.5
Wood & bamboo works	2.0	-	2.0	-	-	-
Saw mill	-	-	-	1.0	7.0	8.0
Furniture making	-	-	-	1.0	2.0	3.0
Handloom weaving	-	-	-	1.0	-	1.0
Ice cream factory	1.0	2.0	3.0	-	-	-
Pottery	-	-	-	2.0	1.0	3.0
Net Making	1.0	-	1.0	-	-	-
Cobbler	1.0	-	1.0	-	-	-
Blacksmithing	1.0	1.0	2.0	1.0	-	1.0
Goldsmithing	1.0	1.0	2.0	-	-	-
Tailoring	1.0	3.0	4.0	1.0	-	1.0
Carpentry	-	-	-	1.0	1.0	2.0
Rickshaw repairing	-	-	-	1.0	-	1.0
Stationery/Grocery	1.0	1.0	2.0	1.0	-	1.0
Rice trading	1.0	-	1.0	1.5	-	1.5
Rickshaw/Van transport	1.0	-	1.0	1.0	-	1.0
Boatmen	3.0	-	3.0	1.0	0.5	1.5

Source : PIE Case Study.

As regards the present state of person days employed in vartious activities, Table 8.8 shows that the average person days employed in the impacted areas is generally higher than those employed in the control areas; the only exceptions are rice trading and boatmen.

8.6 PRODUCTION AND INCOME

With a view to obtaining a trend of change, the respondent entrepreneurs were asked during the PIE case study, for the extent of changes (if any) in their production and income compared to the pre-project period.

The incidence of change is presented in Table 8.9. The resultant overall changes (positive or negative) in production and income for the sample (weighted by individual production and income) are presented in the last column of the table.

Table 8.8 Annual Person Days Employed per Enterprise (post-Project)

Activities	Annual person days employed					
	Impacted			Control		
	Family	Hired	Total	Family	Hired	Total
Rice milling	450	300	750	228	342	570
Wood & bamboo works	682	-	682	-	-	-
Saw mill				320	2240	2560
Furniture making				270	540	810
Handloom weaving				270	-	270
Ice cream factory	235	470	705	-	-	-
Pottery				344	172	516
Net Making	225	-	225			
Cobbler	315	-	315			
Blacksmithing	210	210	420	301	-	301
Goldsmithing	200	200	400			
Tailoring	360	1080	1440	230	-	230
Carpentry				234	234	468
Rickshaw repairing				177	-	177
Stationery/Grocery	339	339	678	260	-	260
Rice trading	286	-	286	398	-	398
Rickshaw/Van transport	314	-	314	296	-	296
Boatmen	630	-	630	290	145	435

Source : PIE Case Studies, October, 1991

As can be seen from Table 8.9, almost 87 per cent of the enterprises in the impacted area reported increase in production, and about 73 per cent reported increase in income (net of all costs including hired labour). In the control areas, however, the corresponding percentages are slightly less - 72 and 61 per cent respectively. The actual overall production of all types of enterprises taken together also appears to have shown an increase by 5 per cent in the impacted area but a decline by 11 per cent in the control area. As regards income, again the enterprises in the impacted area have experienced an increase by 5 per cent, as against a decline by about 7 per cent in the control area.

Table 8.9 Changes in Production and Income Compared to Pre-project Period

Item	Area	% of enterprises reporting			Actual change (%)
		Increase	Decrease	Same	
Production	Impacted	86.7	13.3	-	+5.1
	Control	72.2	16.7	11.1	-11.4
Income	Impacted	73.3	13.3	13.3	+5.4[1]
	Control	61.1	27.8	11.1	-6.8[1]

Source : PIE Case Studies.

Table 8.10 presents information on enterprise annual income, as at present, from various non-farm activities. Given that the enterprises under study widely vary in capital employed, scale and employment, the annual figures are standardised by computing return per family labour unit, shown in the last column of the table. The Table indicates that compared to the control areas, income per family labour for most of the comparable enterprise types is higher in the impacted areas, except for boatmen, carpentry and few other cases where, perhaps, capital employed is relatively higher.

Table 8.10 Annual Return to Selected Non-farm Enterprises
(Taka)

Activities	Per enterprise annual family income		Annual income per family labour unit	
	Impacted	Control	Impacted	Control
Rice milling	61070	22429	40713	22429
Cane & bamboo works	43335	-	21668	-
Saw mill	-	177816	-	177816
Furniture making	-	109910	-	109910
Handloom weaving	-	38748	-	38748
Ice cream factory	90403	-	90403	-
Pottery	-	22840	-	11420
Net Making	5565	-	5565	-
Cobbler	24030	-	24030	-
Blacksmithing	17205	20411	17205	20411
Goldsmithing	43300	-	43300	-
Tailoring	20700	40200	20700	40200
Carpentry	-	35700	-	35700
Rickshaw repairing	-	22295	-	22295
Stationery/Grocery	79010	33300	79010	33300
Rice trading	48000	53600	48000	35733
Rickshaw/Van transport	21025	15550	21025	15550
Boatmen	29600	23775	9867	23775

Source : PIE Case Studies

8.7 PERCEPTIONS OF BENEFITS FROM THE PROJECT

During the case studies, the entrepreneurs' perceptions of benefits from the project were recorded. The perceptions of benefits towards development of non-farm activities are presented in Table 8.11. As can be seen from the Table, 11 out of 15 (73 per cent) enterprises in the impacted area were stated to have benefited from the project, but most were stated to have benefited by way of increased demand for their output. Not surprisingly, because of the poor internal road network, the project appears to have not to have produced benefits in terms of transportation of raw materials and output (only 18 per cent mentioned otherwise).

8.8 DAMAGE BY 1988 FLOOD

The project does appear to have reduced the risk of damaging floods (affecting infrastructure and property), and in 1988 the impacted area seems to have suffered less damage than outside the polder. Table 8.12 gives information on type and extent of damage caused to enterprises by the devastating 1988 flood. As can be seen from the table, out of 15 enterprises in the impacted area, 8 (i.e. 53 per cent) have suffered losses, whereas 16 out of 18 (i.e. 89 per cent) in the control areas have suffered such losses. Also, the extent of losses caused per enterprise is much higher in the control area (Tk.5000) than in the impacted area (Tk.3000).

Table 8.11 Respondents' Perceptions of Project Benefits for Non-farm Activities)

Ways benefited	% of benefited respondents
Eased transportation of raw material and output	18.2
Increased supply of raw material	27.3
Increased demand for output	90.9
Others	-
Benefited enterprises	11
% Benefited	73

Source : PIE Case Studies

Table 8.12 : Type and Extent of Damage by 1988 Flood

Area	Total Sample	No. of units affected by 1988 flood	%	Per enterprise[1] amount of damage on account of (in Tk)					
				Structure	Machinery	Raw Material	Output	Working days	Total
Impacted	15	8	53	703	-	1000	-	1323	3026
Control	18	16	89	1117	297	268	250	3324	5256

[1] Averaged over all enterprises.

Source : PIE Case Studies.

9 GENDER IMPACT

9.1 INTRODUCTION

9.1.1 Limitations

There are several ways in which women and their roles vis-a-vis those of men may be affected due to flood control measures. Furthermore, women from different types of household, (farm, labour, fishermen) are likely to be affected differently and in different degrees. Then again, in a patriarchal society the outcome of any process, when it involves women, depends not only on the process itself but also on tradition and social factors which make the final outcome rather uncertain. What all these factors mean is that it is not possible, without a thorough investigation, to clearly understand the impact of flood control interventions on women's lives. The analyses and descriptions that follow, therefore, will only try to indicate the broad direction in which changes may have taken place, if at all, and any conclusion that may be drawn will be rather tentative, necessitating further validation.

9.1.2 The Areas of Investigation

The analyses that follow in this section fall in four broad areas, viz.,

i. nature of women's involvement in household and outside work;

ii. activities related to homestead production;

iii. nutritional issues;

iv. problems faced by women during severe floods.

In each of these areas, several issues will be picked up for focus.

9.2 NATURE OF WOMEN'S INVOLVEMENT IN HOUSEHOLD AND OUTSIDE WORK

9.2.1 Hiring of Women

In MDIP, households have been found to be only infrequently involved both in hiring-in and hiring-out of female workers. Among the farm households hiring-out is extremely rare (Table 9.1) in both impacted and control areas, while even among the farm households the incidence of hiring-in of women is not high (17 per cent of households).

In MDIP, there has been a substantial gain in paddy production due to the project, creating an opportunity for farmers to hire-in more labour and for labourers to be better employed. The above findings indicate that the output gain has only to a limited extent been translated into better employment opportunities for women.

Table 9.1 : Employment of Women in Out-of-Home Activities in MDIP
(No. of respondents)

Type of household	Hire in		Hire out	
	Impacted	Control	Impacted	Control
Farmer	12 (17)	- (0)	1 (1)	- (0)
Labourer	- (0)	- (0)	3 (10)	- (0)
Fishermen	- (0)	- (0)	- (0)	1 (7)
ALL	12 (10)	- (0)	4 (3)	1 (2)

Source : FAP 12 PIE Household Survey

Note : Figures parentheses indicate percentages of total number of respondents

9.2.2 Sexual Division of Work in Agricultural Activities

Prior to the construction of the embankment in the MDIP area the responsibilities of men and women in agricultural operations were generally clear-cut (Table 9.2). Men used to be involved mostly in field activities during the pre-harvest and harvesting periods. Women's jobs were confined mostly and not surprisingly to those which could be performed in seclusion within the household. They were thus involved in seed preservation, drying and parboiling of paddy and to a lesser extent in threshing and husking of paddy. In threshing they shared the burden with men. In parboiling and threshing women from outside the households were also employed. The patterns were the same for both the impacted and the control areas with the exception that employment of hired women were extremely rare.

In the post-project situation the basic pattern of sexual division of work has remained broadly unchanged. However, the work burden of women fell in the case of husking, in which men are now found to be engaged more frequently than before, particularly in the control area. On probing, it has been found that in the control area, mechanised husking has become more common than before due to the use of STW engines for the purpose during the off-season. Such a change was not prominent in the impacted area. On the whole, therefore, the project has had little, if any, impact on the employment of women in agricultural work.

9.2.3 Change in Agricultural Activities of Women Family Members

Several factors may influence the direction and magnitude of change in the work burden of women in agricultural activities. A rise in output which is the case in MDIP impacted area (with an estimated 191 per cent increased paddy production) will demand more of the time of women in most of the activities in which they are engaged. The actual outcome in the case of women from the family will, of course, depend on how much of the additional load is shared by either men or hired women labourers. There is no *a priori* hypothesis about such substitution and the final outcome must therefore be judged empirically.

Table 9.2: Sex-wise Role Distribution in Agricultural Work in Farm Households in MDIP (percentage of respondents)

Activity type	Impacted						Control					
	F. Women		H. Women		Men		F. Women		H. Women		Men	
	B	A	B	A	B	A	B	A	B	A	B	A
Seed pres.	98.6	97.2	1.4	2.8	22.2	22.2	100.0	100.0	-	-	43.3	43.3
Pre-harvest	1.4	1.4	-	-	100.0	100.0	-	-	-	-	100.0	100.0
Harvest	-	-	-	-	100.0	100.0	-	-	-	-	100.0	100.0
Threshing	68.1	73.6	20.8	15.3	94.4	91.7	56.7	56.7	-	-	-	100.0
Parboiling	97.2	97.2	20.8	13.9	6.9	6.9	100.0	100.0	-	-	-	-
Husking	73.6	68.1	2.5	2.8	33.3	38.9	83.3	43.3	-	-	46.7	86.7
Storage	97.2	97.2	2.8	4.2	13.9	16.7	96.7	96.7	-	-	10.0	10.0

Source : FAP 12 PIE Household Survey

The information from the MDIP area indicates that the situation is rather mixed. In the impacted area, however, more women appear to have experienced an increasing work load than a decrease (Table 9.3). In parboiling, husking and storage the those who claimed an increasing load outnumber those who experienced a decrease. This is in clear contrast to the control area where no increase in load has been claimed by anybody for any type of work, while in the case of parboiling and husking, significant numbers of women have claimed a decreased work load.

Table 9.3 : Changes in Activities of family Women in Agricultural Operations in MDIP Farm Households (No. of respondents)

Activity type	Impacted		Control	
	Increased	Decreased	Increased	Decreased
Seed pres.	17	8	0	0
Pre-harvest	0	0	0	0
Threshing	8	2	0	0
Parboiling	40	21	0	10
Husking	2	13	0	15
Storage	25	11	0	4

Source : FAP 12 PIE Household Survey

Among those who could identify the reasons for the change in the impacted area, practically all ascribed it to higher output (Table 9.4). Of the reasons identified for a decreasing work load, two types stand out clearly. One is land loss (possibly due to erosion) while the other relates to the widespread use of husking machines, particularly in the control area. A question therefore arises whether the land loss, if it is due to erosion, can be related to the construction of the embankment. The geographical boundaries of the project and control areas indicate that probably this is not so.

Table 9.4 : Reasons for Change in Women's Involvement in Agricultural Activities in Farm Households in MDIP (No. of responses)

Reasons	Impacted	Control
A. *Increase*	45	-
Higher output	40 (89)	-
Others	5 (11)	-
B. *Decrease*	45	25
Flood/water logging/rain	5 (11)	2 (9)
Land loss	17 (38)	6 (24)
Cut in emb.	-	-
More husking machines	15 (33)	12 (48)
Pest attack	-	-
Lower yield	5 (11)	4 (16)
Others	3 (7)	1 (4)

Source : FAP 12 PIE Household Survey

Note : Figures in parentheses indicate percentages of total number of response by type of change

9.3 HOMESTEAD PRODUCTION

9.3.1 Number and Types of Trees

The average number of trees per household, including bamboos, has risen in both the impacted and control areas but more so in the latter, compared to the pre-project situation (Table 9.5). The number of trees per household is the highest among the farm households as they have more land than others in and around the homesteads, but in their case one finds the lowest increase in the average number compared to the pre-project situation in the impacted area.

Many types of trees are grown in the homesteads. One may categorise them, however, as fruit-bearing or timber-yielding. The data from MDIP indicate that there has been little change over time in the proportion of the former (from 51 per cent to 53 per cent in the impacted area and remaining unchanged at 46 per cent in the control).

Table 9.5 : Average Number of Trees in and Around Homesteads in MDIP

Household type	Impacted		Control	
	Before	After	Before	After
Farmers	35	48 (37)	26	63 (142)
Labourers	5	11 (120)	13	18 (38)
Fishermen	6	4 (-33)	4	14 (225)
	24	33 (38)	17	41 (141)

Source : FAP 12 PIE Household Survey

Note : Figures in parenthese indicate percentage change over the pre-project situation

9.3.2 Sexual Division of Work in Caring for Trees

Women, whether in association with men or working alone, are involved in tree care and harvest. Their role is much more prominent than that of men in the case of collection of fuelwood and leaves for use as fuel. In planting and felling of trees their role is however quite limited. This is the general pattern across all occupational groups and in both the impacted and control areas.

What may have happened over time in the relative roles of men and women in caring for trees is difficult to assess. However, it may be noted that the percentage of fruit-bearing trees has remained unchanged while the average number trees (of all types) has gone up. This indicates that over time the work burden of women in general tree-care may have risen as it is the fruit-bearing trees which demand more attention from the tree-owners. On the other hand, however, as the demand for fuel wood per household has probably remained unchanged, if it has not increased, this may mean more time has to be spent in collection and gathering of fuel wood.

In actual decision making the process seems more participatory, even in tree-felling particularly in the impacted area in which across all the groups about 40 per cent of women have participated (Table 9.6). In other types of decision making the proportion of women who claimed to be involved is much higher.

9.3.3 Vegetable Production : Incidence and Sex Roles

Practically all households have a vegetable producing plot, usually quite tiny, no more than 0.01 - 0.02 acres in size. It appears from the information collected in the field that in the case of farmers there has been some reduction in the average plot size, particularly in the impacted area. In other cases there has been an increase in the size of the plot both in the impacted and the control area, but there seems to be no definite pattern.

For all practical purposes vegetable gardening and all types of related activities in the homestead is a woman's domain. Men help mostly with land preparation, sowing and weeding. There appears to be little difference in the patterns between the impacted and the control area.

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Table 9.6 : Incidence of Women's Role in Decision-making in Tree Plantation
(No. and % of women responding positively)

Type of household	Plantation		Harvesting		Tree-felling	
	Imp	Cnt	Imp	Cnt	Imp	Cnt
Farmers	44 (61.1)	10 (33.3)	51 (70.8)	30 (100)	28 (38.9)	0 (0)
Labourers	12 (40.0)	2 (18.1)	18 (60.0)	9 (81.8)	6 (20.0)	0 (0)
Fishermen	6 (40.0)	3 (20.0)	6 (40.0)	9 (60.0)	4 (26.7)	0 (0)
ALL	62 (53.9)	15 (26.8)	75 (65.2)	48 (85.7)	38 (33.0)	0 (0)

Source : FAP 12 PIE Household Survey

9.3.4 Poultry Keeping : Relative Sex Roles

The role of farm household women in decisions regarding poultry keeping appears to be quite prominent (Table 9.7), but they seem to be more involved in the control area than in the impacted. This may be a reflection of the greater diversity of occupation needed for survival in the control area. Lack of further information does not allow a more definitive explanation, however.

Table 9.7 : Incidence of Women's Role in Decision-making in Poultry Keeping in MDIP
(No. and % of women responding positively)

Household type	Sale		Purchase		Sale money use	
	Imp	Cnt	Imp	Cnt	Imp	Cnt
Farmer	27 (37.5)	16 (53.3)	24 (33.3)	- (-)	38 (52.8)	24 (80.0)
Labourer	9 (30.0)	4 (36.4)	5 (16.7)	- (-)	9 (30.0)	5 (45.5)
Fishermen	4 (26.7)	1 (6.7)	2 (13.3)	- (-)	3 (20.0)	3 (20.0)
ALL	40 (34)	21 (38)	31 (26)	-	50 (43)	32 (57)

Source : FAP 12 PIE Household Survey

Note : Figures parentheses indicate percentages of total number of respondents by category

9.3.5 Homestead Income and Its Use

The estimated income per household from homestead production by source and type of household for the impacted and control areas are shown in Table 9.8. The overall impression is that the average homestead income is higher in the impacted area compared to the control only for farmers. There also seem to be some difference in the composition of the income as respondents in the impacted area seem to receive a considerable proportion of their income in the form of vegetables while poultry and eggs seem to be the major source in the control area. This seems to bear out the hypothesis that with reduced flood damage households may be more induced to cultivate vegetables, and is in agreement with comments received during the RRA on increased availability of vegetables.

Table 9.8 : Average Returns from Homestead Production in MDIP
(Tk/household/annum)

Household type	Impacted				Control			
	Veg.	Pty.	Egg	All	Veg.	Pty.	Egg	All
Farmer	218 (19.4)	564 (50.1)	344 (30.6)	1125 (27)	149 (16.9)	519 (58.8)	216 (24.5)	883
Labourer	87 (21.5)	173 (42.8)	144 (35.6)	404 (-14)	82 (17.5)	283 (60.3)	104 (22.2)	469
Fishermen	72 (42.1)	54 (31.6)	45 (26.3)	171 (-45)	64 (20.6)	167 (53.9)	80 (25.8)	310
ALL	165 (20.2)	398 (48.7)	254 (31.1)	818 (26)	113 (17.4)	378 (58.2)	158 (24.3)	649

Source : FAP 12 PIE Household Survey

Note : Figures in parenthese are percentage difference over the control area returns

Very few households sell vegetables or poultry or eggs. Hence it is difficult to make any comment on the general pattern of sex-differences in receipt of sale money.

The homestead income accrues in kind and practically all of it is consumed by the household. Practically all women who answered the question on the use of the homestead income, therefore, identified it as being spent mainly for the household. Very few seemed to have spent it for personal purposes, except in some farm households in the impacted area where there has been a general rise in the economic well-being of the households.

9.4 NUTRITIONAL ISSUES

9.4.1 Caveats

A rise in income of the people living in the project area, it is hoped, would lead to better nutritional levels in the households. As a full-fledged nutritional survey was not possible during the present study, the Consultants emphasised only the level of intake of major food items which are consumed most frequently (rice, wheat, parched rice and pulses) and tried to elicit women's ideas about adequacy of food intake in the family. In addition, gender-differences in rice consumption were investigated.

The four types of food mentioned above contribute nearly 84 per cent of total calorie intake (BBS; 1991) in rural Bangladesh. Using this ratio, the total calorie consumption in the sampled households was estimated, as also was protein consumption. It should be noted that the timing of the field work for these investigations may have resulted in seasonal biases in the estimates. In MDIP the field work coincided with the latter part of the monsoon which is generally a lean period period in many areas but not so in the MDIP as aus whether transplanted or mixed with aman is an important crop in the area. Nevertheless, it is quite likely therefore that the estimates made by FAP 12 will be show a downward bias. With these caveats we turn to the estimates.

9.4.2 Food and Calorie Intake

Table 9.9 shows the estimated average consumption of rice and energy on a per capita basis. The most interesting conclusion is that the impacted area households are better off than those in the control area on both counts, and that the superiority is maintained across all occupational groups. Farmers are more fortunate than others in the sense that their consumption of rice and calories are both substantially higher than others. However, the impact of the project appears to have been most beneficial for labourers, who have gained most in the impacted compared to the control area. For fishermen, the impacted-control differences do not seem to be substantial, possibly because of the proximity of the Meghna which is a major fishing ground for both groups of fishermen.

Table 9.9 : Per Capita Daily Rice and Calorie Intake in MDIP

Household type	Rice (gms)		Kcal	
	Impacted	Control	Impacted	Control
Farmer	457 (22)	376	2100 (24)	1692
Labourer	345 (33)	260	1609 (44)	1114
Fishermen	437 (21)	362	1865 (16)	1609
ALL	430 (22)	352	1963 (25)	1569

Source : FAP 12 PIE Household Survey

Note : Figures in parentheses indicate percentage differences over control.

9.4.3 Poverty Profile

The estimated calorie consumptions were used to construct a profile of households on the basis of attainment of certain levels of calorie intake. The households were divided into three groups, viz., those categorised as hard core poor (consuming at most 1805 Kcal/person/day), absolute poor (consuming between 1805 and 2122 Kcal/person/day) and the non-poor (consuming above 2122 Kcal). The results are shown in Table 9.10.

Table 9.10 : **Distribution of Households by Level of Nutritional Poverty in MDIP** (No. of households)

Household type	Hard core		Absolute		Non-poor	
	Imp	Cnt	Imp	Cnt	Imp	Cnt
Farmer	26	14	11	9	35 (51)	7 (23)
Labourer	19	11	8	0	3 (10)	0 (0)
Fishermen	8	12	3	2	4 (27)	1 (7)
ALL	53	37	22	11	42 (38)	8 (14)

Source : FAP 12 PIE Household Survey

Note : Figures in parentheses indicate percentages of total number of respondents by category

The estimates in the table seem to confirm further the finding above that nutritionally the sample households are better off in the impacted area as the proportion of non-poor households is higher there. On further scrutiny it seems that it is mainly the farmer households in the impacted area who have benefited. The impacted-control area differences are considerably smaller in the case of other types of households.

9.4.4 Adequacy of Food Intake

The female respondents were asked about the adequacy of food intake in the family. It is not surprising, given the findings discussed above, that the sense of deprivation is felt less in the impacted area by all groups of households (Table 9.11). The pattern closely follows their replies on rice consumption and the differences between the impacted and the control areas. The labourers appear to be the most disadvantaged in both areas but more so in the control area.

Table 9.11 : Adequacy of and Gender Differences in Food Intake

Household type	Percent stataing inadequacy		Women/men ration in rice intake (%)	
	Impacted	Control	Impacted	Control
Farmer	25	37	78	84
Labourer	87	100	73	79
Fishermen	53	33	80	82

Source : FAP 12 PIE Household Survey

9.4.5 Gender Differences in Food Intake

Two indicators of gender differences were used, viz., the difference in rice intake of adult men and women, and that between boys and girls of about 8 years of age. The latter showed little difference in food intake, around 350 grammes per day. In contrast, there is an appreciable difference difference between the intakes by adult men and adult women, who have been found to consume around 20 per cent less than men. The deprivation seems to be of similar but slightly lower magnitude in the control area.

9.4.6 Consumption of Non-grain Food

A rise in income of the people, one may hypothesise, will lead to an increased consumption of quality foods like meat, fish, eggs and milk, as the income elasticity of such foods is high. Whether this is the case in the project areas experiencing a substantial growth in output has been tested in a very crude manner by looking at the frequency of consumption of such foods. Table 9.12 shows the incidence of consumption of these types of food over the week preceding the survey. Several conclusions can be drawn:

- fish appears to be the the most frequently consumed non-grain food. Practically all the households in the impacted area and in the control have consumed fish during the reference week;

- meat and eggs appear to be the least frequently consumed food both in the impacted and the control areas, but farmers in the impacted area appear to eat meat somewhat more often than those in the control;

- milk is consumed by farmers and fishermen fairly frequently in both the impacted and the control areas but somewhat less so in the latter. Labour households rarely, if ever, consume milk.

Table 9.12 Incidence of Consumption of Non-grain Food During the Last 7 Days
(no. and (%) of households)

Food type	Farmer		Labourer		Fishermen	
	Impacted	Control	Impacted	Control	Impacted	Control
Meat	22 (30)	7 (24)	4 (13)	0 (0)	3 (33)	2 (12)
Fish	70 (97)	30 (100)	30 (100)	9 (82)	15 (100)	15 (100)
Egg	21 (29)	3 (11)	2 (7)	0 (0)	0 (0)	1 (9)
Milk	47 (65)	15 (62)	3 (11)	1 (14)	9 (60)	5 (38)

Source : FAP 12 PIE Household Survey

Note : Figures in parentheses are percentages of total number of respondents by category

9.4.7 Frequency of Cooking

A substantial proportion of the farm households (22 per cent) in the impacted area cooks meals only once a day. The situation is better in the control area. For labourers, the proportion cooking only once daily is much higher in the impacted area.

9.4.8 Incidence of Starvation

Despite a growth in annual income, people may still starve partly or fully during a part of the year because of seasonal lack of employment and income. When asked about the incidence of hunger, the responses seems to indicate that there had been little change in the proportion of households so affected before and after the project, irrespective of impacted or control areas, for any specific occupational group (Table 9.13). Among the occupation groups, however, as may be expected the farmers are the most fortunate, while a much higher proportion of labourer and fishermen's households have to starve during parts of the year.

Table 9.13 : Incidence of Starvation in Pre- and Post-Project Situation in MDIP

(No. of respondents)

Household type	Impacted		Control	
	Before	After	Before	After
Farmer	40 (56)	38 (53)	17 (57)	19 (63)
Labourer	25 (83)	29 (97)	8 (73)	8 (73)
Fishermen	11 (73)	10 (67)	14 (93)	15 (100)
ALL	76 (65)	77 (66)	39 (70)	42 (75)

Source : FAP 12 PIE Household Survey

9.4.9 Seasonality in Starvation

Starvation is related to the seasonal peaks and troughs of economic activities. Aman being the major paddy crop, in general one expects a rise in dietary intake of farmers and labourers in general and a low incidence of starvation during the post-monsoon period (Bengali months of Poush and Magh). Among fishermen too this is a period of peak income both because the catches are good during the winter while the Aman harvest keeps effective demand at a high level. Where Boro is a dominant crop one would expect a dip again in or around May (Bengali months of Baishakh and Jaistha). Unless Aus is a major crop one would expect the level of income and employment to fall progressively from then and reach their lowest levels around Kartik and just before Aman harvest begins in Agrahayan (October - November) when the incidence of starvation may be the highest.

In MDIP, paddy is cultivated during all the seasons while HYVs are cultivated on nearly 87 per cent of all paddy land. In the control area, one finds mainly B. Aman, some mixed Aus-Aman and some local Boro. In none of these are HYVs important. Only 21 per cent of the paddy land is under HYVs indicating that the demand for labour, particularly hired labour, may not be very prominent in the control area. Note, however, that in the control area some wheat and potatoes are grown during the rabi period.

In the above situation the winter period dip is likely to be preceded by a rather muted peak (due to the Aus harvest) in the impacted area compared to the control. On the other hand the Boro period dip may occur earlier in the control area because of the harvesting of wheat and potatoes which take place earlier than Boro paddy in the impacted area where the dip will occur later.

The seasonal patterns in starvation for the different types of households are shown in Figs. 9.1 - 9.3. It is clear that in the case of the farmers the pattern is exactly what has been hypothesised above. In the case of labour households, the dip occurs in both Boro and and the post-monsoon seasons but the cultivation of Aus does not bring them much relief during the peak and late monsoon as these crops are not dependent on hired labour. Still, the Aus cultivation has some impact which causes the the peak to occur earlier, and during the harvest period for Aus, the proportion of starving families begins to fall.

In the case of fishermen, the characteristic winter dip occurs, but what sets the MDIP fishermen apart from those in other project areas is their opportunity to fish hilsa during the whole of the monsoon in the River Meghna. As a result the peaks in starvation during this period are largely absent in both the impacted and the control areas.

9.4.10 Adjustment Mechanisms

When the prospect of starvation looms large, people mostly either borrow from others, or try to eat less, or both (Table 9.14). This is true across all groups of households and in both impacted and control areas. There appears to be a subtle difference between the two areas, however. Those in the impacted area seems to prefer to adjust within the household by eating less while those in the control go more for borrowing. The reasons are not known.

Table 9.14 : Measures to Cope with Starvation in MDIP
(No. and % of response)

Type of measure	Farmer		Labourer		Fishermen		ALL	
	Imp	cnt	Imp	Cnt	Imp	cnt	Imp	Cnt
Borrowing	31 (43.1)	21 (70.0)	24 (80.0)	11 (100.0)	10 (66.7)	14 (93.3)	65 (56.5)	46 (82.1)
All ate less	29 (40.3)	17 (56.7)	27 (90.0)	9 (81.8)	12 (80.0)	13 (86.7)	68 (59.1)	39 (69.6)
Women ate less	27 (37.5)	16 (53.3)	10 (33.3)	6 (54.5)	5 (33.3)	9 (60.0)	42 (36.5)	31 (55.4)
Others ate less	4 (5.6)	2 (6.7)	0 (0)	2 (18.2)	1 (6.7)	0 (0)	5 (4.3)	4 (7.1)
Disin-vestment	3 (4.2)	-	-	-	-	-	3 (2.6)	-
Others	8 (11.1)	1 (3.3)	14 (46.7)	1 (9.1)	1 (6.7)	1 (6.7)	23 (20.0)	3 (5.4)

Source : FAP 12 PIE Household Survey

Note : Figures in parentheses indicate percentages of total number of responses by category of household

Figure 9.1 **Seasonal Incidence of Starvation among Farm Households**
(% reporting by month)

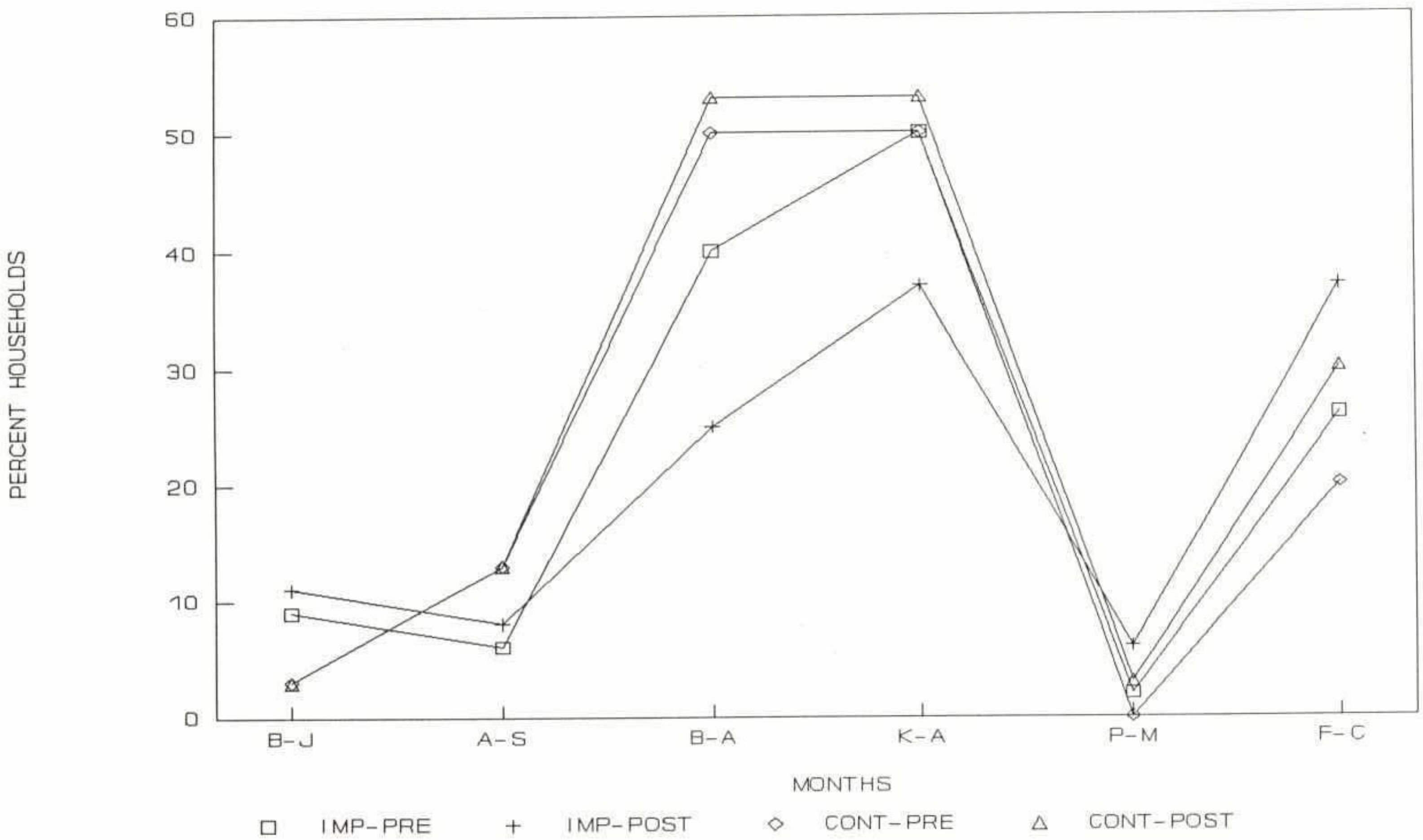


Figure 9.2 **Seasonal Incidence of Starvation among Labour Households**
(% reporting by month)

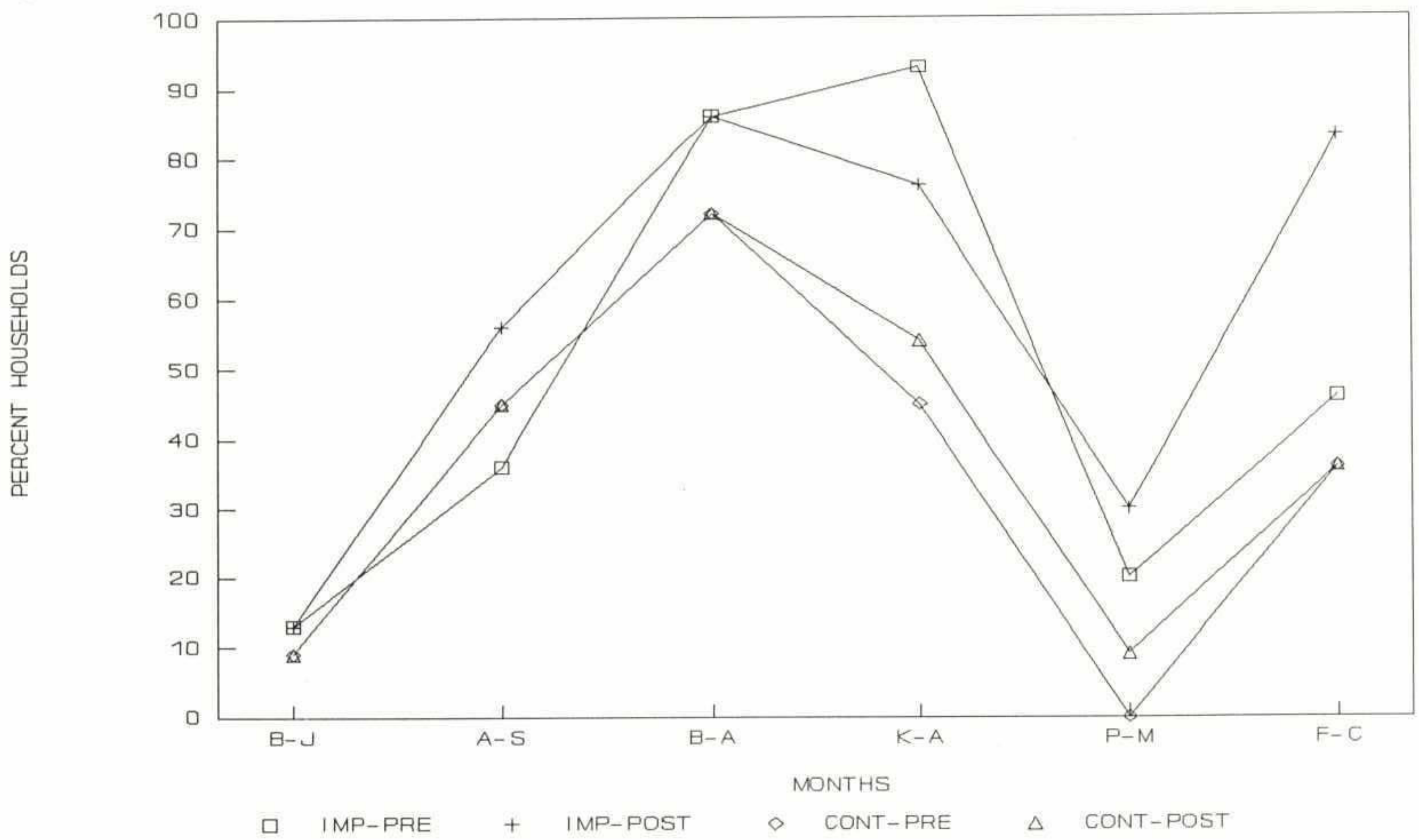
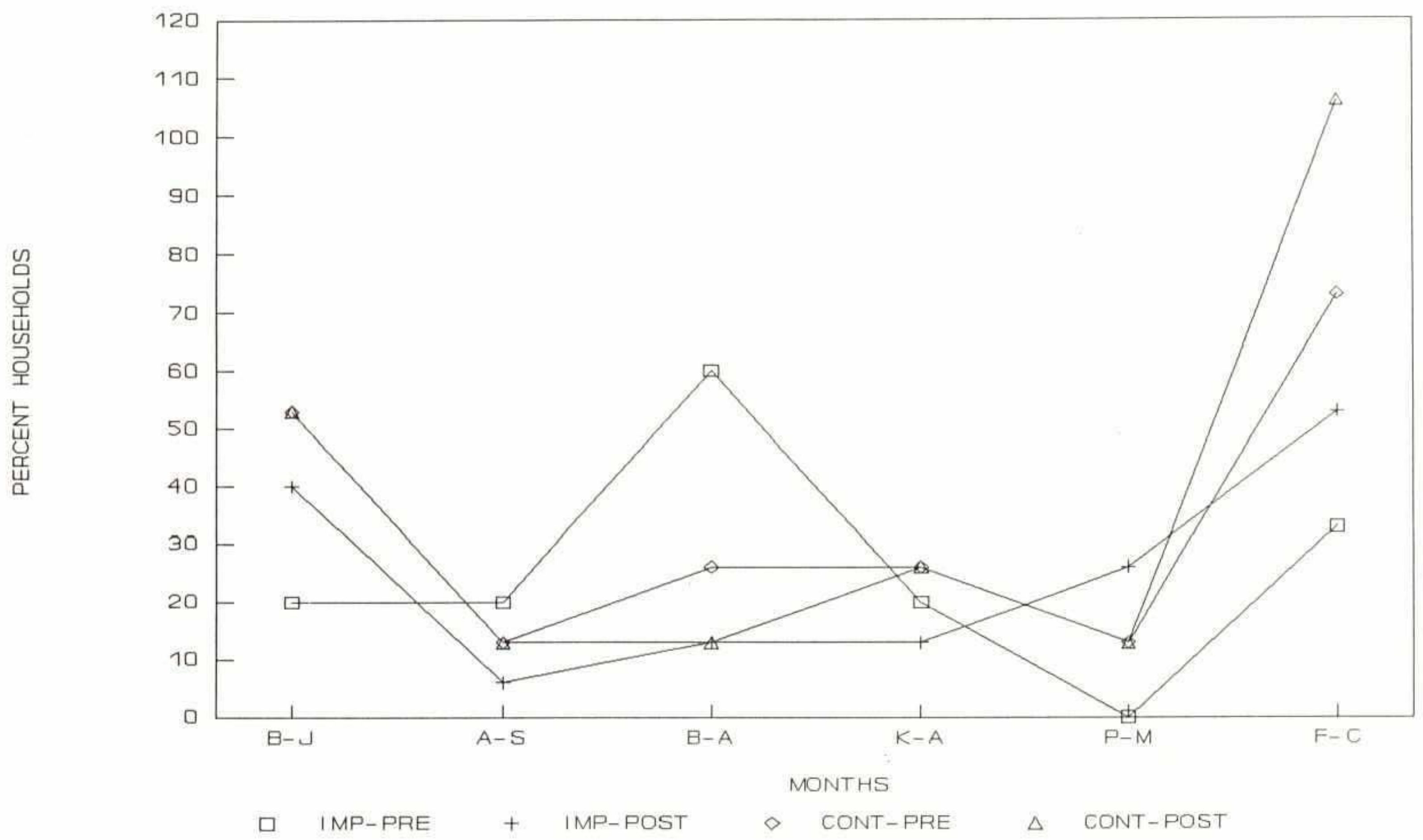


Figure 9.3 **Seasonal Incidence of Starvation among Fishermen's Households**
(% reporting by month)



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The burden of internal adjustments seems to fall disproportionately on women, and more so in the farm households. While in a quarter of the farm households in the impacted and control areas everyone in the family shares the hunger, in another quarter of cases only women alone have to do so. In the case of other types of households, the proportion of women alone going hungry is lower in both impacted and control areas. What these findings clearly bear out is that a general rise in the economic well-being in the family may be no guarantee of women's sharing the 'prosperity' equitably with their men counterparts. In times of distress, they may still hve to bear a disproportionate burden of the suffering.

9.4.11 Access to Safe Water

Table 9.15 shows the pattern of access to water by source and by type of use. The table clearly indicates that in the case of drinking water most households in both the impacted and control areas depend on safe sources (generally hand tube wells), but for cooking and cleaning the practice of using unsafe water continues, thus nullifying to a large extent the positive impact of drinking safe water.

Table 9.15 : Present Sources of Water by Type of Use in MDIP
(No. and percentage of total response by category of use by the type of household concerned)

Household type	Area	Cleaning		Cooking		Drinking	
		S	US	S	US	S	US
Farmer	Imp	2 (2.8)	70 (97.2)	5 (6.9)	67 (93.1)	67 (93.1)	5 (6.9)
	Cnt	-	30 (100.0)	-	30 (100.0)	30 (100.0)	-
Labourer	Imp	2 (6.7)	28 (93.3)	2 (6.7)	28 (93.3)	27 (90.0)	3 (10.0
	Cnt	-	11 (100.0)	-	11 (100.0)	11 (100.0)	-
Fishermen	Imp	-	15 (100.0)	-	15 (100.0)	6 (40.0)	9 (60.0)
	Cnt	-	15 (100.0)	-	15 (100.0)	12 (80.0)	3 (20.0)
ALL	Imp	4 (3.4)	113 (96.6)	7 (6.0)	110 (94.0)	100 (85.5)	17 (14.5)
	Cnt	-	56 (100.0)	-	56 (100.0)	53 (94.6)	3 (5.4

Source : FAP 12 PIE Household Survey

Note : Figures in parentheses indicate percentages of total number of responses by category of household

9.4.12 Problems of Water Quality and Associated Changes

Most women complained about changes in water quality and diseases, with the former dominating in both the impacted and control areas.

Fever, amongst adults, and gastro-enteric diseases amongst minors, are the most widespread types of diseases mentioned by women. There is not much of an impacted-control area difference.

9.5 PROBLEMS FACED BY WOMEN DURING FLOODS

Women face many problems during floods. Lack of dry space and toilet facilities creates grave difficulties for them (Table 9.16). Other major problems include those of movement and cooking. There is not much difference between the impacted and control areas except in case of movement and toilet facilities (more acute in the impacted area) and of dry space (more scarce in the control). Furthermore, homelessness appears to be a major problem in the control area. This finding corroborates the complaints made by women regarding loss of land as a major reason for the loss of their work opportunity.

Table 9.16 : Problems Faced by Women During Floods in MDIP
(% of respondents - all groups)

Type of problem	Impacted	Control
Dry space	61 (52.1)	45 (80.4)
Drinking water	11 (9.4)	8 (14.3)
Toilet	81 (69.2)	29 (51.8)
Cooking	65 (56.0)	33 (58.9)
Food availability	10 (8.6)	7 (12.5)
Movement	58 (49.6)	11 (19.6)
Homelessness	-	13 (23.2)
No problem	-	-

Source : FAP 12 PIE Household Survey

Note : Figures in parentheses indicate percentages of total number of responses.Somke respondents have given more than answer.

10 SOCIO-ECONOMIC IMPACTS

10.1 BACKGROUND INFORMATION

Meghna-Dhonagoda Irrigation Project has been relatively well studied from a socio-economic viewpoint in the pre-completion phase. In addition to the Feasibility Study (Chuo Kaihatsu, 1977) there was a major baseline survey in 1986 (CIRDAP, 1987) of eight project villages and four control area villages which included some socio-economic data and was to be a precursor to a monitoring and evaluation study which could not take place. In addition one area of the project was surveyed along with a 'control area' south of the Project as part of the overall control area for a study of the nearby Chandpur Irrigation Project (Thompson, 1990). Also the riverside parts of the Project and the adjacent areas outside the Project form a major study area for the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) which has a field station in Matlab and has investigated socio-economic indicators as part of its research programmes.

Of these studies the Feasibility Study provides very little socio-economic data, being concerned mainly with agricultural data. The sample is unclear, being either 271 or 461 farm households and an unspecified number of non-farm households, nor are details of the villages surveyed in the two stage random sample specified. The CIRDAP (1987) base-line survey covered four villages in the 'interior' of MDIP, four inside but on the 'periphery', and four in a 'control' area (actually relatively close to the Project near its south-western and north-eastern corners). Up to 200 households were supposed to be interviewed in each village, but the actual sample sizes for most variables are unclear and some data were not collected in some villages. Thompson (1990) surveyed 100 households in an area in the centre of MDIP, and 100 households to the south of the Project near to two of CIRDAP's control villages, and collected information from group interviews in nine other villages in MDIP. The PIE survey methodology of this study is fully documented in the FAP 12 methodology report. In the case of MDIP interviews were conducted with 36 clusters of respondents (24 in the project and 12 in the control area), each cluster comprising five cultivating and two non-cultivating households randomly selected in a total of 20 villages inside the project and 12 in the control area (these villages being sampled on a probability proportional to population size basis).

While it has not been possible to make as full a comparative analysis, as would be desireable, of the results of this survey against those of earlier surveys, the other surveys do help to show how changes have taken place and hence supplement the project-control area comparison methodology which has been adopted in the PIEs.

The Project had some clearly defined socio-economic targets (Chuo Kaihatsu, 1977) in addition to the general aim of improving agricultural production and thereby generating economic development. The Project was intended to create an additional 6.3 million person days of employment in agriculture and to increase the incomes of farmers by about 140 per cent. Consequent impacts were expected to be a reduction in out-migration to urban centres and improvements in communications and social services. However, the Project had no objectives for changing the distribution of wealth or for improving the position of disadvantaged groups. In fact, the project documents give no indication that the distributional impacts of the Project were considered at the planning stage.

10.2 DEMOGRAPHIC CHARACTERISTICS

The Feasibility Study (Chuo Kaihatsu, 1977) noted that there was supposedly a population of 217,601 people in the project area in 1974 with a density of 1203 per km^2. However, the 1981 census revealed a population of 257,212, and CIRDAP (1987) noted that the population intended to be served (presumably in 1987) was 280,000. Whatever the figure, it is clear that the Project had a very high population density. It was also noted that the mean size of cultivating households was 5.68 persons, compared with 6.7 in Table 10.1. Family size and sex ratio do not appear to differ significantly between project and control areas, although as is usual labouring households tend to be smaller than farming households. Likewise the level of literacy is similar in the two areas. However, in the two main components of the sample (farmers and labouring households) there is higher school attendance inside the Project than in the control area. This may reflect increased wealth in the Project and an investment by households in the future in terms of educating their children. Moreover the difference applies for both boys and girls, and is particularly marked for labouring households.

Table 10.1 Demographic Characteristics of Sample Households and Population in MDIP

Project	Farmer		Labourer		Fishermen		Others	
	Imp	Cnt	Imp	Cnt	Imp	Cnt	Imp	Cnt
Family Size	6.7	6.3	5.9	5.9	6.9	6.4	5.5	6.6
Sex Ratio	115	115	113	125	126	108	121	119
Dependency Ratio	4.5	3.8	4.1	4.3	3.6	5.0	3.5	4.7
Percentage Literate Heads	56	55	25	21	40	47	67	78
% Boys attending school	81	66	65	24	54	53	63	83
% Girls attending school	77	58	75	21	38	57	88	84

Source: PIE Survey

10.3 OCCUPATIONS AND EMPLOYMENT

10.3.1 Occupations

According to CIRDAP (1987) a relatively low percentage of household heads were engaged in farming (village figures ranging from 18-60 per cent and averaging 33 per cent) with more working as agricultural labourers (22 per cent) or as labourers in the service sector. In the PIE the households were sampled by occupation, but relatively high proportions of household heads had secondary occupations particularly in the control area (labouring) suggesting that more farms are marginal there; in both Project and control areas the main secondary occupations are labouring and trade. Despite the sampling by main income source, a number of households have multiple income sources - salaried service and trade are important primary occupations of other earners inside the Project (9 per cent of households compared with 3 per cent in the control area; overall 19 per cent of people inside the Project and 10 per cent in the control area gain some employment from these two occupations). A high percentage of earners in farming households in both project and control areas have secondary occupations, which may be a consequence of the high population paressure and small farm sizes in this region since a simmilar high incidence of multiple income sources was found in CIP (Thompson, 1990).

There have been very few occupational changes since project completion, particularly main earners moving into trade (five earners) inside the Project. Overall 8 per cent of earners inside the Project and only 3 per cent outside have changed occupations since the Project, suggesting that it has created some new opportunities for employment (or has forced changes).

10.3.2 Employment

Construction of the Project created substantial direct employment for labourers in the Project area, particularly given the need to retire the embankment twice, and the need for very substantial flood damage repairs. However, this is not a permanent gain and the availability of such work has now declined.

The Feasibility Report observed that agricultural underemployment was high before the Project, with substantial out-migration of labourers during the slack season. The RRA confirmed that there had been a common practice of labourers migrating to Mymensingh District during the monsoon for agricultural work. This has now declined and so more people can live with their families throughout the year, with quality of life gains such as being able to take part in festivals.

The PIE survey of agriculture revealed that on average there are 131 days of labour work per hectare inside the Project at full development whereas there are only 105 days per hectare in the control area. The relatively short but higher peaks in labour demand have also meant that much of the employment created in MDIP has gone to hired labourers rather than being absorbed within the family (60 per cent to hired labour in the Project and 30 per cent in the control area). Table 10.2 shows that per labourer there is reportedly 12 per cent more work inside the Project than in the control area, but that labourers' wages average the same between the two areas suggesting that labourers from outside also gain work during the peak periods.

PIE data also indicate that the seasonal availability of non-agricultural labouring work follows the same pattern as agricultural labour. However, there would appear to be more non-agricultural work available in the Project compared with the pre-project period and compared with the control area, since now fewer households reported months to be slack periods and more reported peak demand for their work.

Moreover, a feature not revealed in the PIE but reported in the RRA was some permanent in-migration of households attracted by employment and anticipated security from floods. It is also clear from the RRA that fishermen have suffered a loss of employment in the sense that fishing grounds within the Project are less productive and so the returns per unit effort are reduced and fishermen have been forced to fish more in areas outside the Project. The PIE did not focus on the transport sector, but it is known from the RRA that boat transport has declined in importance in the interior of the Project, that some employment has been created for labourers manually carrying agricultural inputs and outputs, and that the embankment now acts as a local road.

Table 10.2 Level of Employment and Wage Rates of Agricultural Labour Household Head by months, 1990-1991, MDIP

Months	Days employed				Mean Wage rate (Tk/day)	
	Impacted		Control		Inside	Control
	Mean	% days project	Mean	% days project		
Baishakh	25	99	30	-	30	28
Jaistha	24	97	21	1	28	26
Asar	16	99	16	0	23	26
Sravan	19	100	11	4	25	23
Bhadra	18	100	10	4	25	21
Aswin	13	100	7	0	21	21
Kartik	10	99	10	0	20	23
Agrahayan	23	99	23	1	28	31
Poush	22	99	19	1	26	26
Magh	20	100	19	1	24	24
Falgoon	18	98	18	1	23	22
Chaitra	20	98	19	0	24	23
Mean	19	99	17	1	24.8	24.5
Total	228		203			

Source: PIE Surveys

10.4 INCOMES

10.4.1 Introduction

The PIE survey provided an opportunity to compute household incomes and to investigate the distributional differences between project and control areas and hence the potential distributional impacts of the Project. However, it is important to recognise the limitations of this analysis. It is not known whether Project and control areas differed in their income distributions before the Project. Although, to the extent that water regimes and cropping patterns were similar at that time, it is hoped that there would have been similar agriculture related income levels, differences in land tenure, holding sizes and non-farm employment opportunities could still have meant that income distributions differed. Also, the incomes are based on the reported agricultural outputs in the year 1990-91 which may not be typical (although this appeared to be a normal monsoon) and on reported agricultural inputs and their costs (which are subject to a considerable risk of distortion due to a lengthy recall period. Other income sources are based on the incomes reported in direct questioning and again will be approximate figures because of recall problems. With the exception of livestock (where costs of production have been subtracted) they do not take account of any costs incurred.

10.4.2 Income levels and inequality

With these qualifications, Table 10.3 shows that per capita incomes are 47 per cent higher in the Project than in the control area. Incomes of cultivating households were (in 1990-91) 49 per cent higher in the Project area compared with the control area, a substantial difference but a far cry from the intended 140 per cent gain. However, this was to be expected since Chapter 5 shows that the without or pre project agricultural performance was underestimated by the Feasibility Study. There has not been a noticeable gain for non-farming households in terms of household incomes (even though they appear to have more work than they otherwise would have had) - non-farm per capita incomes are only 6 per cent higher in the Project area. Hence the difference between incomes of landed and landless is higher in the Project (and almost certainly because of the Project), the ratio of landed to landless incomes being 3.2:1 in the Project area and 2.3:1 in the control area.

Table 10.3 Household Income by Landholding Category MDIP (Tk in 1990-91)

Landholding	Impacted				Control			
	No. hh	Tk/hh	Tk/person	Tk/earner	No. hh	Tk/hh	Tk/person	Tk/earner
≤ 20d	61	14356	2502	10425	24	11148	1939	8108
21-100d	45	28453	4157	20324	39	18057	2851	10835
101-250d	46	37227	5471	23784	12	26084	3726	14905
251-500d	11	49287	6454	33885	7	38924	6487	22706
501-750d	4	179210	25601	89605	2	70178	11696	46785
+750d	1	78824	15765	78824	0			
All hh	168	30990	4785	21338	84	20210	3246	12669

Source: PIE Surveys

Income distribution has been assessed by dividing the sample according to the size of land holding. Up to 20 decimals was used as the 'landless' category since few households with such an area have any cultivable land of their own, thereafter the standard farm size ranges used in Government of Bangladesh publications were used (Table 10.3). The table reveals that some gains have accrued to each landholding category, but that the differentials

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are wider in the Project compared with the control area. Taking the largest two landholding categories in MDIP together, their average per capita income of Tk 23870 is 9.5 times greater than that of the smallest landholding category, while in the control area the largest landholding category receive on average Tk 11696 per person which is 6 times the income of the smallest landholding households.

Table 10.4 Source of Household Income by Landholding Class, MDIP

a) Impacted area

Landholding	No. hh	Percentage of income from:										
		Cultivation	Trees	Homestead	Livestock	Salaries	Business	Rents	Crafts	Fishing	Transport	Wage labour
< 20d	61	24	6	2	4	14	0	0	4	3	0	44
21-100d	45	54	5	1	4	19	2	2	5	2	1	6
101-250d	46	59	6	1	3	16	3	3	5	1	1	2
251-500d	11	76	6	1	0	4	6	2	0	5	0	0
501-750d	4	82	2	0	1	14	0	1	0	0	0	0
+750d	1	24	2	0	-1	62	0	13	0	0	0	0
All hh	168	56	5	1	3	16	2	2	4	2	1	9

b) Control area

Landholding	No. hh	Percentage of income from:										
		Cultivation	Trees	Homestead	Livestock	Salaries	Business	Rents	Crafts	Fishing	Transport	Wage labour
< 20d	24	8	6	1	1	0	0	0	17	3	4	59
21-100d	39	36	6	1	4	11	0	0	11	3	1	26
101-250d	12	52	10	1	2	10	0	9	7	3	0	6
251-500d	7	59	3	1	1	6	7	20	2	2	0	0
501-750d	2	35	3	1	4	9	0	46	0	2	0	0
+750d	0											
All hh	84	38	6	1	3	8	1	9	9	3	1	21

Source: PIE survey

10.4.3 Sources of income

The main occupations of the surveyed households have already been discussed, but households often have multiple income sources, and the role of different income sources varies between landholding categories. Table 10.4 gives a breakdown of the incomes of households by source, showing that cultivation is relatively more important in the Project area (even for households with very small landholdings), and that labouring is more important in the control area, including for households with up to one acre of land. However, some of the difference between Project and control area may result from the higher proportion of incomes derived from salaries in the Project. Incomes in the control area are more heavily dependent on agriculture since larger landowners derive a considerable part of their incomes from rentals -leasing out land, whereas salaried employment lies outside the Project (there being not even an Upazila town inside the Project), which has better communications to Dhaka (by means of launch) than the control area.

Table 10.5 Sources of Income and Income Levels of Non-Cultivating Households, MDIP

Income Source	Percentage of total income derived from that source				
	Protected area		Control area		Combined
	CIRDAP[1]	PIE[2]	CIRDAP[1]	PIE[2]	area[3]
Mean income Tk/household	10635	10681	11047	10106	15200
No households	101	48	14	24	69
Trees and homestead	4.4	9	3.7	9	2
Livestock	3.6	3	0	2	na
Service and salaries	28.1	12	9.7	1	16
Trade and business	13.9	0	0	0	23
Crafts	4.2	4	25.0	4	na
Rent	na	0	na	0	3
Fish	9.9	4	19.0	4	na
Transport	na	0	na	6	15
Wage Labour	32.6	69	41.3	67	40
Other	3.3	na	0	na	1

Note: 1 CIRDAP incomes in 1986 prices,
2 PIE incomes in 1991 prices
3 data from MDIP, control area south of MDIP and an area of Lakshmipur District in 1987 prices from Thompson (1990)
na not asked/not reported separately

Source: PIE Surveys and recalculation of data in CIRDAP (1987) and Thompson (1990)

CIRDAP (1987) reported on the sources of income of landless (non-cultivating) households in MDIP and a control area just prior to Project completion. The basis of that study's sample is unclear since not all studied villages have non-cultivator data, but Table 10.5 compares the results of that study with the PIE results. The similarity in incomes per household is notable, but would imply that real incomes have declined considerably for non-cultivators during the five years of the Project. However, much higher proportions of incomes in both Project and control area in the CIRDAP survey are derived from salaries and trade, with a consequently lower contribution from labouring, and hence the CIRDAP households were likely to have higher real incomes. Since the PIE revealed no evidence of major occupational changes this implies that income sources in the villages surveyed by CIRDAP were different initially from those found in the PIE surveys. This seems to be borne out by the data from Thompson (1990) which combines both Project and control areas and also shows a high income contribution from salaries and trade. Hence no conclusion on any changes in the sources of incomes can be reached, but it is clear that the landless have not made any substantial gains and in general have not found new sources of employment.

10.5 LAND

10.5.1 Land holding distribution

Table 10.3 showed considerable inequality in landholding distribution in both Project and control areas, which had also been shown by CIRDAP (1987) with 10-50 per cent landless in different villages of MDIP. In the PIE samples, in both Project and control areas 50 per cent of cultivated land is controlled by about 15 per cent of the households. Section 10.4 showed the positive correlation between landholding size and household income; hence, if any changes in landholding distribution have taken place following the Project, this might affect income distributions. It might be argued that an FCDI project would reduce changes in landholding since it prevents flood losses which lead to distress sales, or alternatively that the agricultural gains created by a project cause those with surpluses to buy more land. There is a general tendency with increasing population for holdings to become smaller.

The PIE investigated land sales and purchases and losses to the Project since just before completion. Inside MDIP, 36 per cent of households had lost land and only 5 per cent gained land during that time, whereas in the control area 20 per cent lost land and 7 per cent gained land. Despite this number of changes in holding, there were few changes between landholding categories (as defined in Table 10.3). Sixteen households inside MDIP fell to the next lowest landholding category, while only two increased their holding to a higher category, but in the control area only two households fell from small to marginal holdings and one rose from 'landless' to a marginal farm. It is likely that this pattern reflects the impacts of the 1987 and 1988 floods when MDIP breached and farmers lost their Aman crops, since the peak of land sales in the Project was in 1988 and 1989 (96 per cent of sales by sample households in the period from 1986), while the peak in the control area was in 1989 and 1990 and was less marked (74 per cent of sales), see Table 10.6. An additional factor applying before project completion was the relatively high land take of the Project for project infrastructure (see Section 10.5.2).

Table 10.7 shows that increases in land prices have been comparable for irrigated land in both project and control areas (since about 1986), although obviously the area under irrigation has expanded more in the Project area. However, non-irrigated land values have increased more in the Project and this presumably reflects the agricultural benefits in recent years from flood protection and drainage, although it may also be in anticipation of the provision of irrigation facilities where the irrigation system is still being repaired. Given the agricultural benefits, increasing land productivity, and potential for more stable agriculture, it may be that in future the trend for declining holdings in MDIP may be reduced.

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Table 10.6 **Amount of Land Purchased and Sold (dec)., MDIP**

Year	Protected		Control	
	Purchased	Sold	Purchased	Sold
1986	-	-	-	-
1987	73	7.5	-	75
1988	32	295	72	18
1989	82	265	22	180
1990	114	15	32	97
1991	45	-	18	6

Source: PIE Surveys

Table 10.7 Land Price in Meghna-Dhonagoda (Tk./dec)

Irrigation status	Protected			Control		
	H	M	L	H	M	L
Irrigated						
Pre-project	591	462	486	485	537	470
Post-project	1181	1137	1026	1200	1000	942
% Change	+100	+146	+111	+147	+86	+100
Non-Irrigated						
Pre-project	549	368	410	645	525	450
Post-project	1094	839	847	1102	904	818
% Change	+99	+128	+106	+71	+72	+82

Note: H - High land, M - Medium level land, L - Low land
Pre-project = about 1986, Post-project = mid-1991

Source: Mouza Surveys

10.5.2 Land Acquisition

Because MDIP is an FCDI project with irrigation distribution within the Project by gravity, it has had a relatively large land take compared with the benefited area (total Project area of 17,584 ha, land acquired 1611 ha). Hence Table 10.8 shows a high percentage of households losing land to the project - it would appear that over 25 per cent of households lost on average 33 decimals of land. The process of land acquisition inevitably leads to discontent. However, Table 10.9 shows that compensation paid was in broad alignment with the pre-Project prices of land (Table 10.7). The problems encountered by land owners were moderate delays in payment (about 7-8 months) and the high proportion (66 per cent) reporting the need to pay a bribe/commission amounting on average to 12 per cent of the compensation paid. An additional problem encountered in part of the Project area was the need for repeated land acquisition because of embankment retirements. Thus, in the south-west of the intended project, people who had expected to benefit from the Project found that their land was acquired, or worse, that their land was not acquired but was eroded by the Meghna.

Table 10.8 Incidence of Land Acquisition, MDIP

Category	Land Type		Total
	Homestead	Agricultural	
No. of households	3	47	49
% of household affected	1.8	27.8	29
Total area acquired (dec.)	11	1652	1663
Mean per HH with land acquired (dec.)	3.7	35.1	33.9

Source: PIE Surveys

Table 10.9 Payment of Compensation for Acquired Land, MDIP

Indicator	No. of Cases Plots	Mean area of plots acquired (dec.)	Total land acquired dec.	Compensation			Mean bribe Tk./dec.
				Average Tk. per case	Average Tk. per dec.	Mean months taken	
Not compensated	6	29	103	-	-	-	-
Compensated bribed	38	34	1276	18094	539	7	66
not bribed	14	20	284	11169	551	8	-
All cases	58	29	1663				-

Source: PIE Surveys

10.6 INVESTMENT AND QUALITY OF LIFE

10.6.1 Quality of Life

One measure of the ultimate impact of the Project on living standards is whether the housing stock has improved. Table 10.10 shows that inside the Project the housing stock is somewhat better with more tin and tiled roofed houses and that their condition is on average somewhat better. However, this may not be a project impact since Thompson (1990) also noted a high percentage (44 per cent) of tin walled houses in MDIP, either reflecting greater pre-Project affluence or lower availability of jute sticks and grasses.

Table 10.10 Percentage of Households with different House Types, MDIP

Construction Type (Main Room)	Impacted	
	Protected	Control
CI Roof and Wall	33	22
Thatched Wall/Tile	57	50
Thatched Roof Wall	10	29
Condition of Main House		
Good	24	10
Fair	46	51
Bad	30	40
Invested in New Construction Since Project		
Major Repair	41	43
New Room	9	6
None	50	51

Source: PIE Survey

Table 10.11 suggests that already fisheries inside MDIP may have declined to the extent that fewer households own nets. Likewise comparing the asset structures reported by CIRDAP (1987) with those found in the PIE suggest5s that boat ownership may have declined (from 45 percent in 1986 to 14 percent in 1991 in the Project, but also from 38 percent to 22 percent in the control area). Only the higher ownership of HTWs might indicate investment of higher incomes in improving living standards, however access to tubewell water for drinking is no different between Project and control areas (96 per cent of households). Likewise sanitation facilities do not differ between the two areas. The dependence of many farmers in Project and control alike for hired in draught power is clear, and this may also limit the proportion of agricultural benefits accruing to small landowners.

A key aspect of quality of life is the quantity and seasonal intake of food. Households on average may have experienced some improvement in food consumption since there is a difference between Project and control areas. Although the seasonal pattern of 'partial starvation' reported is little different between the two areas (Figures 10.1 and 10.2), it does appear that on average satisfaction with food intake is higher inside the Project, particularly during the monsoon months. This is likely to be a result of the major growth in Boro cultivation.

Figure 10.1 Monthly Pattern of Food Consumption, Protected Area

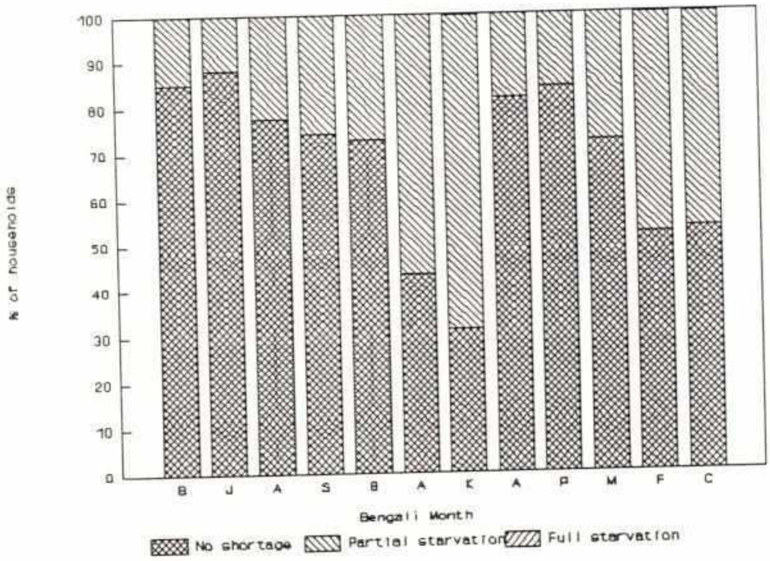
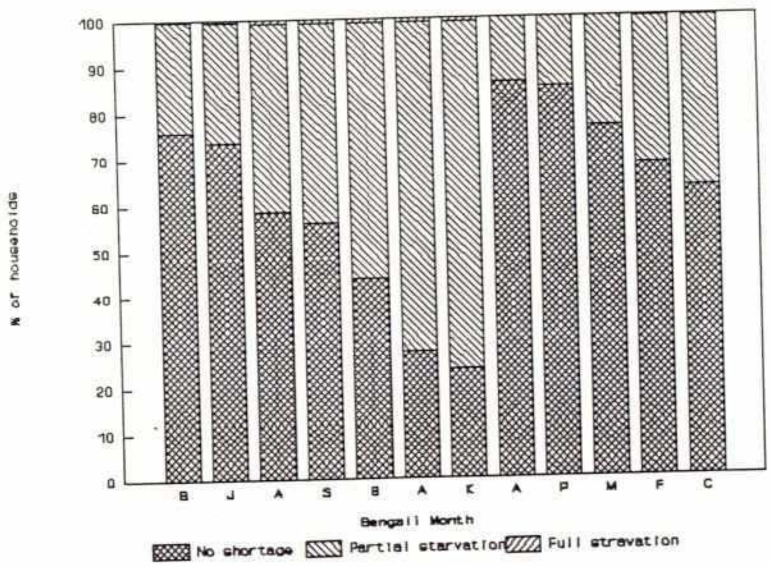


Figure 10.2 Monthly Pattern of Food Consumption, Control Area



Source: PIE Survey October 1991

Note: For Bengali months see Glossary

Table 10.11 Incidence of Ownership of Selected Non-land Assets and Tools (percentage of households owning), MDIP

Type	Farmer		Labourer		Fishermen		Others	
	Imp.	Cont.	Imp.	Cont.	Imp.	Cont.	Imp.	Cont.
Plough	38	42	-	-	-	-	7	11
Fish Net	40	62	23	42	93	80	7	27
Boat	14	22	2	13	80	-	28	17
Bicycle	4	2	-	-	-	-	-	-
HTW/MOSTI	26	12	-	-	-	-	14	17

Source : PIE Surveys

10.6.2 Credit and Investment

The move to crops with high input demands in MDIP should have created a greater demand for credit and increased use in cultivation. Table 10.12 shows on average more households taking loans of more money within the project (farmers receive credit averaging 82 per cent higher inside the Project), but farmers inside the Project still only report using a small proportion (14 per cent) of these loans for investment in agriculture.

Table 10.12 Credit Use During 1990-91, MDIP

	Protected		Control	
	Farmer	Non-cultivator	Farmer	Non-cultivator
No. hh	120	48	60	24
No.receiving loan	60	40	27	15
Mean loan (overall hh)	2767	1531	1516	885
Percentage use of loans				
Cultivation	11	0	4	0
Livestock	3	0	0	0
House repair	1	7	3	0
Necessities	81	91	84	100
Social function	4	3	8	0

Source: PIE Surveys

10.7 RECENT FLOOD EXPERIENCE

10.7.1 Incidence of Flooding

Before the Project the MDIP area was regularly inundated - 95 percent of mouzas reported flooding every year in the pre-Project period. Since Project completion there have been two floods in 1987 and 1988 (see Chapter 2) when the embankment breached and all villages were affected; likewise the control area villages reported only two years of flooding since Project completion (although they reported flooding either every year or in some years before 1986). Hence, since the Project was completed MDIP has flooded when outside areas were flooded, although the incidence of 'floods' in the Project may be reduced.

10.7.2 Crop Damage

In 1987 and 1988 crop damage inside the Project was worse than in the control area because of the sudden inflow of water (Table 10.13). However, the information given in community surveys may not give a true picture: from the community surveys undertaken in 1988 by Thompson (1990) very few experienced damage to Aus crops (which was to be expected since the breach occurred after most was harvested), whereas Aman (particularly HYVs) were flooded deeply and for two months and hence were destroyed.

Table 10.13 : Percentage of normal yields achieved

Crops/ Project	1987			1988		
	Prot.	Unprot.	Control	Prot.	Unprot.	Control
B. Aman	20	-	50	15	-	33
L.T. Aman	8	-	38	3	-	32
HYV Aman	8	-	70	7	-	20
B. Aus	15	-	65	12	-	40
HYV Aus	26	-	50	22	-	25
Jute	26	-	73	22	-	55

Source: Mouza Surveys

10.7.3 Non-crop Damage

The household surveys revealed that 97 percent of households inside the Project and 88 percent in the control area were affected by flooding in 1988, and that flooding of the homestead area was on average deeper inside the Project (Table 10.14). As a consequence damages to homesteads (buildings and other property) were about 76 per cent higher inside the Project than outside it (Table 10.15). Hence, in a breach situation the Project has not provided any greater security from flooding; in fact it worsened the flood experience, although in more normal years (since 1988) it has obviously greatly benefited agriculture.

Table 10.14 Characteristics of Last Flood of Homestead, MDIP

Flood year	Characteristics	Protected	Control
1988	No.hh water in household	163	74
	Mean depth ft.	2.95	2.30
	Mean duration days	21	18

Source: PIE Surveys

Table 10.15 Non-Crop Damage in 1988, MDIP

	Characteristics	Protected	Control
Affected	No. hh	163	74
	Tk/hh	1433	813
Damaged	No. hh	157	73
	Tk/hh	1488	824
% flooded hhh reporting damage		96	99

Source: PIE Surveys

10.8 LOCAL PARTICIPATION, OPINIONS AND SOCIAL CONFLICTS

Although a complex system for management of the Project after completion involving farmers and administration was proposed (Chapter 4), there was no public participation in the planning of the Project. During design and construction there was no effective consultation or discussion with local people, although in six out of 20 villages there was a local committee for implementation. For most people participation amounted to paid work on project construction, which provided employment for most (83 per cent) of the landless households surveyed and for a substantial number of cultivating households (30 per cent), some of whom acted as contractors or labour leaders. Dissatisfaction arose from the land acquisition process, as has been discussed, and also from the Project failure in 1987, so that people were reluctant to attempt to strengthen the embankment in 1988 when the danger of breaching became apparent. It was reported that in 65 per cent of villages visited in the Project, people doubted the necessity of the Project, although in only 15 per cent of these did the Project result in feuds.

Opinions regarding the impact of the Project appear somewhat conflicting. Sixty eight per cent of households reported flood protection benefits to crops (and over 50 per cent noted an extra crop could be grown), but the same percentage reported better communications even though 38 per cent complained of the decline of water transport. Damage to the capture fishery has clearly been a major problem perceived by project inhabitants (77 per cent reported it to be a disbenefit), but despite the apparent good agricultural performance 45 per cent reported problems of waterlogging. Other than these, the main problem created by the Project is regarded to have been embankment damage (47 per cent), although pollution of water bodies is also regarded to be a problem by 32 per cent of households.

There was very wide agreement among respondents on the distribution of benefits and disbenefits (Table 10.16) from the Project and the qualitative information from project inhabitants is also consistent with the data reported: that farmers (particularly the large ones), but also the landless, gained; and that fishermen, boatmen and people outside the Project disbenefited (in this particular case the latter were not captured in the PIE sampling).

Hence the Project has polarised differences between groups - some benefiting and others losing, with all disadvantaged in the first two flood seasons. Problems with the Project have created some distance between officials and local people. Had local people been consulted at the early stages of the Project, local cooperation and participation might have been strengthened.

Table 10.16 Percentages of Respondents Believing that Different Interest Groups Benefited or Disbenefited from MDIP

Category	benefit	disbenefit
Large landowners	90	1
Marginal landowners	5	1
Mainly labourers	75	1
Mainly farmers	57	2
Mainly fishermen	1	65
Mainly buisinessmen	11	5
Mainly boatmen	1	47
People outside project	0	39
No Households	168	168

Source: PIE Surveys

11 ENVIRONMENTAL EVALUATION

11.1 PRE-PROJECT SITUATION

The Meghna-Dhonagoda Irrigation Project (MDIP) was constructed over a period of nine years, from 1978 to early 1987. Thus there have been five monsoon seasons to date, including the exceptional 1987 and 1988 years. The main components planned were irrigation, based on two main pump stations and two internal booster stations, and a network of mainly gravity flow canals; flood protection, from a perimeter embankment; and drainage, along both artificial channels and natural khals, removed by pumping from the two main stations. Other components were to have included navigation locks through the embankment, agricultural and fishery support through a pilot farm and strengthened extension services, and a comprehensive internal roads system; none of these have materialised. MDIP, therefore (and despite its name), is an FCD/I project, but with much more emphasis than usual on irrigation.

The FAO (1988) agroecological maps and reports, which cover the whole of Bangladesh, provide a reasonable overview of pre-project environmental conditions. Agroecological regions (AER) and subregions (AES) are mapped, along with soil associations. Maps and reports are based on soil surveys and related field studies during the period 1965-1977. In MDIP the relevant soil survey took place in 1967 and was revised in 1971. The reports review physiography, drainage, climate, soils, water resources, land use and constraints, development potential, research needs, and ecological hazards.

Other pre-project information and trends have been derived from the discussions and in-depth interviews during the RRA and environmental field visits in March-April and November, 1991, and from the sources noted in Section 11.3.6.

The MDIP Area forms an island between weakly tidal stretches of the Meghna River and of its anabranch formed by the Dhonagoda and Gumti Rivers. The whole area falls within FAO's Middle Meghna River Floodplain AER. This occurs where young Meghna alluvial sediments have partially buried what was the active meander floodplain of the Brahmaputra River until about 200 years ago. Thus the land comprises old sandy chars, with variable depths of younger and finer sediments deposited on them.

The result is a variable pattern of ridge-and-trough topography throughout the Project Area, so that the typical saucer-shaped relief of many FCD projects does not occur. The peripheral rivers have not as yet had time to establish commanding levees to form a central depression, although the process has begun. As a result there are no large beels in the area.

FAO does not attempt to differentiate AES in this complex landscape, although a degree of correlation between their soil associations and subtle but distinctive topographic patterns have been established in the Project Area (Table 11.1). These form agroecological divisions (AEDs), as defined by FAP 12 (1991b). They are mapped in Figure 11.1 and the different characteristics of the AEDs are schematically illustrated in Figure 11.2. The refinement by FAP 12 reflects the very small scale (1:750,000) of the FAO soil maps, compared to the FAP 12 scale here of 1:75,000.

Table 11.1 : Meghna-Dhonagoda: FAO Agroecological Classification

Agroecological Region	MIDDLE MEGHNA RIVER FLOODPLAIN		
Soil Association	Mm 769	Mm 771	Mm 770
Approx % of Area	71	22	7
Land Types (Flooding -cm)	%	%	%
Settlements	18	12	25
H (0)	0	0	0
MH1 (0-30)	0	0	0
MH2 (30-90)	0	0	0
ML (90-180)	65	75	53
L (180-300)	17	13	22
VL (300+)	0	0	0
Total	100	100	100
Agroecological Division: FAP 12	A	B	C
Approx. % of the Area	43	50	7

Sources : FAO, 1988 and FAP 12

Pre-project conditions in the three agroecological divisions (AEDs) are discussed below. The nomenclature is from FAP 12, as FAO had not established any at this level. Differences between the three AEDs are not as marked as in the other FAP 12 PIE areas.

AED A: Old Meghna Floodplain

The Old Meghna Floodplain (AED A) occupies the north of the Project Area, accounting for 43 per cent (about 7,600 ha) of the total area. It has marginally the highest average elevation (mostly 2-4 m above PWD datum) in the Project Area but differs from land further south more in its distinctive, regular terrain of narrow ridges and wider, parallel troughs (Figure 11.2) forming an obvious pattern tending north-north-west to south-south-east.

AED A consists wholly of FAO's Soil Association Mm 769, in which the narrow ridges were almost entirely occupied by settlements, even pre-project. ML land slopes down to form the troughs, with a narrow bottomland of Land Type L, in which a small north-flowing, seasonal khal often occurred. It is possible that this topographic pattern has been largely created by man, with the ridges consisting mostly of made land.

In pre-project times, flooding by the tidal rivers and heavy rainfall (about 2,300 mm per year) badly affected all but the narrow ridges, which only suffered in the highest floods (Table 11.1).

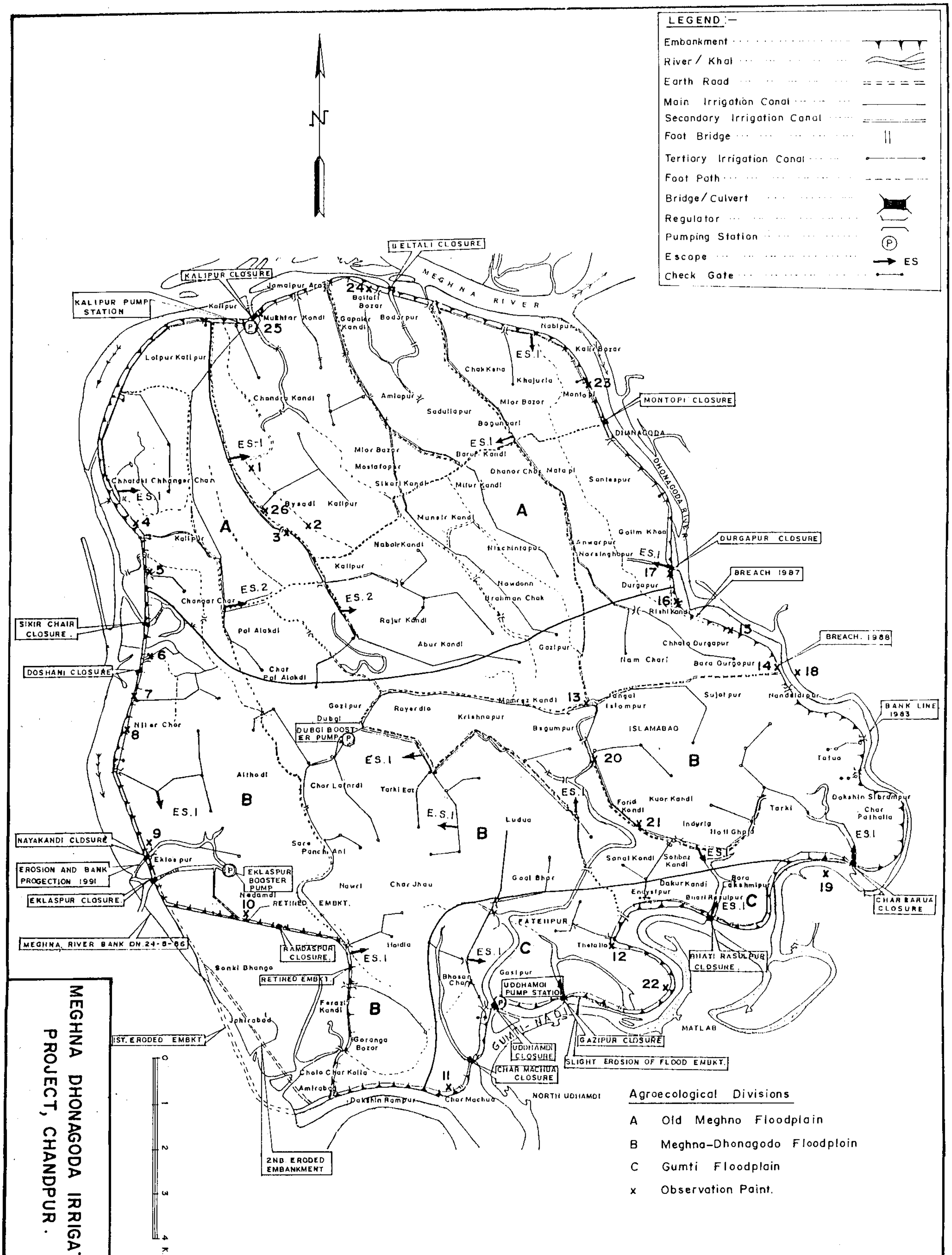
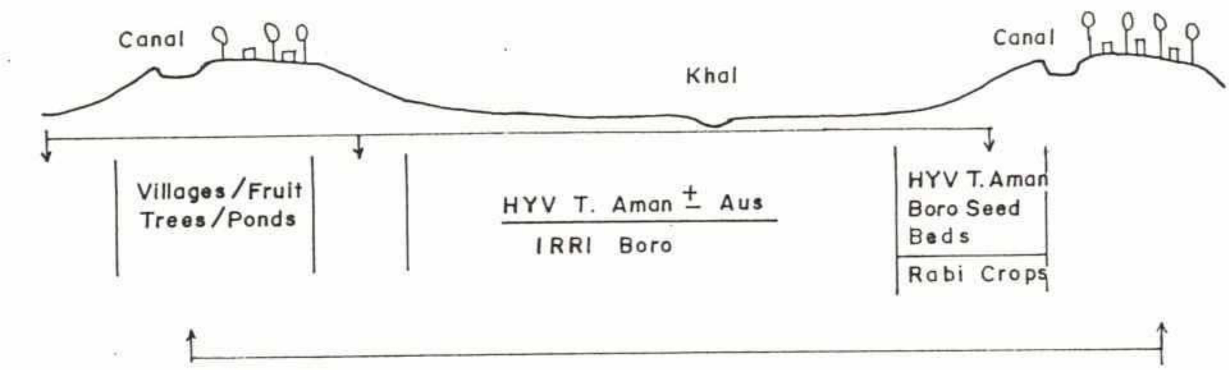


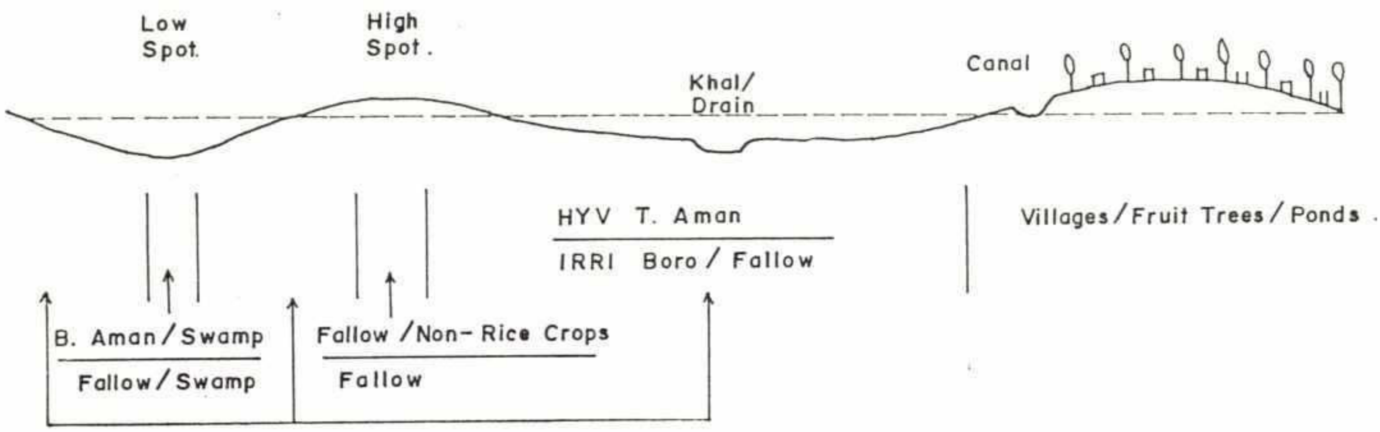
FIGURE: 11·1 AGROECOLOGICAL DIVISIONS AND OBSERVATION POINTS.

FIGURE : II·2 **MEGHNA — DHONAGODA : AGROECOLOGICAL DIVISIONS (AED**

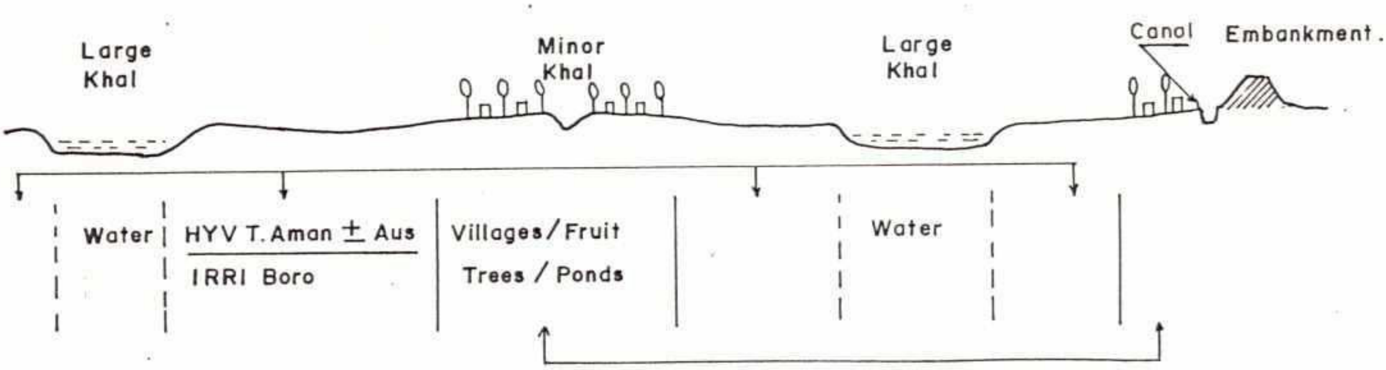
AED A : Old Meghna Floodplain



AED B : Meghna — Dhonagoda Floodplain



AED C : Gumti Floodplain



Soils are classified by FAO (1988) as Noncalcareous Grey Floodplain Soils (Eutric Gleysols). The highest ridge soils are probably anthropic. On the ridge flanks silt loam and silty clay loam are dominant in the upper soil layer, grading down into silty clay or clay on lower slopes and bottomlands. Topsoils are strongly acid due to paddy cultivation (pH 4.5 - 5.5) but become less so in the subsoil (pH 6.0 - 7.0). A key soil variable is depth to any underlying sandy Brahmaputra alluvium. The sandy nature of the canal dykes in this area suggested that the finer-textured upper layer of soil was of limited thickness.

Land use pre-project faced deep flooding of uncertain timing and duration. As a result only one paddy crop was possible on a given piece of land. This was mostly B. Aus or B. Aus-B. Aman mix on the upper slopes, with B. Aman downslope. In the lowest, wettest areas LV Boro was grown on residual water. There was only very limited irrigation development, with traditional manual lift methods increasingly supplemented by LLP, using khal water. Additional rabi cropping following the Aus/Aman crops seems to have increased steadily over the long period of construction, comparing the Feasibility Study (Chuo Kaihatsu, 1977) and the CIRDAP (1987) socio-economic baseline. By 1987 considerable areas of wheat, potato, pulses, oilseeds, vegetables and perennial sugar cane were grown. The increased rabi intensity probably reflected the growing use of LLP irrigation. Jute declined in importance, as elsewhere in Bangladesh, over the same period but was still a common alternative to Aus in early kharif. There was virtually no use of HYV rice varieties and the inputs associated with them.

Cattle and other livestock were grazed on the rice stubble in rabi and on rabi crop residues when they were harvested. Capture fisheries must have been dependent mainly on the adjacent rivers, as the regular alternation of relief created few true seasonal wetlands of any size. No beels of any are mapped on the old 1:50,000 topo-sheets, but only narrow strips of temporary wetland along the trough bottoms. Fishing in the interior was very much a secondary occupation, mainly harvesting river water trapped in localised depressions, ponds and khals. There was no sizeable traditional fishing community away from the rivers.

AED B : Meghna-Dhonagoda Floodplain

AED B occupies most of the central and southern of the Project Area, apart from the south-east corner (AED C). Altogether it covers 50 per cent (some 8,800 ha) of the total area. It seems to have been an area of deeper and longer flooding then AED A, in that the terrain is much less regular. Villages are noticeably less linear and the intervening relief includes both high and low spots (Figure 11.2). It is ridge-and-basin rather than parallel ridge-and-trough terrain, with the basins more extensive than the northern troughs. Even so, there are again only sporadic, small seasonal patches of wetland. None of the basins is large or deep enough to create a genuine beel. The pattern of khals, here draining mainly to the south, is correspondingly confused and irregular. Pre-project the khals were subject to weak tidal influences, but were never threatened by salinity.

Despite these subtle topographic difference, the amplitude of the relief, soils and the degree of flooding were much the same as in AED A. Much of AED B is occupied by the same Soil Association (Mm 769) as AED A, but it also includes Mm 771. The latter has a slightly higher combined proportion of ML and L lands (Table 11.1), which reflects the larger extent of the basins compared to the northern troughs. Mm 771 soils, in fact, seem more representative of AED B. It seems likely that the masking layer of finer-textured upper soil overlying sandy char material might be slightly thicker in the basins of AED B.

As a result of this lack of major physical differences, pre-project land use was also similar, with rice or sometimes jute followed by a variety of rabi crops or, in the lower parts, LV Boro rice. The same limited use of irrigation occurred, mainly for rabi crops, with HYV varieties rarely to be found. Livestock and fishing were perhaps slightly more important in the larger basins but again the lack of any major beels meant that capture fisheries relied more on the adjacent rivers and on khals and ponds within the Project Area.

Communications were less straightforward as village roads had to cross or skirt basins, so that small boat transport was important during the floods.

AED C: Gumti Floodplain

AED C is of limited extent, only 7 per cent of the total (or about 1200 ha). It occupies the south east of the Project Area, along the right bank of the Gumti River. The distinctive feature of AED C are the numerous large khals that occur, seeming to be formed often in old channels and meander scars of the Gumti or its ancestors. Again, pre-project they were weakly tidal but fresh, and so important waterbodies.

Relief seems more subdued and is dominated by the old channels. Village settlement appears to follow the minor khals, again possibly on anthropic "levees", while avoiding the banks of the large channels.

AED C coincides with FAO Soil Association Mm 770. This shows a higher density of settlement (possibly influenced by proximity to Matlab and its ferry) and consequently slightly less ML and L land. Even so, in pre-project times it seems likely that flooding along the large channels would have been as much a problem as elsewhere in the Project Area. Soils seem not to differ significantly from AEDs A and B, except perhaps for thinner superimposed finer sediments in what appears to be a relatively younger landscape.

As a result, the land use pre-project perhaps had different emphases than further north, although following a similar overall pattern. Fishing was likely to have been significantly more important than in the interior. In addition to the adjacent river fisheries, the large channels and close network of interlinking khals must have formed valuable fishing grounds within AED C. Grazing may also have been slightly more important, on seasonally flooded land alongside the channels. The opportunity for LLP and other methods of lift irrigation was substantially greater.

11.2 PROJECT OBJECTIVES

No account was taken of environmental aspects in the project preparation documents (Section 11.3), although they included some useful and relevant information relating to the environment. As with most of the FCD projects, and especially the larger ones, the need for a full Environmental Impact Assessment is in retrospect evident. Project appraisal based on economic analysis largely ignored or dismissed a number of key issues that the holistic perspective of environmental evaluation would have considered further. Such issues include: external areas affected by the Project, both adjacent and downstream; fisheries; livestock; wetland ecology; river behaviour and ecology.

11.3 APPROACH AND SOURCES OF INFORMATION

11.3.1 Preliminary Environmental Post-evaluation (PEP)

Preliminary environmental post-evaluation (PEP) has been defined here as the post-evaluation equivalent of environmental appraisal (as defined by ODA) or initial environmental examination (ADB). This is an intermediate level of post-evaluation, a main purpose of which is to identify projects which have had sufficient negative environmental impact to warrant a detailed environmental audit. In less extreme cases, the PEP should enable a more precise identification of any mitigatory measures required. Alternatively the PEP may show that the project has proved environmentally sound and requires little in the way of environmental monitoring and management.

The PEP approach proceeds beyond the screening-scoping activities of the initial RRA and is the environmental element of the PIE. In particular, more detailed and controlled information is acquired locally by systematic and structured interviews and multiple visits conducted by the FAP 12 PIE teams, while the environmental field observations and interviews are more intensive along carefully selected transects. The selection of transects is important because the PEP attempts to evaluate environmental impacts in terms of the different agroecological divisions, so that the transects must cross a representative selection of these, enabling contrasts and interrelationships to become apparent.

The PEP adopts different time and spatial perspectives to those of the PIE socio-economic surveys. The latter compare the Project Area with a purposively selected Control Area (see Section 11.3.5) for a specific crop year (Aus 1990 to Boro 1990/91). This permits comparison of with and without project scenarios. The PEP, on the other hand, retains the before-and-after approach of the RRA studies, thus confining itself to the Project Area and any identified external areas (Section 11.3.3) affected by the Project. The PEP also evaluates the environmental impacts of the Project over all the years since project completion (and where necessary any impacts during construction that are of long-term significance).

This enables the PEP to take account of certain impacts which the PIE surveys will miss. In addition, the PEP covers the ecological (i.e. physical and biotic) impacts of the Project, as well as the human (largely socio-economic) impacts covered by the PIE surveys. The PEP takes advantage of the much more detailed level of the PIE findings with regard to human environmental issues. As the above comments show, however, the different temporal and spatial perspectives of the PEP and PIE surveys mean that their conclusions are not meant to be identical, but rather to complement each other.

11.3.2 Agroecological Divisions

The agroecological divisions used within the Project Area are the six AEDs defined in Section 11.1, with external (off-site) impact areas defined below in Section 11.3.3. However, as Section 11.1 has shown, the differences between the AEDs in the MDIP are less marked than in the other PIE areas, so that impacts are generally likely to be similar. In the other PIE areas the AED sequence A-B-C-D has indicated a definite sequence from predominantly higher to predominantly lower lands. Such a sequence is barely evident in MDIP.

11.3.3 External Areas

The FAP 12 approach to environmental evaluation stresses the importance of taking into account not only environmental impacts within the Project Area, but also in areas outside it which may be significantly affected by the Project. Project planning for MDIP and many similar projects in Bangladesh in the past has payed scant regard to such aspects. The FAP programme clearly must correct this.

There are only two external areas affected by MDIP:

- Meghna Riverine Area (MRA)
- Dhonagoda-Gumti Riverine Area (DRA)

The Meghna River flanks the MDIP to the north and west, as a major river around 5 km in width. It seems unlikely that the Project could significantly impact upon a river this size, or the land beyond it, especially as it is not surrounded by similar projects creating the sort of cumulative impact found in the Atrai Basin or the Lower Ganges system. Impacts are therefore identified only in the setback land, between the Meghna and the embankment. This is fairly intensively cultivated and settled, but where the Meghna gets bigger, along the western flank, the setback is subject to persistent bank erosion and loss of land. Erosion is especially fierce in the south west, where the embankment has already had to be retired twice south of Eklaspur. The setback is about 200-300 m wide in the north east but west and south from Kalipur it is 600-700 m. The new tract created by the latest bund retirement in the south west covers a block of about 1,000 ha, but this is being reduced by bank erosion. A problem for this area is that it is more or less opposite the confluence with the huge Padma River and therefore at an obvious point for bank erosion.

The Dhonagoda in the east and its continuation as the Gumti on the south form a much smaller river than the Meghna, but still one capable of large floods and considerable erosive power. The dangers from Dhonagoda flooding were demonstrated in 1987 and 1988, when the embankment failed in both years, though the main causes are believed to have been faulty site investigation and design. Setback is never more than 200-300 m and is often almost non-existent. There is some cultivation and occupation, but a large part of the impact area consists of the adjacent unprotected lands across the river, on both the east and south.

No downstream impact area is considered, for the reasons already noted concerning the proportional size of the Meghna, especially below the Project Area, after it is joined by the joint flows of the Brahmaputra and Ganges (the Padma River) to form one of the largest rivers in the world.

11.3.4 Control Area

The Control area chosen to provide the without-project comparison for the PIE socio-economic surveys (Chapter 1) comprises land adjacent to the MDIP on the south east, inland from the Dhonagoda-Gumti River from north of Kachua as far west as Matlab. For reasons discussed in Section 11.3.1, the Control area has not been included in the environmental fieldwork, although the PIE findings there are taken into consideration in the impact assessment for many of the human environmental issues in Section 11.6.

The Control area is of less value for the physical and biological assessment because it is ecologically not comparable with MDIP. This is because Kachua falls in different agroecological regions, as defined and mapped by FAO (1988); in the west it is part of the Lower Meghna River Floodplain AER and in the east it passes into the Old Meghna Estuarine Floodplain.

There is also a marked contrast in settlement density between the Project and Control areas, which was especially evident in pre-project times (as clearly shown by the 1:50,000 topographic maps, dated 1961).

This significant difference is, and continues to be, the result of MDIP's isolation caused by lack of macro-communications. The Control area is nearer to major population centres such as Comilla and Chandpur, with which road and rail connections are good.

11.3.5 Identification and Assessment of Environmental Impacts

It is clearly important that the environmental evaluation assesses project impacts relative to what would have been the continuing pre-project trends, rather than to specific points in time, such as 1978 or 1987. The main ongoing trend both before and after the Project has been the steady growth in population and the resultant pressure on land and water resources.

Another important trend that became very strong during the Project's lengthy construction period was the widespread availability and acceptance of HYV paddy varieties. Almost certainly a without-project situation in MDIP would have seen at least some expansion of HYV Boro cultivation, such as happened in the Control area. Physical conditions for tubewell irrigation are likely to be excellent in MDIP.

A third trend, the high incidence of fish disease in the last three years throughout Bangladesh, has strengthened the ongoing background negative trend in capture fisheries, caused by overfishing.

It is necessary to assess also the impact of what the Project has achieved in practice, rather than the anticipated impact of what was planned. In two of its five monsoon seasons, as noted, MDIP has suffered catastrophic flooding due to major breaches of the embankment. Important components such as internal roads, navigation locks and agricultural support were abandoned.

The initial screening-scoping during the RRA has identified many of the significant environmental issues and impacts. The PEP uses a scaling matrix rather than a checklist, with the vertical axis comprising the issues already established and the horizontal axis consisting of the agroecological divisions (AED).

An attempt is made at scaling the **positive (+)** or **negative (-)** levels of impact as follows:

0 - nil or negligible impact
1 - minor impact
2 - moderate impact
3 - major impact

The rather simplistic scaling or scoring values reflect the essentially qualitative nature of PEP. They do have the advantages, however, of:

- ensuring that each primary impact is individually considered, while taking into account its often complex linkages with other primary impacts and with secondary or tertiary impacts;

- presenting a clear and very concise assessment, which is quickly and easily assimilated by the PEP user, enabling him to agree with or query it;

- avoiding voluminous and repetitious written presentations which soon become confusing, if not impossible, to read.

The environmental issues and related impacts are considered within three categories: physical, biological and human.

Some refinement in scaling can be imposed upon the three levels of impact by qualifying them as **strong** or **weak** at each level, although this is avoided so far as possible in order to retain simplicity.

Scaling of impacts is achieved by considering each impact within each AED or external impact area in turn and applying five **assessment factors**:

- magnitude (degree of impact);
- prevalence (extent);
- duration and/or frequency;
- risk of serious environmental damage;
- importance of the issue affected.

In addition, overall values are broadly assessed for the Project Area as a whole and collectively for the external areas.

Other important elements of the PEP approach include preliminary suggestions for means of mitigating the main adverse impacts, and recommendations for any future environmental monitoring or management requirements.

Methodology is discussed more fully in the FAP 12 Methodology Report (FAP 12, 1991b).

11.3.6 Sources of Information

The main existing sources of information have been the Feasibility Study by Chuo Kaihatsu Corporation (1977), the ADB (1977) project appraisal, the ADB (1990) Project Completion Report, and CIRDAP's 1987 socio-economic baseline study.

Other sources have included the post-evaluation study of the nearby Chandpur Irrigation Project (Thompson 1990) and the BWDB's various 1988 Project Completion Reports on MDIP.

In addition the environmental evaluation, by its nature, relies heavily upon the work and findings of the engineering, agricultural, fisheries, livestock, institutional and sociological components of the FAP 12 team, by whom much of the information synthesised here has been collected, during the RRA and PIE field surveys.

FAO (1988), as noted, provided much of the ecological background.

11.4 PHYSICAL ENVIRONMENTAL IMPACTS

Physical issues have been subdivided into water-related and land-related (Table 11.2); other physical issues such as climate and atmosphere have not been affected by the Project.

11.4.1 Physical Impacts (Water)

(a) River Flow

There are no active rivers within the Project Area; the khals and old channels are considered below as waterbodies, in (g) and (h). River flow, therefore, is considered only within the three external areas. The main parameters are discharge, velocity, timing, rate of rise, and duration. There are few FCD projects in the region, so that cumulative impact is not significant.

As noted already, it is evident that the Project could not significantly affect the flow in so large a river as Meghna. In the Dhonagoda-Gumti, however, it appears from local reports and observations that flow is slightly increased during the wet season, with discharge and velocity increased as attenuation by right bank overspill is prevented.

Throughout the environmental assessment, sufficient weighting is given to the local importance of the Dhonagoda-Gumti Riverine Area (DRA) for impacts there to register an overall external impact also, despite the much greater size of the Meghna.

(b) River Quality

Potential key parameters are sewage, agrochemicals, sediment load and salinity. Again, the scale of the Project relative to the Meghna River precludes any significant impact.

The Dhonagoda-Gumti River is also unlikely to be affected. Kalipur Pump Station evacuates drainage effluent to the Meghna, while Uddhamdi Pump Station is very near to the Gumti's exit from the Project Area and confluence with the Meghna. The main threat is likely to be from the large increase in the use of agrochemicals for HYV rice crops. It would be informative and easy to monitor drainage effluent quality at the two main pump stations.

(c) River Morphology

Bank erosion is clearly very active in the Meghna Riverine Area (MRA), but this is not influenced by the Project. Unfortunately, the opposite is not the case and in the long term bank erosion by the Meghna will remain a constant threat.

The slightly greater wet season flows contained in the DRA by the bund perhaps have a minor negative impact in strengthening bank erosion and bed scouring. However small this influence might be, it becomes significant because setback is so narrow and the embankment apparently so weak and vulnerable along some stretches of the Dhonagoda. The impact would be greater if the DRA were bunded on both sides. In the dry season as the river drops, some increase in siltation is also claimed. Erosion of the embankment itself is considered in Section 11.4.2 (d).

(d) Flooding and Drainage

The Project was designed to provide complete river flood control and drainage. The main parameters here are the level, timing, rate of rise, duration and extent of floods. In the Project Area flooding continues to result from heavy monsoon and sometimes pre-monsoon rains, but since 1988 the Project has achieved its objective of complete river flood control. However, the environmental assessment must address what has actually happened (Section 11.3.5) and what has happened is that in two of the five project years, the Project Area (and especially the eastern part of AED B), was devastated by the Dhonagoda breaches. In the south west, over 1,000 ha has had to be permanently sacrificed to the Meghna.

Table 11.2 Physical Environmental Impacts.

Physical Issues	Environmental Impact						
	Project Area (AEDs)				External Areas		
	A	B	C	Overall	MRA	DRA	Overall
WATER							
a. River Flow	-	-	-	-	0	-1	-1
b. River Quality	-	-	-	-	0	0	0
c. River Morphology	-	-	-	-	0	-1	-1
d. Flooding and Drainage	+2	+1	+2	+2	-1	-1	-1
e. Groundwater Levels/Recharge	0	0	0	0	0	0	0
f. Groundwater Quality	-1?	-1?	-1?	-1?	0	0	0
g. Wetlands and Waterbodies Extent/Recharge	0	0	0	0	0	0	0
h. Wetlands and Waterbodies Quality	-1	-1	-2	-1	0	0	0
LAND							
a. Soil Fertility	-1	-2	-1	-1	0	-1	0
b. Soil Physical Characteristics	-2	-3	-2	-2	0	-1	-1
c. Soil Moisture Status	+3	+2	+3	+3	0	0	0
d. Soil Erosion	-1	-3	0	-3	0	0	0
e. Soil Salinity	0	0	0	0	0	0	0
f. Land Capability	+3	+2	+3	+3	-1	-1	-1
g. Land Availability	+1	+1	+1	+1	0	0	0

Source: Consultants

Note : ? = Uncertain impact.

An important point is that the 1987 and 1988 breaches were structural failures; despite the exceptional river levels, the embankment was not topped. Even the most casual inspection of the Dhonagoda bund between Nandalalpur and Durgapur indicates that the next time it is seriously attacked by the river, another major breach will occur. The embankment is riven with gullies and riddled with incipient piping, possibly related to rat-holes. Thus the risk factor in impact assessment is considerable in this area.

Similarly, over a much longer timeframe but even more inexorably, the Meghna embankment in the west will always be threatened. The cost of maintaining it near Eklaspur is plain to see, as concrete block defences are hastily being established.

It is apparent, therefore, that despite what may be temporary success in flood control, the long-term technical sustainability of this project is seriously in doubt, except at yet more exorbitant cost. Even with funds available, a very much higher standard of inspection, maintenance and emergency flood response will be required than has been seen to date.

Part of the problem is that MDIP is located in what is still a very dynamic landscape, where in comparatively recent geomorphic time a huge river once flowed. The natural fluvial and sedimentary activities in the area since then have yet to establish fixed patterns for themselves. An understanding of these geomorphological uncertainties during project preparation might have led to a sounder project concept, in both environmental and economic terms.

This situation, therefore, poses problems for both environmental and economic evaluation, but especially for the former, since flooding is the most important primary environmental issue. Assessment here is based on the achievements and failures in flood control over the five flood seasons to date, but as noted in Section 11.3.5 one of the five key assessment factors is risk of serious environmental damage.

On this basis, moderate positive impacts are assessed for AEDs A and C, but only a minor positive impact in AED B. These assessments reflect the great success of flood control post-1988, the damage (enormous in eastern AED B) and loss of land (extensive in south west AED B) in other years, the considerable risk factor, and also a degree of local dissatisfaction everywhere with the efficiency of drainage. The breach floods, it must be noted, caused loss of crops, property and even life throughout much of the Project Area, as reported at Byasdi in the north, at Sataki and Subandi in the north west, and at Machua and near Thetalia in the south.

Overall, a moderate positive impact is assessed, compared to the apparent very major impact that might be recognised if only, say, 1990 or 1991 years were considered and the underlying risk factor was ignored.

In both the external areas, the chief impact on flooding results from the embankments holding back river water and raising flood levels. There is much local complaint about this, including in the adjacent land across the Dhonagoda, but only a slight negative impact is given. Flooding within the lands near the rivers, especially the Meghna, must always have caused problems.

(e) Groundwater Levels/Recharge

Given the very large river to the north and west and the probably near-continuous and sandy alluvial aquifers in this area, it seems unlikely that even efficient flood exclusion in every year (rather than in three out of five) could have a significant impact in the Project Area. Groundwater in the riverine areas is certainly not affected.

(f) Groundwater Quality

The possible sources of groundwater pollution are agrochemicals and indiscriminate sewage, with salinity not a factor. The weak tidal influence is far outweighed by rainfall (2,300 mm per year) and the vast freshwater recharge from the north, where salinity is concerned. The general awareness of possible sanitation problems and widespread use of latrines suggest that coeliform pollution of groundwater is unlikely to be significant.

However, more than in any other of the FAP 12 PIE areas, the Project has led to a major upsurge in the use of agrochemicals, with fertilisers and biocides essential in the cultivation of the now dominant HYV T. Aman and HYV Boro crops. The thin veneer of finer-textured soils over sandy char alluvium makes over-application and vertical leaching more likely than in most other FAP 12 areas. Agrochemicals pollution is an incipient problem in many parts of Bangladesh, especially where FCD/I projects occur. MDIP provides an excellent opportunity to monitor the seriousness and rate of development of this problem.

Actual impact, after only five years, cannot be great but the substantial long-term risk factor involved suggests that at least a minor negative impact be recorded in the Project Area. It remains an uncertain impact because, apart from the lack of data as evidence, it is difficult to estimate how much irrigation and HYV development would have occurred without the Project, especially following the deregulation of STWs.

A difficulty with groundwater for domestic use, and possibly also for irrigation, appears to be high iron content. In every part of the area, local people claimed that their domestic hand-pump tubewell supply was not usable for cooking rice, for which they had to use pond water. However, this problem is unrelated to the Project.

No impact is likely in the external areas.

(g) Wetlands and Waterbodies Extent/Recharge

The absence of large seasonal wetlands or more permanent beels has been noted, along with the presence of a comprehensive network of once-tidal but freshwater khals and (in AED C) large channels once part of the Gumti River.

The point should perhaps be made that the often extensive pre-project areas of flooded B. Aman are not considered as wetlands. The term is reserved for areas where flooding outpaced B. Aman and any wet-season vegetation was aquatic. It should also be noted that in two out of five years, most wetlands and waterbodies have received recharge from the breach floods.

The limited size of the waterbodies and the few small wetlands made them of little ecological importance pre-project (although important for harvesting fish left behind by river floods). The khals and channels are still re-filled under the Project either as part of the drainage system and to allow low-lift rabi irrigation, or by rainfall run-off. The wet areas in small and scattered bottomlands are often uncommanded by the drainage system and still accumulate rainfall floodwater. In terms of extent and recharge, therefore, the limited negative impact does not seem significant.

(h) Wetlands and Waterbodies Quality

The same anxiety and opportunity for definitive monitoring exists in this respect as for groundwater, noted in (f) above. An added factor, which confirms a minor negative impact, is the stagnant nature of many old khals and channels which are not directly part of the new project irrigation and drainage system. Apart from being a wasted asset, such sites are likely to be more affected by the agrochemical build-up and are also obvious sites for indiscriminate sewage accumulation. The long-term risk factor is obvious.

Again, 1987 and 1988 provided ameliorative flushing of such sites and so far there have been only three years for deterioration to proceed fully. On this basis, a minor negative impact is postulated in AEDs A and B, increasing to moderate in AED C where waterbodies of much greater relative extent occur.

For both (g) and (h), the external areas are not affected.

11.4.2 Physical Impacts (Land)

(a) Soil Fertility

Despite the usual ubiquitous complaints about the loss of river silt (which was anyway received by much of the Project Area in 1987 and 1988, beyond the area of sand deposition), the Project has probably caused only a minor negative soil fertility impact, apart from sand deposition. This would result from the reduced aquatic micro-biota (such as nitrogenous blue-green algae) due to HYV T. Aman replacing B. Aman. Large areas of "natural" wetlands with relatively high organic soil and nutrient contents did not exist pre-project.

The infertile sand, with its negligible cation exchange capacity, deposited by the breach floods in the east of AED B increases the negative impact to moderate there. Overall impact remains minor, as only a part of AED B is affected.

No impact occurs in the external areas.

No account is taken of effects on soil fertility by the large increase in the application of artificial fertilisers under the Project. This is assumed to be consumed by crops or wasted by leaching or run-off each year. A worrying aspect is that farmers insist that more fertiliser is required each year to achieve the same yields.

The only off-site impact is a weak negative one in the DRA, where the increased flooding is said to have caused some sand deposition, downgrading cultivated land near the river.

(b) Soil Physical Characteristics

The impact on soil physical characteristics has been more serious than on fertility. Throughout the Project Area there is already a major complaint that the soil is too hard and dry to cultivate in the rabi season. Effectively, what seems to have happened is that the switch to two and often three rice crops has destroyed any soil structure, created a more pronounced plough-pan at shallow depth, and prevented the total wetting and mellowing of the soil provided by the lengthy duration of a B. Aman crop. This creates a real problem for farmers wishing to switch from HYV Boro back to the higher-value rabi crops envisaged in project preparation (and quite widely grown prior to implementation - see Section 11.6.1(a)).

This moderate negative impact is accentuated in eastern AED B by the sterile and structureless sand deposited by the breach floods. The high risk factor noted in 11.4.1 (d) suggests that this is likely to re-occur, so again risk is a factor.

There is also an off-site impact in the DRA, where farmers in land across the river have suffered increased sand deposition during the slightly higher post-project floods. Such an impact attributable to the Project is unlikely alongside the Meghna.

(c) Soil Moisture Status

The improvement in flood timing and duration in most years, reflected in Section 11.4.1 (d), has led to positive impacts on soil moisture status. In addition to the risk factor and some drainage inadequacy however, moisture status also suffers from increased soil droughtiness on the higher lands in the rabi season. On the other hand, except in the high spots, the Project has provided irrigation and thus a considerable improvement over pre-project rabi moisture status, in much of the Project Area, although possibly this would have happened to some extent without the Project. Net impacts are assessed as major positive in AEDs A and C, and moderate in the high-risk AED B. There are no off-site impacts, as flood timing and duration are not significantly affected in the MRA and DRA.

(d) Soil Erosion

The only soil erosion to occur, apart from the river bank erosion considered under Section 11.4.1(b), is erosion of the embankment, considered separately here. This, however, assumes paramount importance in AED B, where the embankment is under threat. The less immediately threatened western bund is suffering some erosion but it is on the more critical eastern side, especially between Nandalalpur and Durgapur, that the situation is most serious. Urgent attention is needed to strengthen the embankment there. Gullying and piping are pronounced.

Thus a major negative impact is ascribed in AED B. In AED A there is a minor degree of erosion, while in AED C the bund is in relatively good condition, protected along its crest on the river side by a tall hedge of Cajana Cajanus, a bush which is also useful for fuel and edible lentil-like seeds. Overall impact remains major because of the very high risk factor involved.

(e) Soil Salinity

Soil salinity is not a significant issue in MDIP. The permeable soils, high rainfall of 2,300 mm, and irrigation (and hence leaching) with river water having an electrical conductivity of less than 200 micromhos/cm make any form of salinisation impossible.

(f) Land Capability

Land capability has clearly improved greatly, but the qualification noted for impacts on flooding in Section 11.4.1 (d) still applies. The conflicting effects on soil physical characteristics and moisture status complicate the assessment. If land suitability for particular crops, rather than general capability, were considered, then there are two answers: a more positive impact where rice mono-cropping is concerned and a less positive impact if rabi crops are preferred. Overall, the great benefit on land capability conferred by irrigation and vastly improved dry-season soil moisture status should be an overriding factor, but then without the Project tubewell and lift irrigation would probably have accelerated.

The impacts assessed in AEDs A and C are major positive, assuming a still substantial net irrigation benefit. This last is based on the relatively slow irrigation development in the adjacent Control Area, despite its vastly superior communications and accessibility. In AED B the alarming risk factor reduces the positive impact to moderate, although remaining major for the Project Area as a whole.

In the riverine areas there has been a minor negative impact on land capability, due to the increased flooding caused by the Project.

(g) Land Availability

Land availability is a more clearcut issue. As there were no large uncultivated areas, such as wetlands, before the Project, land availability has not changed spatially to any significant extent in AEDs A and C. What waterbodies and small wetlands do occur remain at about pre-project dimensions. In temporal terms, however, flood protection and drainage have released extra land in the rabi season for HYV paddy cultivation. The question is how much land was already available anyway, if irrigation had been on hand. Estimates suggest that as river flooding was neither early nor rapid in this estuarine location, then much of the HYV area would have been possible without flood protection. The convoluted problem of what are sound comparative baselines is again evident.

Ultimately, a minor positive impact is assessed. In AED B some 1,000 ha of land in the south west was lost due to retirement needed during the construction period (in 1980 and again in 1986-87) as a result of inappropriate bund alignment. This land, however, would have been lost without the Project, as erosion there is natural.

Land availability outside the embankment has not been affected by the Project, although it is diminishing steadily in the MRA due to the activities of the Meghna River, as noted.

11.5 BIOLOGICAL ENVIRONMENTAL IMPACTS

Any attempt to assess the biological impacts of projects such as MDIP has to take account of parallel trends that were initiated long before such projects were conceived (Section 11.3.5). These are essentially the trends associated with the accelerating increase in population pressure both on the physical resources which provide biotic habitats and on the biotic communities themselves. Cultivation, land settlement, vegetation clearance, hunting and fishing have all increased as population density has soared over the last few decades. The high incidence of fish disease over the last three years has added another strong background trend to be taken into account.

Realistic assessments of the relatively recent project impacts, therefore, are unlikely to reveal the excessive ecological damage claimed by many detractors of the development planning process. The population growth and unplanned development of the past have already wreaked ecological havoc in most of Bangladesh, including the MDIP Area.

Table 11.3 summarises the limited biotic impacts in MDIP.

11.5.1 Biological Impacts (Fauna)

(a) Bird Communities/Habitats

This issue provides a prime example of the point made above. Undoubtedly, in the distant past, the wetlands and waterbodies of MDIP Area, even through relatively small, must have provided a haven for both local and migrant waterbirds. However, once settlement and cultivation began to approach the distribution pattern established pre-project, the bird communities and habitats were doomed. Few parts of the area are any distance from settlement and none from cultivated land. The absence of extensive natural wetlands, so ecologically important until quite recent times in PIE areas like Kolabashukhali and Chalan Beel D, gave birdlife no refuge from man.

Thus, long before project completion, birdlife in the area had diminished to today's meagre situation, on which there was no scope for any significant project impact.

Table 11.3 Biological Environmental Issues

Biological Issues	Environmental Impact						
	Project Area (AEDs)				External Areas		
	A	B	C	Overall	MRA	DRA	Overall
FAUNA							
a. Bird Communities/Habitats	0	0	0	0	0	0	0
b. Fish Communities/Habitats	0	0	-1	0	0	0	0
c. Other Macro-fauna Communities/Habitats	0	0	0	0	0	0	0
d. Micro-fauna Communities/Habitats	-1	-1	-2	-1	0	0	0
FLORA							
a. Trees	0	0	0	0	0	0	0
b. Other Terrestrial Vegetation	0	0	+1	0	0	0	0
c. Aquatic Vegetation	0	0	-1	0	0	0	0

Note : ? = Uncertain impact.

Source: Consultants

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(b) Fish Communities/Habitats

The same comments apply as to birds, except that to add to the downward trends caused by overfishing, over the last two to three years the Project Area has suffered considerably from the ulcerative fish disease that is sweeping the country. This has been experienced in many other countries and seems from evidence elsewhere to be in no way related to factors, such as increased agrochemicals use, which could make the disease an indirect impact of the Project (Chapter 7).

It would seem that for many decades now the fish population within the Project Area derived largely from the river floods entering the area with minimal breeding stock returning to the rivers. The small wetland areas mostly dried out and were in any case too easily accessible from nearby settlements. It is significant that fishing was almost wholly a secondary occupation in pre-project times (CIRDAP 1987). Thus there was very limited opportunity for fish communities to develop and breed. The continual rich harvest from ponds and khals reflected the rich fisheries of the estuarine Meghna River, rather than any favourable ecological habitats in the Project Area.

Thus no significant negative biotic impact on fish is recognised in AEDs A and B, especially when the brief period of time since 1986 and the breaches in 1987 and 1988 are taken into account. In AED C, with its large old channels and dense network of khals, there is possibly a minor negative impact. These would have provided valuable fish habitats when still seasonally connected to the rivers.

The decline in fish population is claimed locally to be just as great in the riverine areas. The Dhonagoda is clearly under tremendous fishery pressure, especially from the left bank, with continuous beds of water hyacinth held along the bank in the post-monsoon period to attract fish for the catch. Every conceivable means of catching fish seems to be practised. The impact of disease is just as great.

Clearly MDIP as an isolated project has had scant effect on the DRA fish ecology and even less on the Meghna. The comparable decline in fisheries in the riverine areas would seem to show conclusively that what is being seen in the Project Area interior is the result of trends largely unrelated to the Project.

(c) Other Macro-fauna Communities/Habitats

Most terrestrial fauna has long been reduced to negligible or low levels by population pressure. The only influence that the Project seems to have had, as elsewhere in FCD projects, is on the rodent population. The rat population is said to have increased, and the rats even to be larger than previously! Certainly, embankments provide an excellent habitat for rodents. Snakes also take advantage of disused rat-holes, but no increase in the snake population was reported.

Rats are causing increasing damage to Boro crops in AEDs A, B and C, and to crops and life in the riverine areas on the other side of the embankments. As a biological impact, however, the effect on the already depleted terrestrial or other fauna seems negligible.

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(d) Micro-fauna Communities/Habitats

Natural micro-biota communities and habitats relate primarily to wetland ecosystems in most of Bangladesh. To some extent, it seems that the lengthy, deep flooding of B. Aman rice could continue to support some elements of this micro-biota, notably micro-organisms such as the blue-green algae.

It is evident from the lack of true wetlands of any size in MDIP that the main impact here must result from the general change from B. Aman to HYV T. Aman, with its much shorter and shallower inundation. As in Section 11.4.2(a), a minor negative impact is inferred for this. However, in the numerous waterbodies of AED C there is likely to have been an additional impact on aquatic micro-biota, once they were cut off from the Gumti River.

There are no off-site impacts.

11.5.2 Biological Impacts (Flora)

(a) Trees

The tree population in the area has not been significantly affected ecologically. There is more scope for planting fruit and fuel trees (Section 11.6.1(e)) but nothing much has happened to date. No advantage has been taken of the embankment as a habitat for trees.

(b) Other Terrestrial Vegetation

A weak minor positive impact can perhaps be recorded for AED C, where the successful planting of Cajanus cajana along the bund crest has already been noted. Elsewhere the already virtually totally depleted natural bush and grass vegetation is unaffected.

(c) Aquatic Vegetation

Pre-project aquatic vegetation was concentrated in the small, scattered wetland tracts and waterbodies. This remains the situation, although it is possible that with time the pollution feared in Section 11.4.1 (h) could affect this. Given the short time since project completion and the subsequent breach floods, the only possible significant negative impact is in the AED C waterbodies, due to their relative extent.

11.6 HUMAN ENVIRONMENTAL IMPACTS

Some of the most important impacts of the MDIP are those affecting the human environment. This is inevitable in one of the most densely populated areas in the world, where the pre-project environment was already essentially an anthropic one.

Many of the human issues are covered in detail in other chapters of this report. Here they are presented in Table 11.4 and are in most cases only briefly summarised below. They can be conveniently grouped into five sub-categories: human use, social, economic, institutional, and cultural issues. Consideration of the human impacts in terms of the different AEDs and external areas provides an additional distributional perspective to the more detailed discussions elsewhere in the report.

11.6.1 Human Use Impacts

(a) Crop Cultivation

Chapter 5 considers the overall impacts on crop cultivation, including irrigation, in detail. The positive impacts of the Project in this respect are again not easily estimated from comparison with the pre-project situation. The reasons are worth re-stating:

i. It is not clear to what extent lift and pump irrigation would have developed in the Project Area in a without-project situation. It seems that flood timing would generally allow IRRI Boro to survive. There should be excellent groundwater potential, more easy to exploit following the recent deregulation of STWs. However, the more accessible Control Area has a much smaller proportion of irrigated land, which can be taken as an indicator of the without-project trend (see Chapters 3 and 5).

ii. The switch from B. Aman to HYV T. Aman could only have been achieved with the Project, despite the increasing availability of HYV varieties over the long construction period.

iii. The protracted planning and construction period meant that from the mid-1970s the area was committed to MDIP, thus precluding any conflicting initiatives such as tubewell irrigation.

iv. In fact, in two years (1987 and 1988) project crops were destroyed in substantial areas and damaged to varying degrees almost everywhere else. The sand deposited over some 600 ha greatly reduced crop performance in subsequent years also.

v. There are reports that the initial surge in rice yields has been replaced by a possible decline (though this is not borne out by PIE yield data, see Chapter 5), which may be related to soil deterioration. Certainly such deterioration would greatly discourage the adoption of high-value rabi crops that the Project was designed partly to further, but has failed to do so by not imposing any water duties.

vi. Certain high spots and low spots not commanded by the Project suffer droughtiness and waterlogging respectively, with pre-project two-crop systems replaced by single-cropping.

vii. The risk factor is an important element in environmental assessment; as Section 11.4.1 (d) has shown, the Project Area is subject to a high degree of both immediate risk (in the east) and long-term risk (in the west).

viii. Against these conflicting parameters is the visible and, for the farmers, tangible evidence of a tremendous increase in agricultural productivity since 1988. There is no doubt that at present, MDIP has transformed a poor area where out-migration and food-deficits were endemic into a thriving area which can both support its population and produce a substantial food surplus.

Table 11.4 Human Environmental Impacts

Human Issues	Environmental Impact						
	Project Area (AEDs)				External Areas		
	A	B	C	Overall	WRA	ERA	Overall
HUMAN USE							
a. Crop Cultivation (inc. irrigation)	+2	+1	+2	+2	-1	-1	-1
b. Livestock	0	0	0	0	0	0	0
c. Capture Fisheries	-2	-2	-3	-1	0	0	0
d. Culture Fisheries	+1	+1	+2	+1	0	0	0
e. Afforestation	0	0	0	0	0	0	0
f. Agro-industrial Activities	+2	+2	+2	+2	+1	+2	+2
g. Transport Communications	+1	+1	+1	+1	+1	+1	+1
h. Infrastructure	-1	-2	-1	-1	-1	-1	-1
i. Domestic Water Supply	-1?	-1?	-1?	-1?	0	0	0
j. Sanitation	0	0	0	0	0	0	0
k. Recreation	0	0	0	0	0	0	0
l. Energy	0	0	0	0	0	0	0
SOCIAL							
a. Human Carrying Capacity	+3	+3	+3	+3	-1	-1	-1
b. Demography	+3	+3	+3	+3	0	0	0
c. Gender	+1	+1	+1	+1	0	0	0
d. Age	0	0	0	0	0	0	0
e. Health and Nutrition	+1	+1	+1	+1	0	0	0
f. Disruption, Safety and Survival	-2	-3	-2	-3	-1	-1	-1
g. Land Ownership	-1	-1	-1	-1	-1	-1	-1
h. Equity	0	0	0	0	-1	-1	-1
i. Social Cohesion	0	0	0	0	-1	-1	-1
j. Social Attitudes	+2	+2	+2	+2	-1	-1	-1
ECONOMIC							
a. Incomes	+2	+1	+2	+2	0	0	0
b. Employment	+2	+1	+2	+2	0	0	0
c. Land Values	+2	+1	+2	+2	0	0	0
d. Credit Availability	+2	+1	+2	+2	0	0	0
INSTITUTIONAL							
a. Institutional Activity/Effectiveness	-2	-3	-2	-3	0	0	0
b. Public Participation	-2	-2	-2	-2	0	0	0
CULTURAL							
a. Historical/Archaeological Sites	0	0	0	0	0	0	0
b. Cultural Continuity	0	0	0	0	0	0	0
c. Aesthetics	0	0	0	0	0	0	0
d. Lifestyle (Quality of life)	+2	+2	+2	+2	-1	-1	-1

? = Uncertain Impact

Sources : Consultants

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ix. To complete the picture, Chapter 12 assesses the enormous costs incurred by the Project over nine years of construction, followed ever since by the need for rehabilitation on a formidable scale, and accompanied by extremely high annual operating costs due especially to the electrically operated pump stations. Cost is not a factor taken into account in the environmental evaluation, but is worth noting to round off the perspective.

The more positive impact on crop cultivation has to be in AEDs A and C. AED B has suffered two years of catastrophic flooding and sand deposition, and continues to be threatened in the south west; it is subject to a much greater risk hazard, than AEDs A and C.

As Chapter 5 shows, the largest crop productivity factor is the Boro paddy crop, which could reasonably be partially discounted as happening even without the Project. Given this factor, the flood events in two years out of five, and the continuing risk hazard as primary considerations, it is thought unrealistic to assign a major positive impact in the Project Area. Thus, moderate positive impacts are assessed in AEDs A and C, with a minor positive impact in AED B, where both the effects and the continuing threat of catastrophic flooding are greatest.

Weighting results in an overall moderate positive impact for the Project Area, as both moderate and minor impacts in the AEDs are considered relatively strong. Off-site, a minor negative impact in both riverine areas is attributed to the Project, due to increased flooding.

(b) Livestock

The impact of FCD/I projects on livestock is usually conceived as negative due to the loss of dry season and early kharif grazing on wetland pastures and paddy field stubble and weeds and to a decline in rabi crop residues. Where the Project is successful in substantially raising incomes, however, there is scope for compensatory purchase of more nutritious feed materials to supplement what is likely to be a considerably increased availability of rice straw.

This seems to happen in MDIP, where despite local complaints about animal health and reduced grazing, the Project area has higher incomes from livestock than the Control area (Chapter 6). Although the difference may reflect a pre-project situation to some extent, it does not suggest any significant negative impact.

A positive impact of FCD/I projects is the haven provided for livestock by the embankments during floods. This is not important in MDIP except during the catastrophic breach floods which the Project itself created. Pre-project flooding at this estuarine point in the Bangladesh river system, where tidal influences also are weak, was less precipitate than further upstream and in modern times could be anticipated. High ground in the Project Area, although limited in extent, is distributed fairly evenly to provide frequent ridges and islands of safety during floods.

The impacts on livestock would seem to be insignificant in the MDIP Area and its external areas.

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(c) Capture Fisheries

The discussion on fish ecology in Section 11.5.1(b) and the detailed account of capture fisheries in Chapter 7 provide the basis of impact assessment here. Thus while the biotic impacts were thought to be limited, it seems evident that a rich annual harvest of river fish trapped in ponds, khals, old river channels and the scattered, small wetland tracts has been lost. Since the embankment enclosed the area, farmers in the interior (who do most of the fishing) claim that the fish catch is now negligible. CIRDAP (1987) show substantial catches per unit area immediately prior to project completion but these seem to apply over a relatively small total area. Certainly fishing was not a primary occupation pre-project except along the adjacent rivers, as the CIRDAP and Thompson (1990) surveys confirm. The disadvantaged traditional fishing community, typically Hindu in the main, found in the other PIE studies is not as evident in MDIP.

Care has to be taken, therefore, not to exaggerate the impact on capture fisheries here. This is particularly so given the short life of the Project, the incursions of river waters (and presumably fish) on a large scale in two of the five years in question, and above all the strongly negative background trends caused by disease (rampant since 1988) and the obvious intensive overfishing in the Dhonagoda River (and probably in the Meghna also).

A moderate negative impact is assessed in AEDs A and B, becoming major in AED C, with its larger waterbodies. Overall impact on the Project Area is weighted as moderate negative.

There has been a corresponding decline in the adjacent river fisheries, which cannot be ascribed to the Project (Section 11.5.1 (b) but which does put the fallen catches in the Project Area in a correct perspective. Overfishing and disease are the obvious local causes, although on a nationwide scale it can be argued that the cumulative impact of FCD schemes must also be contributing.

(d) Culture Fisheries

The Project has greatly improved conditions for culture fisheries by preventing (at least since 1988) the inundation and flushing out of ponds and other waterbodies that are or could be used for fish culture. Certain of the khals and old channels (and therefore especially AED C) are particularly suited to fish culture, if operated properly. Borrow-pits are also useful in this respect.

DOF is encouraging the trend by distributing free fingerlings, although as elsewhere the rewards seem currently to be going to the larger land-owners and other influential people rather than to the poor and landless. Initially at least, however, the former are more likely to establish fish culture as a successful enterprise in the Project Area. A possible problem is the stagnation and pollution of many waterbodies (Section 11.4.2 (h)).

Given the previous nature of capture fishing in the Project Area, it seems possible that eventually culture fisheries could more than compensate any decline. A negative factor, however, is the current high risk factor implicit in the weakness of the Dhonagoda embankment. Another 1988 would destroy much of the incipient culture fishery initiative.

Thus at present only minor positive impacts are ascribed in AEDs A and B, weighing potential against risk. In AED C the combination of greater potential and lower risk raises this to moderate. There are no off-site impacts.

(e) Afforestation

Some increased tree-planting around settlements was reported by the pre-PIE RRA but advantage has been taken of the opportunity offered by the embankment only in AED C and then on a limited scale (Section 11.5.2(a)). Thus so far there have been no significant impacts on afforestation or other tree-planting.

(f) Agro-industrial Activities

The PIE (Chapter 8) reveals a generally positive impact on agro-industrial and associated activities, notably rice milling and trading and light engineering. For several years the construction of the embankment and other project works had a big impact on local employment in an area where out-migration to find work was endemic. The continued difficulty of access to the outside world has added impetus to local activities. Thus a moderate positive impact is ascribed for all AEDs. Off-site areas, where several of the larger villages and rural industries are centred, have benefitted similarly.

(g) Transport Communications

Project planning originally included the somewhat contradictory elements of navigation locks in the embankment to maintain pre-project boat transport, and a comprehensive internal road network to accompany the embankment road. Neither were built, which has created some problems for bulk transport within the area. The village roads are suitable only for pedal rickshaws; since 1988 they have probably been usable during the wet season to a much greater extent than pre-project, although the 1987/88 breach floods caused them damage.

The embankment road is usually motorable throughout, although subject to the risk hazards already noted. However, there seem to be only two vehicles (both belonging to BWDB) in the area, which still has no vehicle ferry links with the outside world. Mini-taxis ply the eastern embankment, but generally only as far as Nabipur or Beltali, even though the Dhaka river launches come to Kalipur. Large steamers and river launches still dominate peripheral transport, although the embankment road serves both the external riverine areas, in addition to the Project Area.

A minor net positive impact is assessed in both on-site and off-site areas.

(h) Infrastructure

The two catastrophic breach floods of 1987 and 1988 have partially offset the complete security from flood damage achieved in the three years since. Project and local infrastructure, as noted, also suffered due to the large-scale bank erosion in the south west during the construction period. Both immediate (in the east) and long-term (in the west) risk factors remain high regarding infrastructure.

As always, it is difficult to weight the risk hazard against the total security afforded by the Project when the embankment remains intact. Damage in AEDs A and C was said to be worse in 1987/1988 than in normal pre-project flooding, due to the rapid onset of the breach floods. In AED B, of course, infrastructural damage from the breach floods was considerable, with buildings, bridges, canals, etc. destroyed in many places.

Given the persisting high risk, a minor negative impact is assessed in AEDs A and C, and a moderate one in AED B. Overall weighted impact remains as minor negative.

Minor negative impacts are assessed in the off-site areas, caused by the increased flooding there. Very great damage has been done by the Meghna in the adjacent riverine lands, including eroding some 1,000 ha originally within the planned Project Area. Just one example suffices: 60 per cent of Eklaspur market has been lost to the river, which the local people insist was largely due to the embankment.

However, as already noted, the Meghna bank erosion which has caused these major problems cannot be attributed to the Project and is essentially a natural phenomenon, probably related to the confluence with the Padma at this point. The slight increase in flood levels ponded against the embankment has caused relatively minor infrastructural damage, in the riverine land north of Eklaspur, with a similar effect in the DRA.

(i) Domestic Water Supply

A minor negative impact is likely within the Project Area. A negative impact on groundwater quality due to greatly increased use of agrochemicals on what are fairly permeable soils, although uncertain because unproven, has been noted in Section 11.4.1 (f). However, it was also noted that iron content in the domestic tubewell water supply resulted in the general use of ponds for cooking water. The possible increased pollution and stagnation of ponds due to the Project (Section 11.4.1 (h)) adds to the probable negative impact.

Riverine external areas are not affected.

(j) Sanitation

The general awareness of sanitation needs and widespread use of latrines seem to have prevented any significant problems of pollution from indiscriminate sewage. Flushing by the breach floods in two of the Project's five years would also have minimised any increase in the problem so far.

(k) Recreation

The lack of recreational pursuits that would be affected by the Project means that there is no significant impact.

(l) Energy

Negative impacts on energy are identified only where energy is wasted. Thus, although MDIP consumes large quantities of energy, notably by the pump stations but also through increased agro-industrial activities (Section 11.6.1(f)), no significant impacts are assessed.

11.6.2 Social Impacts

(a) Human Carrying Capacity

The large increase in human carrying capacity is the major positive impact of the Project. At whatever high cost (Chapter 12), the Project has clearly transformed an area of endemic out-migration into a thriving rural community with substantial food to spare. In achieving the practical aim of helping Bangladesh to buy time while population growth is brought under control and economic progress is accelerated, the MDIP is one of the country's prime successes. There are obvious qualifications of cost and both immediate and long-term risk, but this central positive impact is undeniable.

In the external riverine areas, a weak minor negative impact is found, due to the increased flooding.

(b) Demography

Both size and structure of the population have benefited from the reversal of the pre-project out-migration trends. Again, a major positive impact is recognised within the Project Area. Demography is not significantly affected in the external areas, where minor negative economic impacts are diluted by the large proportion of residents who own land on both sides of the bund, and so gain net benefits.

(c) Gender

A weak minor positive on the role of women by creating greater employment opportunities, particularly in paddy processing, is detected by the PIE (Chapter 10). There are no significant off-site impacts.

(d) Age

No discernible impacts arise, unless the increased agricultural activity offers more employment for the old or takes children out of school too early. Such impacts are unlikely to be significant and in any case balance each other.

(e) Health and Nutrition

The increased food supply achieved by the Project must represent a benefit in this respect (Chapter 10) although countered to some extent by the reduced protein and diversity of local production, due to emphasis on rice crops and to the negative impact on fisheries. However, most people have the capacity to purchase additional foods. No new health problems were reported as due to the Project, except one or two complaints about increased mosquitoes. In the absence of any real data, it is assumed that net impacts are minor positive in the Project Area.

(f) Disruption, Safely and Survival

The conflicting effects of the Project here have already been noted in the discussions in Sections 11.4.1 (d) and 11.6.1 (h). The personal safety and survival of the population pre-project was rarely threatened because of the relatively steady and predictable nature of the annual floods. Disruption occurred, but usually only as anticipated, and was lived with for many years.

The Project has completely changed this relatively harmless and customary situation, so that there is now either complete safety and security (1989-1991) or catastrophic breach flooding (1987-1988) with tremendous disruption and in several place loss of life. In addition, areas both within and outside the planned Project Area were subjected to dangerous bank erosion and destruction during the long construction period, possibly in part due to the embankment's interference with Meghna flows, although this seems highly unlikely.

The main concern now must be the continuing high risk element, especially the immediate threat in the east of AED B. There is a now-acknowledged inherent inadequacy in the embankment design, which was modified from original wider and stronger specifications at a late stage of project preparation (ADB, 1990). As a result of this inherent and in places plainly visible risk (Section 11.4.2(d)), a major negative impact is assessed there, reducing to moderate in AEDs A and C. The risk to human life becomes paramount in weighting the overall impact on the Project Area as major negative.

In the adjacent riverine areas, the Project's limited influence in increasing flood-levels creates minor negative impacts. As noted, the steady attrition of the Meghna left bank here is considered to be primarily natural. River flooding occurs less rapidly than breach flooding and the Project does provide some safety through refuge on the embankment itself (where, of course, it remains intact).

(g) Land Ownership

Government acquisition of land for the embankment and other works, accompanied by a general feeling of inadequate and delayed payments for it, constitutes a negative impact on land ownership throughout both the Project Area and the external riverine areas (Chapter 9).

(h) Equity

There seems to have been a reasonably proportional distribution of project benefits across the population compared to most other FAP 12 study areas. This probably reflects the very considerable increase in agricultural and associated employments (Chapter 9) and the apparent lack of any sizeable traditional fishing communities away from the rivers.

Thus, assuming the socio-economic reality is accepted that for agricultural enterprises to succeed on a large scale it is inevitable that the large land-owners profit most in absolute terms, then there is no significant impact on social equity.

In the riverine areas, a minor negative impact results, because the better-off residents are usually those with land on both sides of the bund, who gained net benefits, compared to poorer residents, who only felt the impacts of increased flooding.

(i) Social Cohesion

There seems to be little if any internal social conflict arising from the Project in the Project Area, where almost everyone has benefited perceptibly. A minor negative impact arises outside the bunds, where some people have suffered disproportionately.

(j) Social Attitudes

Despite a plethora of complaints, the local people generally appreciate what the Project has achieved for them. This positive attitude extends to a general feeling of safely and security from flooding, contradicting completely the bitterness expressed over losses caused by the 1987/88 breach floods and the constantly retreating embankment in the south west. The main complaint is the perhaps unreasonable one about the capacity of the irrigation and drainage system: why are not all lands commanded for irrigation and drainage? More pertinent is the dissatisfaction with BWDB's operation and maintenance of the scheme and the lack of consultation (Section 11.6.4). Net impact on social attitudes is moderate positive even in AED B.

In the riverine areas there is considerable antipathy to the Project amongst people who do not have additional land within the bund, diluted by the satisfaction of those who do. A net minor negative impact is found.

11.6.3 Economic Impacts

The three main potential economic impacts on the people are on incomes, employment and land values. These have all received very positive impacts from the Project since 1988, but during the first two years the breach floods prevented any marked initial improvement. Thompson (1990) notes the negative impacts of the 1987 floods on employment and incomes in the MDIP area.

Assessment, therefore, is again complicated by the events of 1987 and 1988 and by the immediate and long-term hazards which persist, in the west and east respectively, of AED B. In addition, the original Project area could be considered to have lost some 1000 ha in the south west during construction due to unwise land selection during the planning period.

Taking these factors into account, along with the various human use impacts assessed in Section 11.6.1, the conclusions reached are that moderate positive impacts are likely to have been achieved in AEDs A and C, along with a strong minor positive impact in AED B. It is expected that credit availability will reflect similar impacts.

In the external riverine areas negative economic impacts are largely balanced by benefits to residents owning land inside the embankments. The slight loss of trade suffered by boatmen in the DRA is balanced by the boost to river traffic that the Project must have provided.

It must be emphasised that these economic impacts are assessed at the level of the individuals and households concerned. They do not imply the economic viability of the project as a whole, for which the enormous construction and operating costs incurred by GOB must be taken into account.

11.6.4 Institutional Impacts

All FCD and FCD/I projects assume in their planning and design a high level of institutional activities and effectiveness, especially within the main institution concerned, the BWDB, but also the DAE. Sometimes the DOF is also included in the local institutional strengthening that is implicit in and planned by the Project. In defining institutional impacts by the Project, positive impacts are recognised where performance exceeds the planned levels and achievements and negative impacts where these fall short. Institutional impacts arise, therefore, due to the success or otherwise of project management.

The main institution involved, as in all FCD/I projects, is BWDB. DAE was to have had a substantial role in agricultural extension, including a pilot farm, but this was dropped. DOF was also to have been involved.

The originally planned major positive impacts of the Project on institutional activities and effectiveness, therefore, have not materialised. This is partly due to the virtual abandonment of DAE and DOF inputs, but even more to the poor institutional performance of BWDB, in both the design/construction and the operation/maintenance of the Project. The re-design, poor alignment and inadequate construction of the embankment created the current high risk element. Everywhere in the Project Area, local people complain about serious shortcomings in the operation of both irrigation and drainage and of a lack of consultation. Embankment inspection and maintenance is lacking.

The impact of the Project on BWDB's activities and effectiveness in operating and maintaining such a large undertaking therefore has been to expose this key institution as being inadequate and inflexible. This results partly from lack of funds, equipment and staff. In places where local farmers have largely taken matters into their own hands, using LLP pumps, standards are far higher.

A comprehensive institutional system of committees at all relevant levels planned during project preparation has never been implemented, nor has the O&M Manual prepared then been put into use. Probably the major failing has been the lack of any attempt to levy the water rates, originally anticipated as covering the large operation and maintenance costs.

DOF have achieved some progress with culture fisheries (Section 11.6.1(d)), while DAE undertake some limited demonstrations and other extension activities. One (unplanned) area in which BWDB has been effective, is in providing agricultural staff to supplement DAE's efforts.

Public participation is currently limited to the areas noted above, where local people rely on their own LLP methods of irrigation. Participation and consultation regarding operation of the Project seem to result only after confrontations, such as that in 1990 demanding opening of the Uddhamdi sluice gates to allow much-needed irrigation water into the system on the high tide.

Generally moderate negative impacts are recorded.

11.6.5 Cultural Impacts

The Project has not affected scenic qualities or other aesthetic considerations. Temporary negative impacts on cultural sites arose in AED B during the breach floods, when graveyards and mosques were unusable.

Cultural continuity is unaffected, partly because there is no sizeable traditional fishing community.

Quality of life has clearly improved in the Project Area, due to the reduced flooding and improved economic conditions. However, the high immediate and long-term risk hazards reduce this to moderate levels.

In the riverine external areas there are minor negative impacts due to increased flooding.

11.7 ENVIRONMENTAL SCREENING

Environmental screening uses the scoping exercise carried out in Section 11.4-11.6 to evaluate project activities in terms of their influence on environmental impacts. The Project's primary activities were flood control, drainage, and irrigation. Scoping shows that since 1988 the flood control and irrigation components have been achieved largely as planned, but that in the two years of the Project prior to that, major negative impacts resulted from catastrophic breach flooding, especially in AED B. Also, prior to 1987 during the construction period, about 1,000 ha of badly selected land in the south west was lost to natural bank erosion by the Meghna.

Thus flood protection failed initially but has since helped to achieve large positive impacts. These are qualified, however, by considerable immediate and long-term hazards in the east and west respectively of AED B.

Irrigation, meantime, has been largely responsible for the major agricultural and economic impacts and could probably have been possible without flood protection. Irrigation has focused, however, on HYV paddy rather than on increasing high-value rabi crop production, as originally planned, (due partly to BWDB's failure to levy any water rate).

The drainage component, despite being the major operational expense element, contributes much less to the major positive impacts than irrigation. With flood control, it provides benefits during the kharif season. Although expensive, it does in general avoid the drainage congestion problems found in all other PIE studies.

The agricultural support, roads and navigational components originally planned were not implemented and so create no impacts.

11.8 CONCLUSIONS AND RECOMMENDATIONS

Conclusions can be summarised in terms of the main environmental impacts of the Meghna-Dhonagoda FCD/I Project on the Project Area and on the external riverine areas. Environmental impacts have been assessed by environmental scoping in Sections 11.4-11.6 and are presented in Tables 11.2-11.4.

The agroecological divisions (AED) are defined in Figure 11.1. and in Table 11.1.

(a) Project Area

Major positive environmental impacts have been achieved as follows:

(i) improved soil moisture status, especially in AEDs A and C;

(ii) improved land capability, also especially in AEDs A and C;

(iii) greatly improved human carrying capacity, MDIP's most important achievement;

(iv) favourable demographic impacts, reversing out-migration and stabilising demographic structure.

There are accompanied by number of moderate positive impacts, including:

(i) almost complete control of flooding and drainage since 1988, but not a major impact because of the initial failures in 1987 and the considerable immediate and long-term risk hazards, especially in AED B;

(ii) crop cultivation (and especially irrigation), where a major impact in recent years is again tempered particularly in AED B by the events of 1987/88 and the continued high risks;

(iii) agro-industrial and associated activities, which have flourished following the increased agricultural production;

(iv) an appreciative social attitude to the Project, despite the experiences of 1987/88 and the continuing risk;

(v) considerable economic benefits for local people, in terms of income, employment, land values and credit availability; again since 1988 these have reached major impact levels but are modified, especially in AED B, by the problems in 1987/88 and in the continuing risk factor;

(vi) quality of life, reflecting the same potentially major impacts in most of the above issues, qualified by the 1987-88 breach floods and the risk of reoccurrence that persists.

It is apparent that the positive environmental impacts of the Project were focused on the extensive AED A (Old Meghna Floodplain), covering 43 per cent in the north of the Project Area, and in the much small AED C (Gumti Floodplain - 7 per cent) in the south. AED B (Meghna-Dhonagoda Floodplain - 50 per cent) bore the print of the 1987 and 1988 catastrophic breach floods through its eastern embankment, where the immediate risk of recurrence persists, and of the Meghna bank erosion in the south-west, where a long-term risk continues.

Much of the socio-economic gains are related to the irrigated rabi season crops, dominated by HYV paddy. Since some of this is likely to have been possible without the extremely costly flood control and drainage components, the FCD impacts assessed alone would be less impressive, involving fewer and smaller impacts but still retaining the 1987-88 damage and the inherent risk element.

The other major negative impacts derive from this, consisting of the excessive soil erosion in the Dhonagoda embankment, especially between Nandalalpur and Durgapur (the stretch where both previous breaches occurred), and the resulting major threat to human safety and survival.

Moderate negative impacts relate to the marked decline that is taking place in soil physical characteristics under the now-prevalent rice monoculture and to the limited involvement of the local people in project operation and maintenance.

The main negative impact of the Project was poor institutional performance, especially during the design and construction stages, when embankment alignment in the south west, re-design of the embankment, and reliance on inadequate manual compaction techniques created the current high risk element. These shortcomings have been compounded by limited embankment inspection and maintenance. A basic problem is BWDB's lack of mobilisable resources for operating such a complex and threatened scheme.

It is noticeable from Table 11.3 that negative biotic impacts have been very limited. As in most of Bangladesh, ecological changes in the last few decades have been substantial in the Project Area. Such changes include the reduction in natural wetlands extent, accompanied by the marked decline in birds, fish and other wildlife. These had largely taken place in the MDIP Area by 1978, when project construction started, and would have continued subsequently irrespective of the Project. In the last three years, fish disease has added a further marked negative trend, again apparently unrelated to the Project.

It is difficult to assess, therefore, the degree of additional impact when the Project's influence is superimposed upon these ongoing trends and the already dominantly anthropic landscape. Clearly, starting from such a biologically poor baseline as existed by 1978, overall biotic impacts are unlikely to be other than negligible or occasionally minor.

The physical and human environmental impacts are both frequently conflicting. Even the overall assessment of individual environmental issues is often a net value derived from both positive and negative significant impacts. This reflects the marked contrast between largely negative impacts arising during construction and especially in the 1987-1988, and largely positive impacts (but still tempered by the high risk factor) since then.

A net overall assessment for the Project Area is best set at moderate positive, but is not very meaningful in view of the above.

(b) External Impact Areas

Tables 11.2-11.4 also show the generally minor physical and human impacts of the Project on the external riverine areas along the Meghna and Dhonagoda-Gumti Rivers. There have been negligible biotic impacts there. The Project is not considered to create significant cumulative downstream impacts because it is not part of any close group of similar FCD Projects.

Most external impacts are negligible and some are minor, caused by the primary impact of slightly increased flooding against the embankments.

There is one moderate positive impact, on agro-industrial and associated activities in the Dhonagoda-Gumti Riverine Area (DRA), which have increased due to the rise in agricultural output and incomes in the adjacent Project area. A similar impact occurs in the Meghna Riverine Area (MRA), partly due to increased activities of this type but due especially to long years of construction and reconstruction of the twice-retired embankment south of Eklaspur.

11.8.2 Recommendations

The conflicting experiences of the Project during construction, in its first two years, and in the three years subsequent to that have made environmental impact assessment problematical. Overall, however, the Project is now enjoying success and general appreciation by the local people, who so far have had to bear none of its enormous and continuing substantial costs.

Recommendations need to concentrate on perpetuating the 1989-1991 experience and avoiding that of 1987-88. They include the following.

(i) It is extremely urgent that the embankment is regularly inspected. It is already obvious that the Nandalalpur-Durgapur stretch should be completely rebuilt at the earliest opportunity. BWDB needs both technical and financial support to achieve this.

(ii) The protective defences in the south west should be completed without delay and the behaviour of the Meghna carefully monitored over the coming years to try to anticipate future areas of risk.

(iii) A comprehensive programme should be mounted to monitor water quality in ponds, khals, drainage effluent, adjacent rivers and (especially) groundwater, to assess the possible pollution by agrochemicals and indiscriminate sewage. MDIP is well-suited to be one site of a nationwide monitoring programme, which is urgently needed.

(iv) A similar programme is needed to investigate and monitor the decline in soil physical characteristics, which could usefully and easily incorporate soil fertility. The root of both soil physical and fertility problems is probably related to reduced organic content in the topsoils. One possibility here is the use of composted water hyacinth to raise organic content or as a mulch, as seems to be done in the Control area and also in Kurigram South PIE area. Water hyacinth in MDIP seems mainly to be dried as poor quality fuel.

(v) The development of fish culture in ponds, khals and old channels should be actively encouraged.

(vi) An attempt should be made to encourage the cultivation of high-value rabi crops; where successful it should be used to contribute to the findings in (iv) above. This would be important if realistic water charges are levied, as they must be.

(vii) The potential for embankment protection and production using suitable trees, shrubs and grasses should be explored. Fuelwood, for instance, is clearly in very short supply in MDIP, as even water hyacinth is widely used as fuel.

(viii) In view of the past problems and continued high risk to physical and human environmental issues, there appears to be a need for full environmental project audit at a time after the satisfactory restoration of the embankment.

12 ECONOMIC ASPECTS

12.1 BASIS FOR ECONOMIC POST-EVALUATION

The economic re-evaluation of MDIP is based on the impact of the Project on agriculture and fisheries. Although agricultural impacts are dominated by changes in the paddy cropping patterns and yields (see Chapter 5) account has also been taken of the loss of non-paddy rabi crops which are known, on the basis of data from the control area and from the CIRDAP benchmark survey, to be significant in without-project conditions. Fisheries impacts have been estimated using the methodology set out in Appendix J of the FAP 12 Final Report, the detailed derivation of the volume of fisheries losses being shown in Chapter 7. The re-evaluation is based on the lower of the two estimates of fisheries losses presented there.

MDIP is known to have had adverse effects on water transport, but the magnitude of these is not known and there have been some countervailing benefits to land transport. Transport impacts have therefore been excluded from the re-evaluation.

MDIP suffered severe damage in its first two years after completion, and the consequent delay in achieving agricultural benefits, and costs of rehabilitation, are included in the analysis. For the base case of the re-evaluation it has been assumed that the project would not breach again during its working life. This assumption has been relaxed by examining the effect of a 1987 or 1988 type event recurring every ten years.

Evaluation methodology has in general followed the guidelines set by FPCO (1991). Financial costs and returns to agriculture have been assessed at local prices as measured by the PIE survey of the Project, and have been converted to economic prices using FPCO's Standard Conversion Factors. The cost of capital has been assumed to be 12 per cent, again following FPCO. Project life has been taken to be thirty years; at the discount rate used, the influence of a longer life on economic performance is insignificant.

12.2 PROJECT COSTS

Project capital cost data were extracted from the ADB PCR (ADB 1990), and have been converted to economic costs using FPCO SCFs applied to standard BWDB cost breakdowns for the types of works and structures included in the Project. The financial and economic costs of the Project, broken down by local and foreign exchange components, are shown in Table 12.1. The total economic capital cost at 1991 prices is Tk. 1493 million, or about US$39 million at late-1991 exchange rates, phased over the period 1977 to 1988.

Recurrent O&M costs are Tk. 31.5 million per annum, although substantially larger amounts were expended under this head for rehabilitation works in the years immediately following the 1987 and 1988 floods. Thus, the O&M expenditures in 1989, 1990 and 1991 were Tk. 130.6 million, Tk. 73 million and Tk 79 million respectively (all in 1991 constant prices). Regular O&M cost is around 2 per cent of capital cost, which is lower than many other projects studied by FAP 12 (for example, Halir Haor (5.2 per cent), Protappur (6.6 per cent) and Kurigram South (5.7 per cent)). However, this actually reflects the very high capital cost per hectare of MDIP, nearly ten times that of the next most expensive project studied by FAP 12. Absolute O&M costs are over Tk.2400 per cultivated hectare (see Section 4.6) and this does not include routine earthwork maintenance, little of which has yet been undertaken due to the newness of the Project and the overriding concentration on rehabilitation of flood damage.

Table 12.1 **Project Economic and Financial Costs**
(Tk.'000 in 1991 Prices)

	Local Costs		Foreign	Total	
	Financial	Economic		Financial	Economic
1977	2470.73	2026.00		2470.73	2026.00
1978	5096.34	4179.00		5096.34	4179.00
1979	9241.98	7454.30	10704.00	19945.98	18158.30
1980	24381.11	18568.50	8531.00	32912.11	27099.50
1981	44049.10	33492.40	6087.00	50136.10	39579.40
1982	159240.94	112570.00	61325.00	220565.94	173895.00
1983	158753.87	121209.20	123142.00	281895.87	244351.20
1984	165021.87	120715.50	161361.00	326382.87	282076.50
1985	187316.01	140933.10	22020.00	209336.01	162953.10
1986	156631.87	119200.60	5577.00	162208.87	124777.60
1987	201205.13	153813.70	5002.00	206207.13	158815.70
1988	339134.16	255064.10		339134.16	255064.10
Total				1856292.10	1492975.40

Source and Notes: Based on ADB (1990). Conversion factors derived from FPCO(1991). Standard BWDB breakdowns were used to decompose structures into constituent costs, eg. labour, materials etc.

12.3 VALUE OF GROSS OUTPUT

Table 12.2 presents data on value of crop output and by-products for the with and without project situations, for all paddy crops. The difference in cropping patterns between the protected and control areas is remarkable, with Boro, T.Aus and T.Aman HYV dominating crop output in the project area, while B.Aman is the most important crop in the control area. This suggests a very significant Project impact, which is confirmed by the data on gross value per hectare in Table 12.2. Gross incremental value over all types of paddy is around Tk.12500/ha. in 1991 economic prices.

12.4 COSTS OF PRODUCTION AND TOTAL BENEFITS

Table 12.3 presents data on paddy production costs in financial and economic terms by crops. Average economic production cost per hectare is estimated at TK 8714 in the with Project situation, compared to TK 6084.8 in the without Project situation, yielding an incremental cost of TK 2629.2 per hectare. Deducting this value from the value of gross incremental output gives a net Project impact per hectare of Tk. 9931.

Table 12.2 Gross Value of Output
(1991 prices)

Crop	With Project				Without Project			
	Sample Area (ha)	Output (Tk.'000)	By-products (Tk.'000)	Total (Tk.'000)	Sample Area (ha.)	Output (Tk.'000)	By-products (Tk.'000)	Total (Tk.'000)
Local Boro	.25	4.22	1.64	5.86	-	-	-	-
HYV Boro	36.40	1056.71	143.06	1199.76	5.29	136.20	18.44	154.65
Local T Aus	.88	15.51	5.47	20.98	-	-	-	-
Local B Aus	4.58	53.60	19.82	73.41	0.35	4.02	1.49	5.50
HYV B Aus	7.59	164.25	21.25	185.51	-	-	-	-
HYV T Aus	21.77	590.70	71.66	662.36	-	-	-	-
Local B Aus/Aman	2.40	21.99	8.54	30.53	3.16	19.30	7.49	26.80
Loacl B Aman	1.15	11.52	4.47	16.00	15.88	173.58	67.38	240.96
Local T Aman	3.63	77.26	24.99	102.25	0.81	6.72	2.17	8.89
HYV T Aman	39.91	1096.13	145.06	1241.20	1.02	16.83	4.45	21.29
Total	118.56	3091.88	445.96	3537.85	26.51	356.65	101.43	458.09
Gross value/ha (Economic)				29.84				17.28

Source: Consultants' estimates, based on PIE surveys 1991
Conversion factors from FPCO (1991)

Table 12.3 Costs of Production
(1991 Prices)

Crop	Protected Area				Control Area			
	Cost/ha (Tk.)		Sample Area Total Costs (Tk.)		Cost/ha (Tk.)		Sample Area Total Costs (Tk.)	
	Fin.	Econ.	Fin.	Econ.	Fin.	Econ.	Fin.	Econ.
L Boro	3803.00	3077.00	950.80	769.25			0.00	0.00
HYV Boro	11238.00	10185.00	409063.20	370734.00	14165.00	11812.00	74932.85	62485.48
Local T Aus	7941.20	6936.40	6988.30	6104.03			0.00	0.00
Local B Aus	6525.50	6220.70	29886.80	28490.81	6959.00	5894.50	2435.65	2063.08
HYV B Aus	6761.07	6045.00	51316.50	45881.55			0.00	0.00
HYV T Aus	9343.70	8932.60	203412.30	194462.70			0.00	0.00
Aus/Aman	4900.47	4017.00	11761.10	9640.80	3866.00	3352.00	12216.56	10592.32
Local B Aman	7294.20	5992.00	8388.30	6890.80	5508.00	4611.00	87467.04	73222.68
Local T Aman	7333.70	6660.00	26621.30	24175.80	7076.00	6079.00	5731.56	4923.99
HYV T Aman	9063.30	8669.30	361716.30	345991.76	8154.60	7863.00	8317.69	8020.26
Total			1110104.96	1033141.50			191101.35	161307.81
Average Econ. Cost/ha.				8714				6084.8

Sources and Notes: Consultants' estimates, based on PIE surveys 1991. Conversion factors used for shadow pricing derived from FPCO (1991)

Raising this by the protected area annually cropped to paddy gives an estimate of total project benefits arising out of the impact on paddy production of TK 298.2 million. Deducting the net economic value of the non-paddy crops replaced by Boro, the incremental value of production is Tk. 212.9 million per year.

12.5 FISHERIES LOSSES

The estimates of fisheries losses (see Chapter 5) suggest a range of 374 mt. to 424 mt. per year, valued at Tk. 9.95 to 11.28 million. These figures may however be much too low. For example, CIRDAP (1987) figures on pre-project fish yields are much higher than those assumed in the above estimate, and the FAP 12 RRA, which used the CIRDAP data, suggested that fish losses could be as high as 4000 mt.. The estimates from Chapter 5 have however been used for the economic re-evaluation, as being relatively conservative. By the same token, the lower of the two estimates of fishery losses has been used for the base case in the re-evaluation.

12.6 BENEFIT COST ANALYSIS

The economic cash flows for the base case (mid-point estimate of agricultural benefits, and low estimate of fishery losses) are shown in Table 12.4. EIRR is estimated at 6.7 per cent, NPV at 12 per cent discount is Tk. -337.2 million, and Benefit:Cost Ratio at 12 per cent discount is 0.56. Under the base case assumptions, therefore, the Project is clearly non-viable.

This lack of economic viability is in strong contrast with the technical success of the Project, both in its main hydrological interventions (see Chapter 3) and in their impact on agriculture (see Chapter 5). In view of the undoubted increase in wellbeing that MDIP has brought to many sections of the population, the economic performance was tested for sensitivity to variation in the main technical and cost parameters. The results of these tests are summarised in Table 12.5.

12.6.1 Sensitivity to Statistical Uncertainty

The 'Maximum Agricultural Benefit' case reflects the range of uncertainty attaching to the PIE yield estimates. As described above, the base case estimate of agricultural benefits is derived from the difference between the estimated paddy yields for the protected and control areas, but because they are from sample data the estimates used are merely the most likely single points within a probabilistic range of variation. An estimate of the maximum likely range of variation has been made by taking the difference between the upper 75 per cent confidence limit for protected area yield and the lower 75 per cent limit for the control area. This produces a net return of Tk.13228/ha. compared with Tk.9930 in the base case, and an EIRR of 12.7 per cent - a barely viable performance. It must be stressed, however, that this represents the upper extreme of the range of probability, and that the high likelihood is that the PIE data indicate a worse performance than this, quite possibly worse than the base case. The EIRR is not very sensitive to variation in estimation of fishery losses within the limits stated in Chapter 7, and results for this test are therefore not presented.

Table 12.4 Economic Cash Flows, Meghna-Dhonagoda Irrigation Project (Base Case)
(Tk.'000 in constant 1991 economic prices)

Year	Capital Costs	O&M Costs	Total Costs	Net Agri-cultural Benefits	Fishery Losses	Total Agricltural & Fishery Benefits	Net Economic Benefits
1977 / 78	2026		2026				-2026
1978 / 79	4179		4179				-4179
1979 / 80	18158		18158				-18158
1980 / 81	27099		27099				-27099
1981 / 82	39579		39579				-39579
1982 / 83	173895		173895				-173895
1983 / 84	244351		244351				-244351
1984 / 85	282076		282076				-282076
1985 / 86	162953		162953				-162953
1986 / 87	124777		124777				-124777
1987 / 88	158815		158815				-158815
1988 / 89	255064		255064				-255064
1989 / 90		130630	130630	106450	9948	96502	-34128
1990 / 91		72958	72958	159675	9948	149727	76769
1991 / 92		79007	79007	212900	9948	202952	123945
1992 / 93		31529	31529	212900	9948	202952	171423
1993 / 94		31529	31529	212900	9948	202952	171423
1994 / 95		31529	31529	212900	9948	202952	171423
1995 / 96		31529	31529	212900	9948	202952	171423
1996 / 97		31529	31529	212900	9948	202952	171423
1997 / 98		31529	31529	212900	9948	202952	171423
1998 / 99		31529	31529	212900	9948	202952	171423
1999 /2000		31529	31529	212900	9948	202952	171423
2000 / 1		31529	31529	212900	9948	202952	171423
2001 / 2		31529	31529	212900	9948	202952	171423
2002 / 3		31529	31529	212900	9948	202952	171423
2003 / 4		31529	31529	212900	9948	202952	171423
2004 / 5		31529	31529	212900	9948	202952	171423
2005 / 6		31529	31529	212900	9948	202952	171423
2006 / 7		31529	31529	212900	9948	202952	171423
2007 / 8		31529	31529	212900	9948	202952	171423
2008 / 9		31529	31529	212900	9948	202952	171423
2009 / 10		31529	31529	212900	9948	202952	171423
2010 / 11		31529	31529	212900	9948	202952	171423
2011 / 12		31529	31529	212900	9948	202952	171423
2012 / 13		31529	31529	212900	9948	202952	171423
2013 / 14		31529	31529	212900	9948	202952	171423
2014 / 15		31529	31529	212900	9948	202952	171423
2015 / 16		31529	31529	212900	9948	202952	171423
2016 / 17		31529	31529	212900	9948	202952	171423
2017 / 18		31529	31529	212900	9948	202952	171423
2018 / 19		31529	31529	212900	9948	202952	171423

Source: Consultants' estimates

EIRR %:	6.70
NPV @ 12%:	-337216.00
PV Benefits @ 12%:	430449.59
PV Costs @ 12%:	767665.58
BCR @ 12%:	0.56

12.6.2 Sensitivity to Construction Problems

Since MDIP experienced serious problems of time and cost overrun, and breached twice in the first two years due to defective investigation and construction, sensitivity to removing these problems has been tested. Assuming completion on time, though still with the cost overruns and breaches, EIRR is 7.6 per cent. With completion on cost but with delays EIRR is 8.21 per cent, while completion to time and cost raises EIRR to 9.4 per cent. Finally, the 'Fault-Free' case, assuming completion to time and cost and without the defects which caused the breaches, raises EIRR to 10.4 per cent. This last represent a bare economic viability at the assumed cost of capital at the time of Project appraisal.

12.6.3 Sensitivity to Future Breaches

To test the sensitivity of economic performance to repetitions of the events of 1987-1988, it was arbitrarily assumed that a breach might occur once in 10 years. Rather than make assumptions regarding the timing of breaches, the impacts were annualised. Crop output benefit were therefore reduced by 10 per cent, and the actual rehabilitation costs incurred after the 1987-1988 floods were likewise averaged over a 10-year period. The EIRR under this case is 5.33 per cent.

Table 12.5 Sensitivity of EIRR to Variation in Cost and Technical Parameters

Case	EIRR %
Base Case	6.70
Maximum Agricultural Benefit	12.70
On Time	7.60
On Cost	8.21
On Time and Cost	9.37
'Fault-Free'	10.36
Base case + future breaches	5.33

Source: Consultants' estimates

12.6.3 Reasons for Under-Performance

MDIP is thus clearly non-viable under almost any conceivable combination of circumstances, and should certainly not have been built. Although the combination of unfortunate events to which the Project has been subject have significantly worsened its economic performance, it would still not be viable if it had performed exactly as planned. The reasons for its poor performance must therefore be lie deeper (and be less avoidable) than the well-documented problems of prolonged construction, cost overrun and breach.

The appraisal of the Project estimated an EIRR of 17 per cent, on the basis of which the decision was taken to proceed. There is thus a large gap between appraised performance and the most optimistic estimates of what could actually have been achieved had the Project been trouble free. The reason for the disparity is undoubtedly that the 'without-project' yields assumed for feasibility and appraisal were far too low, and therefore produced an over-estimate of incremental output. The PIE estimate of mean yield over all types of paddy in the control area (representing the without-project situation) is 2.4 mt./ha., with a 75 per cent confidence limit of +/- 0.18 mt./ha.. This agrees closely with CIRDAP's yield estimates for the immediately pre-project period. The Project documents, however, assume a without-project yield of about 1.27 mt./ha. (see BWDB 1988c), which is far beyond any likely margin of error in the PIE estimates.

MDIP was appraised in 1977, 9 years before the CIRDAP survey and 14 years before FAP 12's PIE survey, and some increase in yield might be expected to have taken place in the interim. An increase of nearly 90 per cent is however not credible, given that there had been no significant shift to transplanted varieties and/or HYVs. The inference is that the appraised economic performance of MDIP was based on yield estimates which should have been recognised as inaccurate at the time of feasibility study. It is worth noting in this context that the planning estimates of with-project yield appear, from the PIE data and from the CIRDAP survey, to have been very accurate.

12.7 CONCLUSIONS

The economic re-evaluation of MDIP provides a pointed lesson in the need for realistic estimates of yield benefits in planning FCD/I projects. As a result of the use of inaccurate estimates, Bangladesh incurred a financial cost in 1991 prices of some Tk. 2419 million, much of it in foreign exchange, to construct a project which is non-viable and which generates a large ongoing demand on Government revenues for its month-to-month operation. It is salutary to note that the capital cost of MDIP per hectare benefited is nearly ten times that of Zilkar Haor, the next most expensive project studied by FAP 12, while Zilkar Haor has an EIRR of 40 per cent.

In addition to this practical lesson in project appraisal, the underlying economic weakness of MDIP has important implications for pumped drainage systems. As noted in the FAP 12 Final Report (Appendix G, Volume 3) the orthodox low-cost approach to drainage in Bangladesh using gravity flow has the very serious limitation that high water levels within projects frequently coincide with high river stages outside, and drainage then becomes impossible. Pumping is clearly an attractive technical solution to this impasse, and the MDIP experience since 1988 demonstrates its effectiveness.

The present analysis clearly indicates, however, that pumped drainage for agricultural improvement is at best of sub-marginal economic viability, even when, as in MDIP, the opportunity is taken to double up the benefits to the pump installations by using them for irrigation as well. It is doubtful whether any FCD/I project will surpass MDIP's impact on hydrology and agricultural output, and that impact is insufficient to justify the costs incurred.

Table 12.6 Summary Data For Estimation of Benefits and EIRR

	Point		Maximum		Minimum	
	W	WO	W	WO	W	WO
Yield (mt/ha)	4.38	2.42	4.65	2.215	4.074	2.575
Av. Price (Tk/ha)	5948.6	5550.2	5948.6	5550.2	5948.6	5550.2
By-prod. Yield (mt/ha)	4.65	3.96	4.94	3.62	4.32	4.21
Average Price	809.5	967.2	809.5	967.2	809.5	967.2
Gross Value/ha (Tk, Econ.)	28945	16761	31660	15795	27732	18364
Cost/ha (Tk, Econ.)	8714	6084.8	8714	6084.8	8714	6084.8
Net Returns	20231	10676	22946	9710	19018	12279
Project Impact/ha (Tk)	9931		13228		6739	
Total Paddy Benefits (Tk million)	298.2		397.2		202.4	

Source: Consultants' estimates from PIE survey data 1991

Note: Maximum benefit estimates are based on the difference between the upper 75% confidence limit for protected area yields and the lower 75% limit for control area yields. Minimum benefit estimates are based on the difference between the lower 75% CL for the impacted area and the upper 75% CL for the control.

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