The Environmental and Social Impacts of Flood Defences in Rural Bangladesh: A Cost-Benefit Analysis.

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1. Introduction

Flood mitigation is clearly a very important issue for Bangladesh and is highly related to other high priority policy goals such as food security. As a result, protection against flooding has often been combined with efforts to intensify agricultural production and most of the flood control projects in Bangladesh are so-called 'flood control, drainage, and irrigation' projects. These projects have recovered thousands of hectares of land from the floodplain through the construction of dykes or embankments. This measure, however, has come under criticism because a) it provides benefits in terms of increased agricultural productivity and is therefore biased towards land owners; b) it has resulted in a long run decline in soil fertility due to the cessation of sediment deposition on land during flood; c) it prohibits the migration and spawning of fish, and thereby reduces overall fish stocks and the livelihood of fishers; d) Flood control embankments also hinder water transportation because they prevent free water flows between rivers within and outside embankments. Consequently, flood control projects often reduce the incomes of water transportation workers and force some to leave this sector.

The construction of flood protection embankments therefore has a complex pattern of both positive and negative impacts for different sections and occupational groups within the affected population. Some of these impacts are through environmental channels. As mentioned above, fish stocks are negatively affected by the presence of embankments and hence the livelihoods of those engaged in capture fisheries are affected. Fisher communities in Bangladesh are generally one of the poorest occupation groups. Similarly, negatively affected people engaged in water transportation also tend to be from the poorest strata in the community.

Most of these impacts are long-term impacts, which are difficult to ascertain before the initiation of the project. The Government of Bangladesh has recently proposed its poverty reduction strategy plan where the key objective is to develop a *pro-poor development policy* implying that development projects must be poor-friendly in terms of their impacts. The PRSP also envisages the provision of social security measures for the poor and vulnerable groups in the country, a majority of whom live in the floodplains. Considering this thrust in public policy along with the commitment by the multilateral and bilateral donor organisations and countries, it is important that we understand the long-term impacts of development projects using an ex post framework so that future policies are relevant to Bangladesh's development priorities.

The research objective addressed in this chapter is to revisit these issues with evidence from a case study in which the long run impacts can be assessed. Our chosen flood control project for this research is the *Meghna Dhonogoda Irrigation Project (MDIP)*, which was completed in 1988 and for the last 18 years has protected its target area from flooding. MDIP is located in the Matlab North Thana[1] about 120 km south of Dhaka with a population of nearly 299,000 (2001 census data).

The structure of the remainder of the chapter is as follows: Section 2 sets out the framework for the cost-benefit analysis; Section 3 describes the study and control sites used in the analysis; Section 4 describes the household survey conducted for this appraisal; Section 5 presents the estimations of costs and benefits for each impact category; Section 6 sets out the results of the CBA and examines the distribution of impacts across occupational groups; and Section 7 provides conclusions and policy recommendations.

2. Approach and methods

The analytical framework used in this study to assess the economic, environmental, and social implications of the MDIP is cost-benefit analysis (CBA). CBA is an evaluation method in which all the costs and benefits associated with a project are expressed and compared in monetary terms. Through the calculation of net present values (the discounted stream of future benefits minus the discounted stream of future costs), CBA provides an indication of how much an investment contributes to social welfare.

CBA is essentially a “with and without” analysis, i.e. involves a comparison of the value of economic activities and environmental services in an observed scenario (with embankment)

[1] An administrative unit in Bangladesh under one police station.

against their values in a counter-factual scenario (without embankment). The elaboration of a counter-factual scenario for the MDIP is assisted by the use of “control sites” that have similar characteristics to the study site but do not have a flood control embankment. In this study we use two control sites that are described in the following section.

As mentioned above, the construction of flood protection embankments results in a complex set of both positive and negative impacts that are distributed over the lifetime of the project. The categories of impacts that we include in this appraisal are: a) agricultural crop production; b) capture fisheries; c) aquaculture; d) livestock and poultry; e) fruit trees; f) housing; g) human health; and h) construction and maintenance costs.

The presence of the embankment results in avoided damage costs of flooding to crops, culture fisheries, property, and health. These benefits of the embankment are estimated by comparing the damage costs per household within the project area with the damage costs in the control sites and extrapolating this difference over the relevant population and the lifetime of the project. The presence of the embankment, however, is observed to cause increased water-logging during the rainy season, which results in damages across the various impact categories. Although the embankment allows cropping all year round and prevents flood damage, it also prevents the deposition of nutrients by flood waters and results in declining soil fertility over time. These costs of the embankment are estimated in a similar manner and included in the appraisal. In the case of crop agriculture, the impact of the embankment is more complex and is estimated using a production function approach.[2] By estimating a production function for crop agriculture, these opposing effects can be taken into account. Similarly, a production function is estimated for capture fisheries. These estimations are explained in more detail in Section 5.

In addition to the direct impacts of the embankment on damage costs, the presence of the embankment is also observed to influence land use patterns and population characteristics – and these also need to be taken into account in the appraisal. To accommodate changes in land use (i.e. a higher proportion of land being used for crop agriculture and aquaculture under the project scenario), the land use pattern of one of the control sites is used as the land use pattern under the 'without project' scenario. Population growth, density, and overall pattern of occupation is also likely to follow a different path following construction of the embankment. We use data from

[2] A production function describes the relationship between inputs and outputs in production. For example, the production of rice may be described as a function of labour, fertiliser, pesticides, soil fertility etc. A change in quantity or quality of an input may result in both a change in total output and a change in the use of other inputs (and therefore the cost of production). For example, a reduction in soil fertility result in both a reduction in the harvest of rice and an increase in the quantity of fertiliser required to produce a given quantity.

four separate points in time to extrapolate the changes in population and its distribution. The first two sets of point estimates on the population and its occupational distribution came from CIRDAP (1987) for 1978 and 1986, the third point estimate came from MIWDFC (1992) – popularly known as FAP-12, and the final estimate is derived from our household survey for 2005. Based on these estimates, linear interpolations were made to estimate the population for intermittent years. After 2005 we assumed no further changes to provide a more conservative estimate of changes.

As mentioned above, the various costs and benefits of the MDIP project are distributed over time. The costs of construction are borne in the initial phase of the project, whereas the benefits (e.g. increased agricultural output) and maintenance costs accrue after completion of the embankment construction and until it ceases to function. It is therefore necessary to select an appropriate time horizon over which to estimate the costs and benefits associated with the project. We selected a 50 year time horizon, starting in 1978 (the year in which construction started) and ending in 2038. The analysis in this study is therefore partially ex post (i.e. for the period 1978-2005) and partially ex ante (for the period 2006-2038). Although it is possible that the embankment may continue to function beyond 2038, any discounted costs and benefits accruing after this point will be negligible given any realistic discount rate. We do not consider the case that the embankment is effective for a shorter time horizon.

3. Case study areas

The study site

The MDIP project is situated in the Chadpur district in the South-East of Bangladesh (see Figure 1). The project has a gross area of 33,220 ha of land[3] and water bodies inside it. It is bounded by the Meghna River to the North and West, and by the Dhonogoda River to the South and East. Total agricultural land in the area varies significantly depending on the season. Of the total land area, 24 percent is used as aman[4] crop land, 31 percent is used as boro[5] crop land, 2 percent is

3 We have used GIS maps to determine the exact land and water area in the project. This produced a figure that is about double the estimate of 17,584 ha quoted in existing documentation of this project site.

4 A rice season in Bangladesh in which rice production takes place in between Mid-March to Mid-November.

5 A rice season in Bangladesh in which rice production takes place in between Mid-March to Early-August.

used for potato production, 15 percent is used for human settlement, 12 percent for other production and 16 percent are water bodies (using GIS[6] data).

In terms of land elevation, nearly 47 percent of the land is low lying land (without the embankment this land would be mostly flooded during the monsoon months), 26 percent of land is medium land which would be flooded occasionally, and 15 percent of land is above flooding level. Most of the high land is used for human settlement, whereas other land is used primarily for crop agriculture.

The MDIP project was completed at a cost of US$ 32.8 million to protect nearly 19,060 ha of land, and to provide irrigation facilities to 14,175 ha of crop land (CIRDAP, 1987, p9). The project consists of 64 km of embankment, 282 km of canal system for irrigation and 125 km of drainage canals.

The MDIP has been the subject of three earlier appraisals. It is useful to briefly review these studies in order to allow a comparison with the results of the present study. The first of these appraisals was conducted by the Asian Development Bank (ADB) prior to funding the project (ADB 1977). This analysis included, on the benefit side, only the value of increased rice yield, and on the cost side, only the construction and operation and maintenance costs. Other potential benefits were identified but not monetised, including employment opportunities, environment, and foreign exchange savings. The central NPV estimate from this study is US$ 7.6 million per year, and the estimated internal rate of return is 17.9%. This appraisal has been complemented by a project completion report by the ADB, which details the time and cost overruns experienced by the project (4 years and 36%, respectively), and the breaching of the embankment in 1987 and 1988 (ADB 1990).

An ex-post appraisal of the MDIP was conducted in 1992 for the Bangladesh Ministry of Irrigation, Water Development and Flood Control (Hunting Technical Services Ltd 1992). The study finds a highly negative outcome of the project. In addition to the high cost overrun, the benefits to agriculture were found to be over-estimated in the original feasibility study and appraisal, and a devastating impact on capture fisheries is identified. The NPV was now estimated to be US$ -8.7 million and the IRR to be 6.7%.

The appraisal described in this chapter extends further than these existing studies in terms of the long-run assessment of impacts from the embankment and also in the use of production functions to estimate the net impacts of the embankment on agriculture and capture fisheries.

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6 Centre for Environmental Geographic Information System (CEGIS), Dhaka provided GIS data for this research.

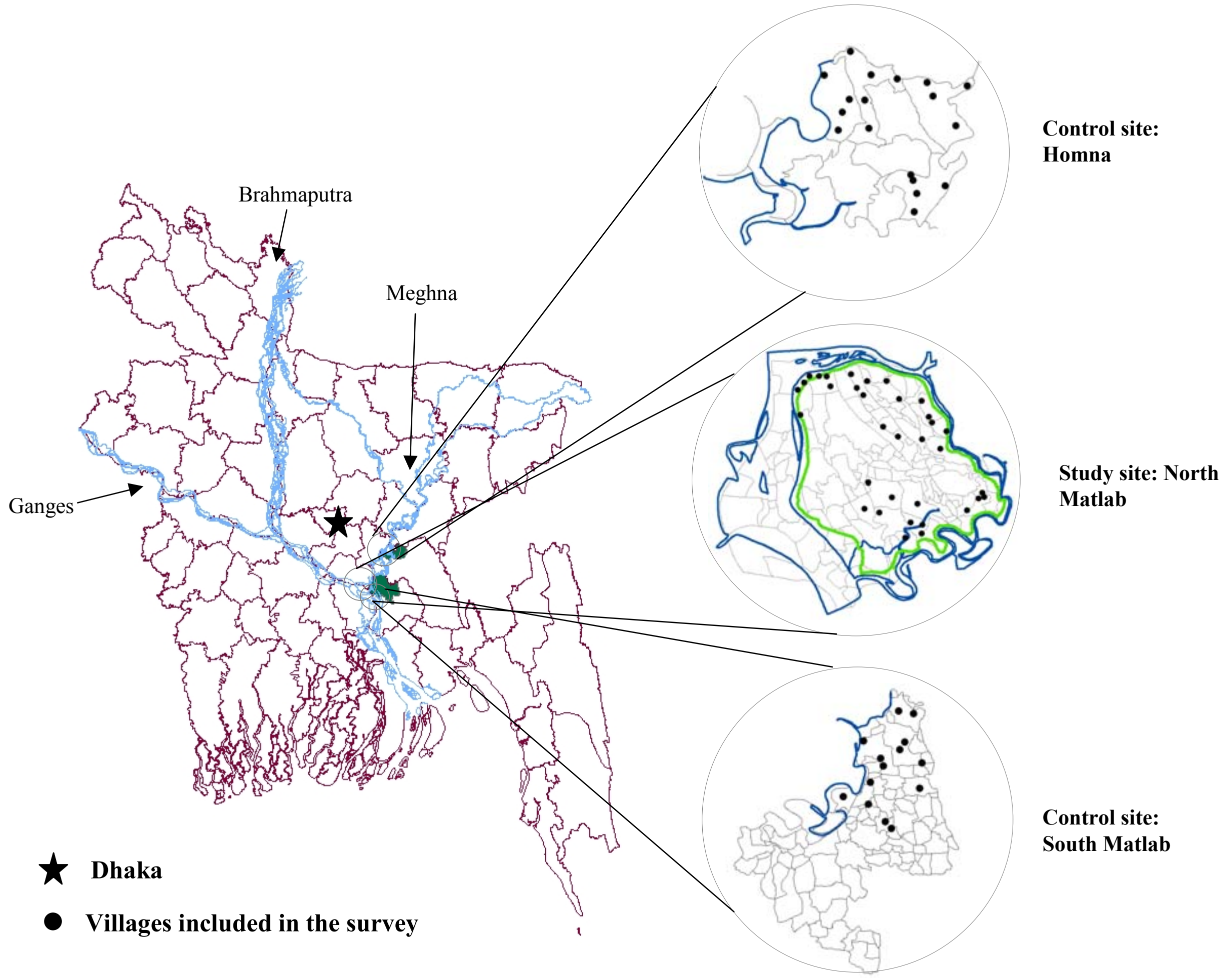

Figure 1. Location of study and control sites. The green line in the in-set map of North Matlab represents the location of the embankment.

The control sites

Since we produce a partially ex post CBA for understanding the overall impact of the MDIP, we needed to develop suitable control areas that would meaningfully represent the without project scenario for the project. After studying the locality, we chose two separate Thanas[7] that might effectively give us a 'without project' scenario. These are: Matlab South - which was part of the Matlab thana until 1991, after which the original Matlab thana was divided into two. Matlab North is the MDIP project area and Matlab South is the area outside the MDIP project. There are, however, a number of reasons why Matlab South may not represent a perfect 'without project'

[7] Thana is the lowest tier of police administrative unit in Bangladesh.

case. First, Matlab South is much more urbanized than Matlab North; second, Matlab South is better linked with the rest of the country by road and hence its economic activities might have been significantly influenced by the factors outside the locality; and third, Matlab South is less prone to flooding than Matlab North because it is located on the south-eastern bank of the river Dhonogoda and not on the larger Meghna river. Considering this, we also used a slightly distant location, Homna thana, as another control area. Homna is located on the south-eastern bank of Meghna river, is a flood-prone area, and is currently without embankments (See Figure 1).

4. Survey Design and the Sample

This study uses data from an extensive rural household survey looking generally at agricultural production, aqua-cultural production, fisheries (capture fisheries), nutrition, recent damages due to flooding in the control area, recent damages due to water-logging in the project area, other health related information, willingness to pay for flood protection, agricultural and fish production, and general demographic, socio-economic characteristics of residents.

A total of 589 households from the project area and 672 households from Homna and Matlab South were interviewed face-to-face in 2005 using a stratified random sampling procedure. A structured questionnaire with several modules for each sub-section of information was used. The questionnaire consists of five main parts, three of which were designed for specific occupational activities (including household production and consumption patterns). Based on the pattern of occupational distribution used in the Flood Action Plan study on the MDIP project, the survey team selected six categories of households in 60 villages. 28 of these villages are from the project area and the rest are from control areas.

Prior to the survey, the field investigators were trained and questionnaires sufficiently tested to reduce possible errors and biases during the survey.

In addition to the household survey, 45 semi-structured key informant interviews were carried out by the research team. Whereas some quantitative information was asked from the key informants, i.e. population of the village, per capita income of villagers, water level during flood etc., most of the information collected was qualitative in nature. Interviews were designed for individuals from different professional backgrounds and were conducted by local college teachers who were trained and briefed thoroughly about the objective of interviews. Local primary school teachers, fishing community leaders as well as field level agricultural extension officials, health workers and NGO workers were interviewed for the study.

The key informant interviews were conducted from the second week of April to the second week of May 2005. On average each interview with key informants lasted for one and a half hours. The questionnaire covered impacts of flooding on different occupational group, coping mechanisms during and after flood, and information regarding household activities during normal and flood years etc.

5. Benefit and cost estimates

The following impacts were estimated as input in the CBA: a) agricultural production; b) capture fisheries; c) aquaculture; d) livestock and poultry; e) fruit trees; f) housing; and g) human health. The impact on agricultural production and capture fisheries are directly estimated using the production function approach while other benefits are estimated indirectly using a two step procedure. In the first step agricultural benefits are estimated and in the second stage other impacts are estimated using a proportion of households affected and the proportion of damage as a percentage of agricultural benefits.

Production Function Approach to Benefit and Cost Estimation

As mentioned above, a production function approach has been used to measure the impact of the embankment on agriculture and fisheries. Combined data for the project and control sites were used to estimate production functions for rice production and fish catch, controlling for variation in input variables and site effects. Given the following production function:

$$Q = f(I, \theta) \qquad (1)$$

Where, Q is the output, I is the vector of inputs, θ is the site dummy with a value of 0 for the project area and 1 for the control area.

$\Delta Q = f(I, 0) - f(I, 1)$ measures the impact of the embankment. A positive value means a gain and a negative value implies a loss due to the embankment. Four production functions were estimated, three for rice production (see Table 1) and one for capture fisheries (see Table 2). These production functions are described in more detail below.

Indirect measure of benefits (and costs) from flood control embankment

For benefits and cost estimation in terms of health, poultry, livestock, agricultural equipment, housing, trees, and acquaculture, this study resorted to indirect measurement using the benefit from agriculture as the benchmark. There are two reasons for using this method: First, to estimate these benefits using the production function approach, a large set of data is required, which could not be collected during the field survey (mainly because it would have increased the number of questions in the questionnaire and would potentially have caused non-sampling errors). Second, protection of agricultural output from flooding was the main reason for construction of the embankment. Therefore, these benefits were estimated as a proportion of agricultural benefits. The following formula is used to estimate benefits from protection of flooding and costs due to water logging in the project area.

$$B_i = \Gamma \cdot \gamma_i \cdot \alpha_I \tag{2}$$

Where Γ is the mean estimate of damage in agriculture found in the no-embankment scenario, γ_i is percent of households affected by flooding and reported ith type of damages, and α_i is the proportion of ith type of damage as a percent of agricultural damage due to flooding. As a result, B_i measures the ith type of benefit due to flood control in the project area.

$$C_i = \Lambda \cdot \phi_i \cdot \beta_i \tag{3}$$

Where Λ is the mean estimates of damages in agriculture due to water logging in the project area, ϕ_i is percent of households reported ith type of damage in the project area due to water logging, and β_i percent of ith damage as a percent of agricultural damage. As a result, C_i measures the ith type of cost due to water logging.

Agriculture

There are four major crops produced in the project area. These are: a) aman rice, b) aus rice, c) boro rice, and d) potato. Figure 2 presents the seasonal production of these crops. The figure shows that the aus and aman crops are likely to be directly affected by flooding without flood protection. Hence, the embankment reduces the damage to aus and aman rice crops and benefits agricultural production. In addition, by preventing flooding there may also be an increase in the net cropping area.

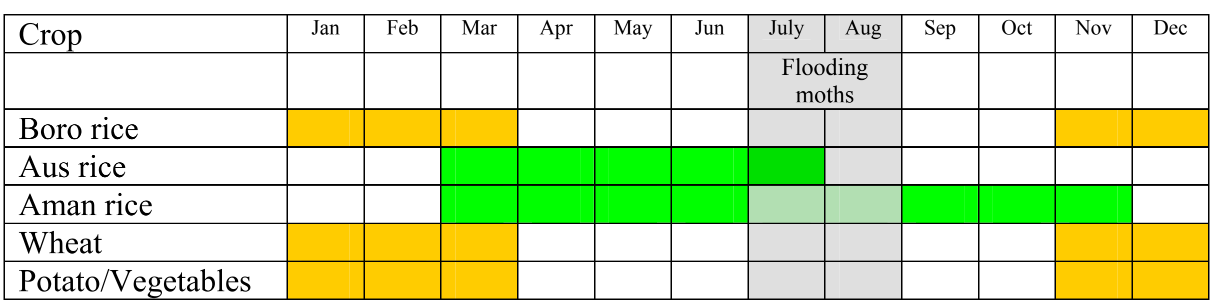

Figure 2. Cropping seasons in MDIP project area

Data on both output and inputs were collected for all crop types from both the project and control areas. Input data on the use of fertiliser, pesticide, labour (both home and hired labour), draught animals, tractors, and irrigation technology were collected in the household survey. However, we did not have enough observations to estimate a production function for wheat and potato. Consequently, benefits in terms of increased production of wheat and potato due to flood protection have not been estimated.

A Cobb-Douglas production function was estimated for aus rice using labour, draught power, fertilizer and pesticides as explanatory variables (see Table 1). The estimated coefficient on each input variable measures the elasticity or responsiveness of output to a change in each input. The model suggests that labour is the most influential input, followed by pesticide and draught power. Fertilizer is found to be not significant but it has the correct sign.

The variable of interest for this study is the site dummy, which is positive and significant. This indicates that, ceteris paribus, aus rice productivity is higher in the control site than in the project site. This is also true for boro and aman rice production. Productivity estimates, therefore, shows that after 13 years of operation of the flood control project, land productivity in the project area has decreased compared to that of the control area despite crops being protected from flooding. In theory, the reduction of land productivity could be due to a large number of factors such as crop variety, production technology, farmers' knowledge on production system, soil quality, etc. However, during the field survey it was observed that the same variety of rice is produced in these two regions, that production technology in the two areas are very similar, and that there is no significant differences in the education level of farmers. Given this, it can be concluded that the productivity difference is mainly due to differences in soil fertility, which has been reported by many farmers during the field survey. Due to the embankment, the land use pattern within the embankment area has changed. This has two opposing effects on crop production. On one hand, the increased cropping intensity has reduced the productivity on a seasonal basis. On the other hand, by growing crops year round, it has increased annual productivity per hectare. In other words, while seasonal output has declined on a per hectare basis, flood-protected land is used for more than two crops a year and hence total output per hectare of land has gone up on an annual basis. Taking this into consideration, present value of net benefits from agriculture were calculated to be 256 million Taka[8] (or 3.7 million US$) for the 50 years life of the project at 10% rate of discount. Net benefits are calculated using a) increased total production per year due to flood control, b) plus crop damage avoided from flooding due to construction of embankment and

[8] 1 US$ = 69 taka.

c) minus damage due to water logging resulting from mismanagement of the irrigation and drainage networks.

Table 1. Estimated aggregate production functions for aus, aman, and boro rice.

	Dependent Variable (Yield in kg per season)					
	Ln (Aus Production)		Ln (Aman production)		Ln (Boro production)	
(all inputs are measured in per ha of land)	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Intercept	5.620674	17.63***	5.425238	5.85***	6.014605	27.67***
ln(Draught power)	.1744899	1.87*			.2600722	4.95***
ln(Fertilizer)	.0954692	1.22	.1540082	1.37		
ln(Pesticides)	.2709896	3.42***			.0683412	1.92**
ln(Labor)	.2960061	3.42***	.2498513	1.10	.1741298	3.43***
Ln(irrigation)					.1500587	3.28***
Site Dummy Target = 0 Control = 1	.2203851	2.34***	.6098547	1.98**	.1550585	2.02**
Other regression parameters	R^2 = .8171 n = 93 F = 77.73 ***		R2 = .3784 n = 16 F = 2.44		R^2 = .3218 n = 383 F = 35.77***	

NOTE: * significant at 10%, ** significant at 5%, *** significant at 1%.
Draught power measured in number of days per ha, Fertilizer in taka value per ha, pesticides in taka value per ha, labour is (home plus hired labour) per ha, and irrigation water is measured in taka per ha. (1 US$ = 69 taka).

Capture fisheries

Using data from the household survey, we estimated a production function for capture fisheries (see Table 2). The site dummy was found to be positive and significant.[9] This indicates that the project area, ceteris paribus, has lower harvest in large fish than the control area.

Table 2. Estimated production function for large fish

Dependent variable: ln (large fish catch measured in kg of production per year per fishing team)

	Coefficient	t-value
Intercept	-0.145	-0.08
ln(No. of fishing trips per year per team)	0.468**	1.91
Dummy for boat type	-0.975+	-1.61
Dummy for net type	-0.008	-0.01
Site Dummy (Project = 0 Control = 1)	0.559***	-2.68
Other regression parameters	R^2 = 0.18 n = 106	

NOTE: ** significant at 5%, *** is significant at 1% and + significant at 11%

9 We initially estimated production functions for three sizes of fish (small, medium, and large) but were only able to find a significant difference in production between the study site and control sites for large fish.

The present value of the loss to capture fisheries is around 10.55 million taka (or 0.15 million US$) over the 50 year time horizon of the project. Prices for fish were collected from Key Informants in 2005 prices.

Culture fishing

This benefit is estimated using an indirect approach. Improved flood control activity induces aquaculture activities in the flood-protected area. We estimate that there is nearly a 501 million taka (in present value terms at 10% rate of discount) or 7.27 million US$ increase in production of culture fishing over the 50 year time horizon of the project.At the same time, it was also observed that due to water logging in the area, some of these fish farms also lost huge sums of money. For a 50 years period the present value of such loss is nearly 40.5 million taka or 0.58 million dollars (see Table 4).

Livestock and poultry

Flooding affects livestock and poultry production negatively. Consequently, it is observed that livestock production and poultry production increased after the embankment was constructed. It was also observed, however, that livestock gains are not significantly different between target and control sites but that there is significant gain in poultry production in the flood-protected area. It was also noted that water logging has been responsible for damages to the poultry industry. Using the control and project area data and the estimates on population and its distribution, it is estimated that the present value of avoided damage costs to poultry is 22 million taka (0.31 million US$) but at the same time there is a loss of 14.8 million taka (0.21 million US$) from poultry and livestock due to increased water logging over the 50 year lifetime of the project.

Property damages

Flood protection is expected to provide a significant positive benefit to people in terms of reduction in property damages. At the same time, because of the protection provided by the embankment, many people have built homes below the flood-level and these are vulnerable to water logging due to mismanagement of the drainage facilities. Table 3 shows the gains in terms of avoided flooding damage to properties in low-lying areas of the project site and Table 4 shows losses due to water-logging in the project area. It is estimated that there is a net loss (in present value terms) of 30 million taka (or 0.44 million US$) over the 50 year lifetime of the project. For all of these estimates the population projections, its distributional changes and the damage cost information from the survey data were used.

Table 3: Estimates of damages avoided due to non-flooding in project area

Type of Damage avoided	Taka per household per year**	Total damage avoided* (million taka)
Crop Damage	16300.59	502.375
Agricultural Equipment Damage	502.06	0.278
Poultry and livestock Damage	2860.75	22.034
Fruit Tree Damage	6864.18	22.919
Homestead Damage	16223.98	47.284
Health Damage	4187.62	10.204
Education related damage	13555.57	3.410
Other Damages	73.35	

NOTE: * in present value terms using 10% rate of discount for 50 years in million taka. 1 US$=69 taka (2006)
** Field Survey data.

Table 4: Estimate of damages due to water logging in project area

Damage type	Taka per household per year**	Total damage costs* (million taka)
Crop Damage	21840.80	245.797
Agricultural Equipment Damage	65.52	0.003
Livestock Damage	681.43	14.294
Aquaculture Damage	7967.52	40.577
Poultry Damage	410.61	0.607
Fruit Tree Damage	4975.33	10.105
Homestead Damage	1994.06	77.334
Health Cost	159.44	0.053
Other damages	54.60	0.002

NOTE: * in present value terms for 50 years with 10% rate of discount and in million taka. 1 US$=69 taka (2006)
** Field Survey Data.

Fruit tree benefits

Again there are both losses and gains in terms of fruit trees. This includes losses due to water logging in the project area and loss avoided due to flood protection - as gains. Per household loss due to water logging has been estimated from the responses on average losses in the project area, where as per household gain or loss avoided due to flood protection is estimated from the responses in the control area. It shall, however, be noted that two areas do not have equal vegetation. Using the indirect method of estimation it has been found that a net loss is 12.1 million taka (or 0.19 million US$) in present value terms for the 50 years lifetime of the project have been avoided due to embankment.

Health benefits

Flooding significantly inflicts health damages on people living in the flooded areas. During a flood the provision of clean drinking water becomes a major problem and the incidence of water borne diseases increases. Indirect method of measurement was used to estimate this benefit. It has been assumed that health Table 3 shows that health benefits associated with the embankment are around 10 million taka in present value terms (or 0.15 million US$). On the other hand, water logging also caused some health problems in the protected area, mostly related to skin related diseases as the quality of water deteriorates in the water logged area. The monetary value of this impact is estimated to be 0.053 million taka (or .001 million US$).

Agricultural equipment benefits

Since most of the economic activities in the floodplains are around agriculture. In the flood plains farmers usually are aware of the cost of floods in terms of damages in their equipment. Yet data from control area suggested that some equipment related to tilling of land, weeding, etc. could be damaged during floods and this could be avoided if flooding is protected. On the other hand, it has been also observed in the survey that farmers in the protected area often increase their number of equipment because they resort to highly intensive use of land and so water logging could also cause some damages. Using indirect approach to measurement it was found that the present value of such net benefits on this account for 10% rate of discount for 50 years time is only 0.28 million taka (or 0.004 million US$).

Other benefits (costs)

Households living in the floodplain reported that flooding has other costs to their families. These includes costs in terms of loss in income to continue education, temporary displacement of families, increased cost of living in flooded areas, etc. These could have been avoided if flooding is controlled. On the other hand, in the protected area, families also report similar costs due to water logging. Using indirect measures, the net impact is around 3.41 million dollars

Finally, Table 5 presents the summary of all costs and benefits for the MDIP project. Once again, to estimate future losses for years up to 2038, a population projection was used based on secondary data from Bangladesh Bureau of Statistics (BBS, selected years). No estimates of benefits and costs in terms of biodiversity losses (due to embankment) were used in this calculation. However, this calculation includes partial estimate of environmental costs in terms of losses in open access fisheries due to embankment.

Table 5: Summary of Benefits and Costs for MDIP Project

Item of Benefits and Costs	PV in million taka (at 10% rate of discount)	Explanatory notes
Agri Equipment – benefits	0.28	Due to flood control
Agriculture production – benefits	466.81	Due to Flood protection
Agriculture production – rice – benefits	35.56	Due to Increased cropping intensity
Culture fishing – benefits	542.46	Due to culture fishing
Fruit Tree – benefits	18.65	Due to flood control
Health – benefits	8.84	Due to flood control
Housing – benefits	47.28	Due to flood control
Livestock – benefits	3.38	Due to flood control
Other Benefits	3.41	Due to flood control
Poultry – benefits	10.20	Due to flood control
Potato and Wheat – benefits	-	Not measured due to lack of data
Total Benefit	**1136.883**	**(A)**
Agri equipment – costs	-0.003	Due to water logging
Agricultural production – costs	-245.797	Due to water logging
Capture fishing – costs	-10.552	Due to flood control **(environmental cost)**
Culture fishing – costs	-40.577	Due to water logging
Fruit Tree – costs	-10.105	Due to water logging
Health – costs	-0.053	Due to water logging
Housing – costs	-77.334	Due to Water logging
Livestock – costs	-14.294	Due to water logging
Poultry – costs	-0.607	Due to water logging
Other Costs	-0.002	Due to water logging
Biodiversity costs	-	Environmental costs
Total Costs	**-399.324**	**(B)**
Total Project Cost	**-1818.049**	**(C)**
NPV at 10%	**-1080.490**	**(A) + (B) + (C)**

6. CBA results and distribution of impacts

The net present value of the MDIP project using a 10% discount rate is –1,080 million Taka (-15.6 million US$) in 2006 constant prices. The internal rate of return of the project (the discount rate at which discounted costs and benefits would be equal) is about 5.32%. This result is different from other studies done on this project. The MDIP project had an ex-ante IRR value of 17.9 percent in its first feasibility report (ADB 1977). In order to examine the distributional effects, we look at the impacts of the project on the income levels of different occupational groups. Figure 3 shows the sources of income for the six main occupational groups in the project area and we use this to deduce the distributional impact of the embankment. It shows that growth in aquaculture is most beneficial to landowning farmers. Similarly, growth in agriculture will mainly benefit farmers, people engaged in business activities, and labourers. The benefit of the embankment to poultry and livestock production is more evenly distributed across occupational groups. The negative impacts of the embankment on capture fisheries and river transportation services are likely to disproportionately affect the fisher and boatman groups respectively. Considering this, it can be inferred that the livelihood impact of the embankment is tilted against the people who are dependent on water and water resources. At the same time it is also important to note that these groups of people did not migrate to other sectors as had been predicted.

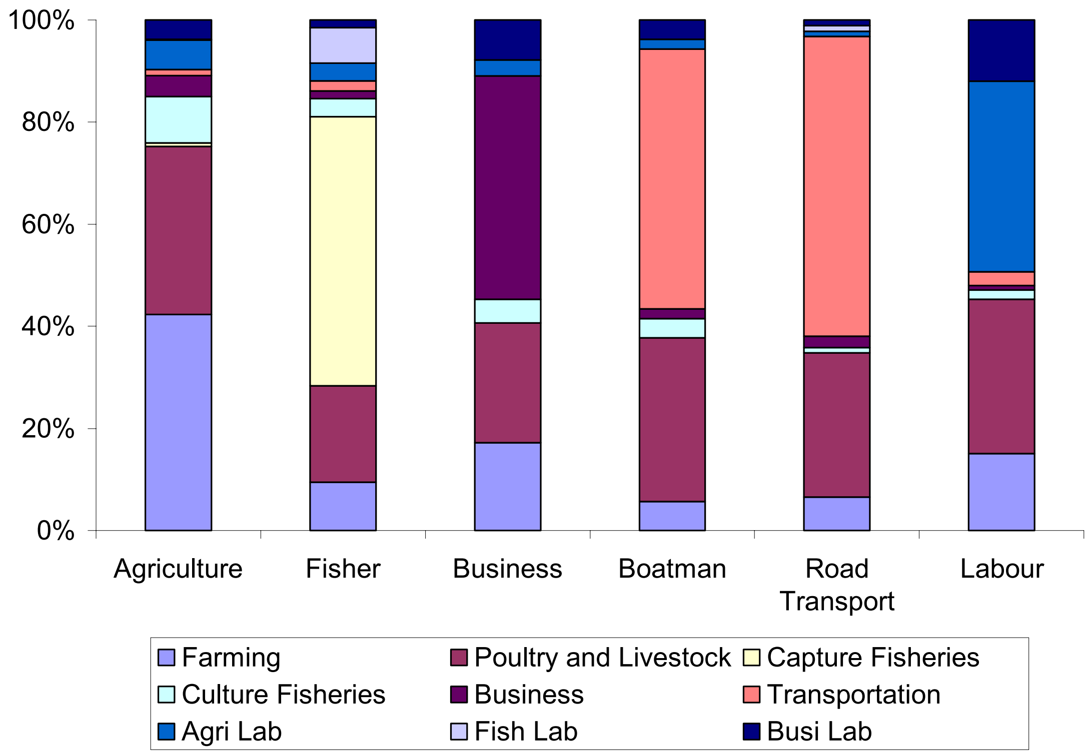

Figure 3: Sources of income by occupation groups

6. Conclusions

The Meghna-Dhonagoda Irrigation Project has come under severe criticism on environmental grounds, particularly in terms of its impact on capture fisheries. Although these impacts have not been quantified in previous appraisals of the MDIP, the Ministry of Water Resources has halted further construction of FCDI projects in Bangladesh on grounds of its potential negative impact on poverty and environment.

The analysis presented in this chapter supports this decision and shows that the MDIP resulted in a net welfare loss, i.e. the costs of the project are greater than the benefits. This outcome is a consequence of a number of factors, including higher than anticipated construction costs, lower benefits to agriculture due to loss of soil fertility over time, higher water logging damages, and the unanticipated highly negative impact on capture fisheries. The combined result is a negative net present value for the project of –1,080 million taka (-15.6 million US$) using a 10% discount rate and an associated internal rate of return of 5.32%. The unanticipated environmental impacts of constructing such an embankment have made this project an expensive mistake. The project has also had detrimental distributional consequences, which compound the already negative outcome. Although landowners as a group have gained from increased crop yields, reduced property damage, and increased poultry, livestock, and aquaculture production, the project has also had a significantly negative impact on two occupational groups who were dependent on water and water resources. They are fishers and the river transport workers, both of which comprise already poor sections of society.

It is important to note that the annual undiscounted loss of around 118 million taka (1.7 million US$) from water logging in the embankment area could have been avoided if proper management could be ensured. If water logging impacts could have been avoided with better management of the project, the internal rate of return would have increased from 5.35% to 7.04%. This highlights the importance of water and irrigation management during the operational phase in ensuring the success of such projects. Together with the need to address negative environmental and distributional impacts of flood protection, this is an important lesson for future flood control projects. The need for flood protection in Bangladesh is evident and, given the anticipated impacts of climate change, this need will increase in the future. Flood protection projects do, however, need to address environmental, distributional and water management issues in order to ensure that they are socially desirable.

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