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**A.K. Enamul Haque**
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**A.K. Enamul Haque*, Luke Brander**, Roy Brouwer**, Sonia Aftab***, Wahid Abdallah*** and Sakib Mahmud*****

* Economic Research Group, Dhaka. akehaque@gmail.com and Professor of Economics, East West University, Dhaka, Bangladesh.

** Institute of Environmental Studies, IVM, Vrieje University, Amsterdam, Netherlands

*** Department of Economics, North South University, Dhaka, Bangladesh

## 1. Introduction

Flood mitigation is clearly a very important issue for Bangladesh. A primary objective for initiating mitigation measures against flooding in Bangladesh is the reclamation of land for intensive agricultural uses. As a result, most of the flood control projects are named as flood control, drainage and irrigation projects. These projects have recovered thousands of hectares of land from the floodplain through construction of dykes or embankments. However, this popular measure came under criticism because a) it provides benefits in terms of an increased productivity and hence is biased towards land owners; b) it encourages the poor and marginal farmers to sell their land (because of high market price), after which they become labourers and eventually poorer in future, and c) it prohibits the migration of fish and thereby reduces the overall stock of fish in adjacent water bodies and reduces the income of fishers. A majority of these impacts are long term impacts, which are difficult to ascertain before the initiation of the project.

While all these allegations are logically true, the current research objective is to revisit this literature with evidence from a case study where flood control was effective and continued for a longer period. Our chosen flood control project for this research is the *Meghna Dhonogoda Irrigation Project (MDIP)*. The construction of this embankment was completed in 1988 and for the last 18 years it has protected the people in its target area from flooding.

### Poverty-environment nexus

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). About 47.88 percent of its households are engaged in agricultural production, 15.79 percent are in engaged in capture fisheries from rivers surrounding

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

the embankment, 10.52 percent are engaged in trade, business and services, 11.55 percent are labourers and the rest (14.26%) are engaged in transportation related services. Of those working in transportation, 44 percent are involved in road transportation and the rest are in water transportation. These numbers indicate the influence of water on the people of the area. Fisher communities in Bangladesh are generally the poorest occupation group. The reasons are a) fisher communities do not own much of land and as a result their income is solely dependent on their physical skills and labour productivity; b) their rights on rivers to catch fish are not recognized by the law and as such it is easy for fishers to be dislocated if the government decides to lease out the open water bodies for fishing activities. As mentioned above, fish stocks are negatively affected by the presence of embankments. Shallow water bodies in the floodplains of Bangladesh are the spawning ground for a variety of fresh water fishes. Flood control embankments have been heavily criticized for preventing the migration of fish to these spawning grounds.

Similarly, people engaged in water transportation also tend to be from the poorest strata in the community. 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.

To summarize the impacts of such mitigation projects in Bangladesh, the following benefits are often listed in the literature: a) increased agricultural output; b) higher diversity of crops or higher agri-diversity; c) higher productivity of land and so a better rent on land; d) increased demand for agricultural labourers; d) higher demand for draught power for agriculture; e) increased number of livestock and poultry in the area; f) higher income and employment because of increased economic activities in the region. Other benefits include: a) protection of property from flooding; and b) protection of health due to better quality of living inside the embankments and due to higher income. Of the negative impacts of the project, the list includes; a) environmental impacts; b) poverty impacts; and c) costs due to water logging in terms of crop damages, property value losses, losses in trees and plantations, if the project is not managed properly.

### Policy relevance

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 has also envisaged that ensuring social security measures for the poor and vulnerable groups of people 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 organizations and countries, such as the Netherlands, it is important that we understand the long-term impacts of some of the development projects using ex post framework so that future policies are relevant to Bangladesh's development priorities.

The structure of the remainder of the chapter is as follows: Section 2 describes the research method, the study and control sites, and the household survey; Section 3 presents the estimations of costs and benefits for each impact category; and Section 4 provides conclusions and policy recommendations.

## 2. Method and study sites

The analytical framework used in this study to assess the economic, environmental, and social impacts 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) with their values in a counter-factual scenario (without embankment). The elaboration of a counter-factual scenario can be assisted by the use of “control sites”, which have similar characteristics to the study site except for the investment under consideration.

### Existing appraisals of the MDIP

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).

A full 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 Case Study Area

The MDIP project is situated in the Chadpur district of Bangladesh in south-western part of Bangladesh (see Figure 1). The project has a gross area of 33,220 ha of land[2] and water bodies inside it. It is bounded by the Meghna river to the North and East, and by the Dhonogoda river to the South and West. Total agricultural land in the area varies significantly depending on the season. Of the total land, 24.49 percent are used as aman crop land, 31.21 percent is used as boro crop land, 1.68 percent is used for potato production, 15.12 percent land is used for human settlement, 11.8 percent for other production and 15.7 percent are water bodies (GIS data, 2003 by PREM project).

In terms of land elevation, nearly 46.9 percent of the land is low lying land (mostly flooded during the monsoon months, 26.2 percent land is medium land which is flooded occasionally and 15.12 percent of land is non-flooding land. Most of the non-flooding land is used for human settlement, where as other land are used primarily for crop agriculture.

The MDIP project was completed with a cost of US$ 32.8 million to protect nearly 19,060 ha of land (GIS data, 2003), and to provide irrigation facilities to 14,175 ha of crop land (CIRDAP report on Impact Assessment of MDIP, p9). The project consists of 64 km of embankment, 282 km of canal system for irrigation and 125 km of drainage canals.

2 We have used GIS maps to determine the exact land and water area in the project. This produces a different figure to that quoted existing documentation of this project site, which generally gives figure of 17,584 ha in land area.

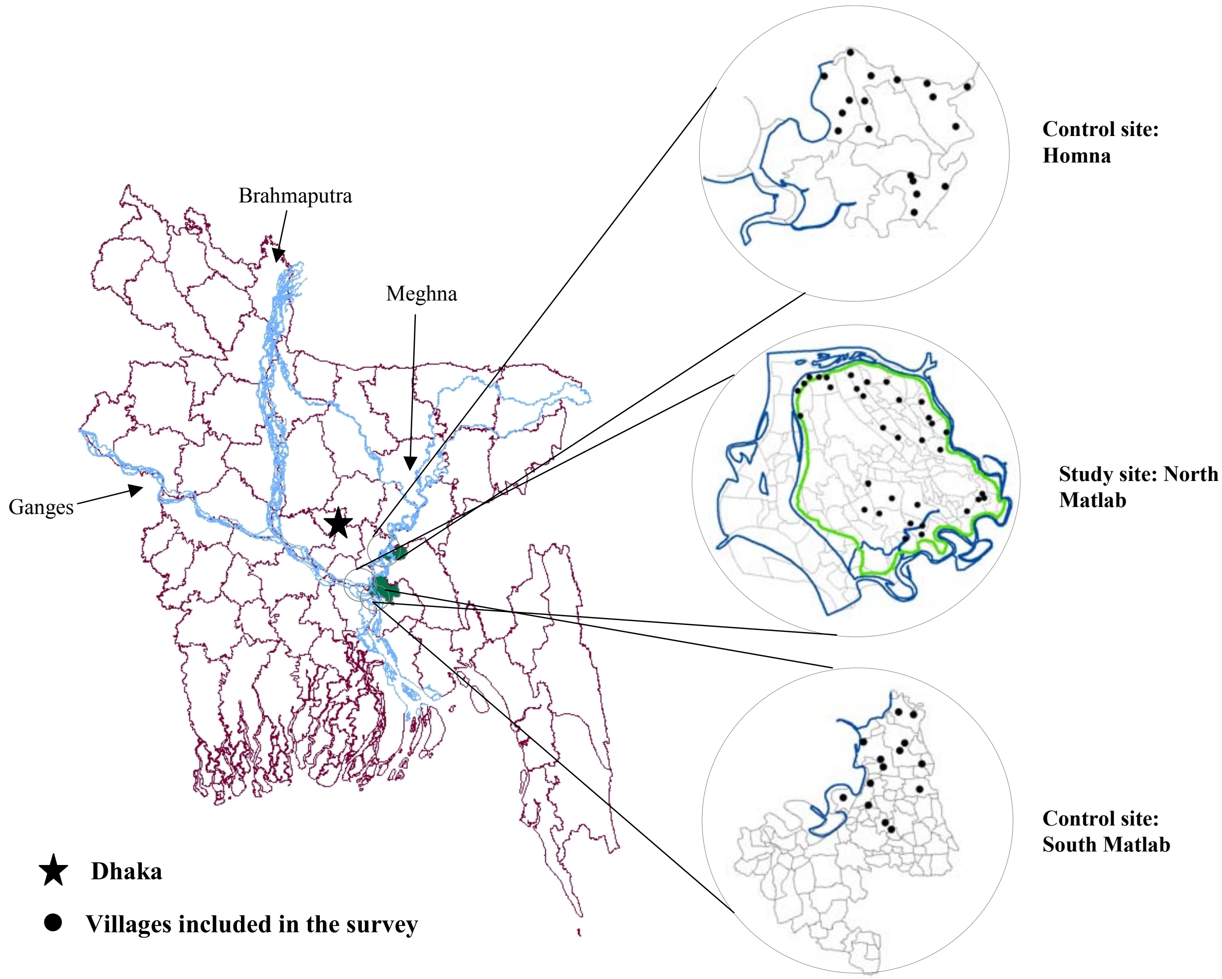



Figure 1. Location of study and control sites. The green line in the in-set map of North Matlab represents the location of the embankment.

### The Control Areas

Since we produce an ex post CBA for understanding the overall impact of the MDIP, we needed to develop suitable control areas which would meaningfully represent the **without project** scenario for the project. After studying the locality, we chose two separate thanas 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 is divided into two. Matlab North is the MDIP project area and Matlab South is the area outside the MDIP project. However, there was a problem to use Matlab South as the true 'without project' 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. Third, Matlab South is less prone to flooding than Matlab North because it is located on the south-eastern bank of the river Dhonogoda. Considering this, we also used a slightlly 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).

### Survey Design and the Sample

This study uses a wider, 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 systems in flood plains, and general demographic, socio-economic characteristics of floodplain residents in one of the most severely flood prone areas in Bangladesh.

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 in each survey that took place for about 30 minutes per household. 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 responsible for face-to-face survey were trained to reduce possibility of errors or biases during the survey. Moreover, three rounds of pre-tests were used to finalize the questionnaire over a period of two and a half months.

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; interviews 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/NGO workers were interviewed for the study.

The key informant interviews were conducted from second week of April to 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.

## 3. Benefits and costs from the MDIP

The following impacts were calculated as input in the CBA. These are on: a) agricultural production b) fisheries, c) aquaculture, d) poultry and livestock, e) housing, f) fruit tree, and g) health. Although the list if items included in this study is very similar to existing appraisals of this project, the methodology used to estimate these impacts differ significantly in this study. The following section presents the methods used to estimate these net benefits and the results.

### Agricultural Benefits

There are four major crops produced in the project area. These are: a) Aman rice, b) Aus rice, c) Boro rice, and d) Potato. The following chart present the seasonal production of these crops. The figure shows that the Aus and Aman crops are likely to be affected by flooding without flood protection. Hence, the project reduces the damage in Aus and Aman rice crops and benefits the agricultural production. In addition, by preventing flooding there may also be an increase in the net cropping area.

| | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Flooding moths | | | | | |
| Boro | | | | | | | | | | | | |
| Aus | | | | | | | | | | | | |
| Aman | | | | | | | | | | | | |
| Wheat | | | | | | | | | | | | |
| Potato, Vegetables | | | | | | | | | | | | |

Figure 2. Cropping Seasons in MDIP project area

**Estimation of a production function for rice**

The rice production functions are estimated for all the three rice cropping seasons: aus, aman and boro. For each season, there are several varieties of rice. A single production function is estimated for each season. In the questionnaire, data on both output and input were collected from all the crops from both project and control areas. A translog production function was initially estimated to understand all the cross-effects and also to determine whether the Cobb-Douglas production function would fit the rice production data. Input data on fertilizer usage, pesticide usage, labour usage (both home and hired labour), draught animals, tractors, irrigation technology were collected during the survey.

It was finally observed that multicollinearity between labour and other factors of production exist and so we finally dropped some of these variables from the estimation in order to correct the econometric problems. Finally, after elimination of the low response variables, each production function has been estimated using a more general and flexible translog function. Kim (1992) argues that the translog function is more flexible as it allows both variable returns to scale and non-homothetic production function. The function takes the standard form of

$$\log Q = a_0 + a_k \log K + a_L \log L + \tfrac{1}{2} a_{kk}(\log K)^2 + \tfrac{1}{2} a_{LL}(\log L)^2 + \tfrac{1}{2} a_{kL}(\log K)(\log L).$$

Furthermore, it is possible to show that under certain conditions this function reduces to CES or simply to a Cobb-Douglas production function. We used a binary variable to capture impact for project and control area.

**Aus rice production function**

There are four varieties of aus rice: a) broadcast aus (local variety and HYV), b) transplant aus (local and HYV varieties). Broadcast HYV Aus did not exist in the survey and hence was dropped from the estimation. The inputs that were finally included in the function are fertilizer, pesticide and labor.

The initial translog function estimation result shows that almost all the input variables are insignificant. In particular, the coefficient of $\ln(X_i)\ln(X_j)$ variables ($X_i$ is an input here) are mostly insignificant. This implies that the production function might be of Cobb-Douglas type in nature.

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

| | Dependent Variable | | | | | |
|---|---|---|---|---|---|---|
| | Ln (Aus Production) | | Ln (Aman production) | | Ln (Boro production) | |
| | 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<br>Target = 0<br>Control = 1 | .2203851 | 2.34*** | .6098547 | 1.98** | .1550585 | 2.02** |
| Other regression parameters | $R^2$ = .8171<br>n = 93<br>F = 77.73 *** | | R2 = .3784<br>n = 16<br>F = 2.44 | | $R^2$ = .3218<br>n = 383<br>F = 35.77*** | |
| NOTE: * significant at 10%, ** significant at 5%, *** significant at 1%. | | | | | | |

Consequently, a CD production function for aus rice was finally estimated using the labour, tractors, fertilizer and pesticides was estimated (see table 1).

The model suggests labour to be the most influential input (with the highest elasticity of production) followed by pesticide and tractor. Fertilizer is found to be not very significant partly because fertilizer and pesticide applications are highly correlated for HYV production. The interesting variable for the purpose of this study is the site dummy which is both significant and positive. Since the site dummy is 0 for project area, it suggests that output in the control site where there is no embankment has a higher output than that of target site. This shows that after 13 years of successful operation of the flood control project, land productivity in the project area has decreased compared to that of control area where heavy deposit of silts accumulate each year during the monsoon flooding. Consequently, the project has now negatively affected the production of aus rice, quite contrary to the initial expectations.

**Aman rice production function**

Aman rice also has four varieties: a) Aus-Aman mix, b) Broadcast Aman LV, Transplant aman LV, Transplant Aman HYV. Similar to above, a translog function estimation did not produce the expected results. As a result, a more usual Cobb Douglas type production function was estimated.

**Boro rice production function**

Boro crops has two varieties, Boro LV and Boro HYV. After using the initial translog function estimation we finally used the Cobb-Douglas type production function for boro crop too. (See Table 1). The most important determinants of boro rice are tractor, labour and irrigation. Although statistically significant, pesticide contributes least among all the inputs. The site dummy is again positive implying a higher output at control site implying high land fertility in that site.

**Land Use Pattern Changes**

The pattern of land use has changed before and after the project operations. To accommodate these changes, the land use pattern of Matlab South (control area) is used as the land use 'without project' while the pattern at Matlab North is used as a measure of 'with project' scenarios.

**Population Changes**

The population growth, density and overall pattern of occupation has also changed with and without project cases. The study used four separate point estimates to extrapolate the changes in population and its distribution. The first set of point estimate on the population and its occupation distribution came from the CIRDAP study of 1987 for 1978 - the baseline, the second point estimate came from FAP study of 1991, the third estimate came from CIRDAP study for 1986 and the final estimate is derived from our household survey of 2005. Based on these point estimates, linear interpolations were done to estimate population and its changes for intermittent years. After 2005 we assumed no further changes to provide a more conservative estimate of changes.

**Net Agricultural Benefits**

Based on the above discussion, the farming population for with and without project case are estimated. It shows that except for the few initial years of operation, farming population in the project area have decreased in terms of proportion of total population. This is contrary to ex-ante estimates where it is expected that farm productivity will increase and it will increase income of farming population. It is, however, true that net benefits from increased agricultural output is still higher for with project scenario. It can be argued that because of other economic activities, people in project areas might have switched to other jobs or was able to leave agriculture which was over populated. Net benefits from agriculture is around 1300 billion Taka for the 50 years life of the project. Figure 1 further shows that proportion of people remained engaged in agriculture did increase for an initial few years after the embankment however, embankment did create new opportunities for other activities and hence the proportion has decreased. However, given the population growth rate, the total number of people engaged in agriculture has remained very high.

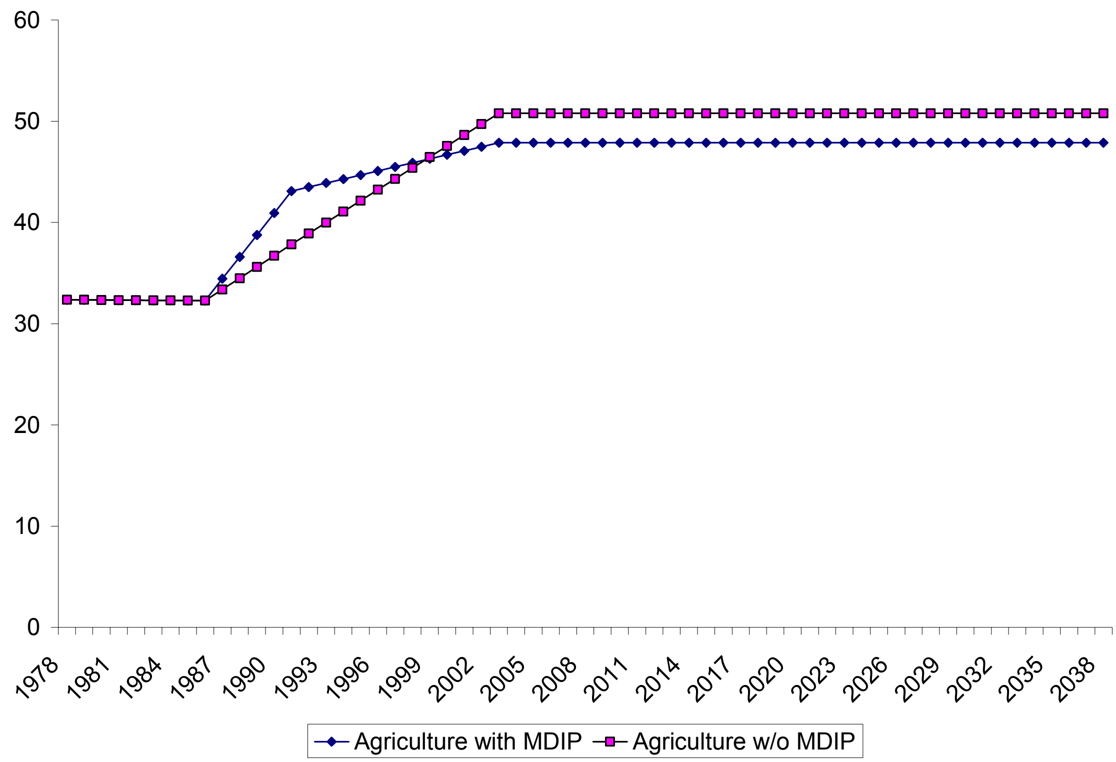



Figure 3. Proportion of households farming

## Fisheries net benefits

### Capture fisheries

As discussed a large negative impact of the project on fisheries are expected with the project. Based on the household survey, we estimated production function for three types of fish which are regularly harvested by the fisher communities from nearby river and open water bodies. Except for large size fish, this study did not find any significant change in the harvest of fish from these rivers between project and control areas. The site dummy which was used to delineate the impact of the project was found to be significant and negative for large fish. The negative site dummy implies that the project area has lower harvest in large fish than the control area. Here also a translog functional form was tried initially. Consequently, it is concluded that despite the general hypothesis that fish output will fall due to embankments, it was validated only for large fishes. Net losses on fish catch from rivers and water bodies is around 492 million taka in 50 years life of the project.

$$\ln(\text{Large Fish Quantity}) = -0.145 + 0.468^{**} \ln(\text{Number of Fishing Trip}) - 0.975^{+} (\text{Dummy for Boat type}) - 0.008(\text{Dummy for Net type}) - 1.497 (\text{Dummy for Site}) \qquad R^2 = 0.18,\ n = 106$$

Where, * means significant at 1%, ** means significant at 5%, *** means significant at 10% and + to show significance at 15%.

### Culture Fisheries

It is expected that culture fisheries will increase in the project area due to flood protection as risk of fish loss during flooding decreases. Using the changes in the population, the survey results in terms of proportion of household reporting income from capture fisheries, a simple arithmetic was used to estimate the gain from culture fisheries due to the project. It is found that nearly 25 billion taka additional benefits will accrue from capture fisheries from the project. Figure 2 shows the changes in fishing population with and without project.

**Figure 2: Changes in the Fisheries Activities**

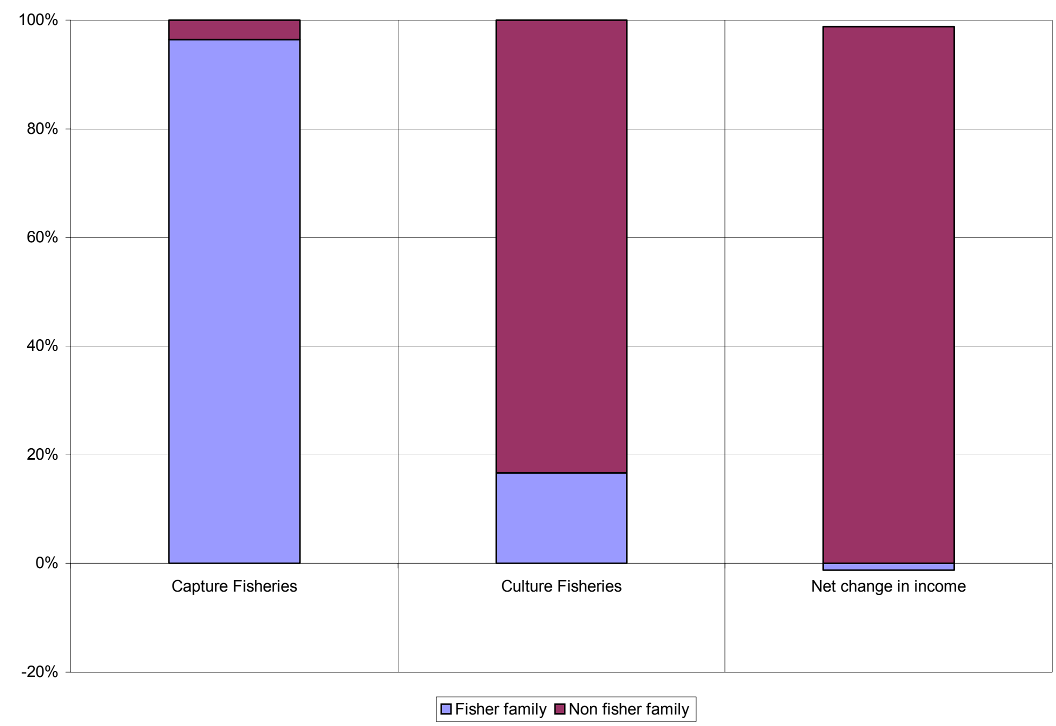
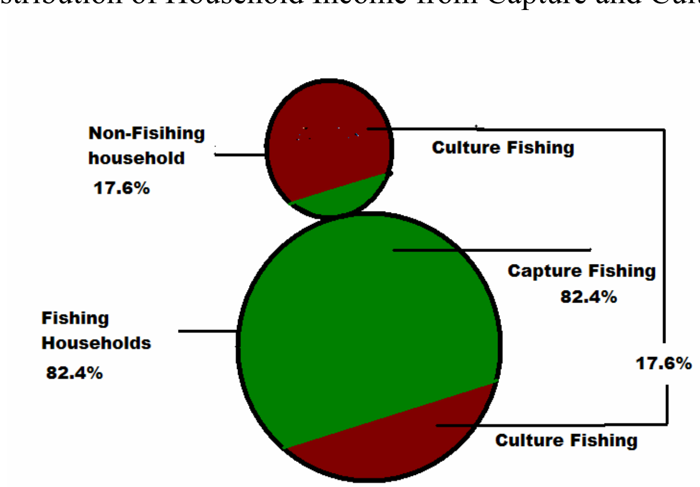



Figure 4. Changes in fisheries activities.

However, Figure 2 shows the most interesting picture of change that has taken place in the MDIP areas due to continued success in protecting floods. The fisher families, who are mostly involved in capture fishing activities from the rivers, did not switch to culture fisheries due to

Figure 3: Distribution of Household Income from Capture and Culture Fisheries



embankment. While culture fishing activities become an attracting source of income, the income is mostly accrued to the non-fisher families. The last column in figure 2 shows that fisher families lost in terms of net benefits while the non-fishing families gained due to changes. It is therefore, evident that non-fishing families who had landed properties gained due to embankment while the fishing families who had little ties with land (except homestead) are the net loser from the embankment. Figure 3 provides a breakdown of gainers and losers in terms of fishing and non-fishing households. It clearly shows that as the fishing activities within the embankment area switches from capture to culture fishing activities, the net gainers are the non-fishing households. It was clear from the study that net benefits for culture fishing is very high while net benefits from capture fishing is negative due to embankment.

### Livestock and Poultry

Flooding affects the livestock and poultry production negatively. Consequently, it is expected that livestock production and poultry production will increase with project than without project cases. Using the control and project area data and the point estimates on population and its distribution, it has been estimated that net benefits from livestock will be equivalent to 4 billion taka in 50 years from the project. It is to be noted that project area people also suffered some losses in poultry production due to waterlogging in the project area. This losses are deducted from the gross benefits from this activities. However, it should be noted that such losses could have been avoided if water logging can be removed using management efficiency, which is equivalent of 289 millions in 50 years time of the project.

### Property Damages

Flooding affects properties and particularly people living in low lying areas. These people are mostly poor. It was observed that a large proportion of people receive such benefits if flooding could be avoided. Similarly, water-logging in the project area reduced the benefits of the project. Using similar techniques, we estimated net benefits from the project considering with and without scenarios. It is estimated that 83 billion taka is the net benefit from 50 years life of the project. In all of these estimates the population projections, its distributional changes and the following damage table from the survey data were used.

**Table 2: Estimate of damages due to water logging in Project Area**

| Damage type | % of people Affected | % of damage Index of loss | Taka per household |
|---|---|---|---|
| Crop Damage | 47.62% | 100% | 26622.7976 |

| | | | |
|---|---|---|---|
| Agricultural Equipment Damage | 0.34% | 0.30% | 80.9912075 |
| Livestock Damage | 1.87% | 3.12% | 831.246344 |
| Fish Damage | 12.07% | 36.48% | 9712.62363 |
| Poultry Damage | 13.10% | 1.88% | 501.750407 |
| Fruit Tree Damage | 48.13% | 22.78% | 6063.83146 |
| Homestead Damage | 14.63% | 9.13% | 2429.73622 |
| Health Cost | 6.46% | 0.73% | 195.011024 |
| Other damages | 1.02% | 0.25% | 66.3732822 |

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

| Type of Damage | % of people Affected | % of Damage with respect to agri | |
|---|---|---|---|
| Crop Damage | 32.7380952 | 100% | 27108.72 |
| Agri Equipment Damage | 1.93452381 | 3.08% | 834.6156 |
| Poultry Damage | 22.7678571 | 17.55% | 4758.312 |
| Fruit Tree Damage | 52.827381 | 42.11% | 11416.44 |
| Homestead Damage | 87.6488095 | 99.53% | 26981.52 |
| Health Damage | 65.0297619 | 25.69% | 6964.654 |
| Other Damage | 9.52380952 | 83.16% | 22542.77 |
| Education related damage | 0.74404762 | 0.45% | 121.5581 |

### Fruit Tree net benefits

There were 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. Using the table 2 and 3 and the estimates of population projections, the net benefits in this area is around 13 billion taka in 50 years time.

### Health net benefits

Flooding significantly inflicts health damages to people living in the flooded areas. The MDIP project has benefited the people by avoiding such losses. On the other hand, because of continued water logging in some areas people also suffer from certain diseases. This is now an added loss in the revised estimate of benefits of the project. The net benefit from health costs is around 20 billion taka from the project.

### The Net Present Value and Internal Rate of Return

The net present value of benefits from the project becomes negative at 5% rate of discount. It is -172 million Taka in 2003 constant price. The internal rate of return is 2.15% which is significantly lower than what was originally estimated. This project was revisited in terms of CBA without the poverty and environmental aspect and the IRR was found to be 6.7 percent (Hunting Technical Services Limited 1992).

Our result shows, when we consider the environmental aspect, particularly the fisheries losses the internal rate of return reduces by another 4.5%. Figure 5 shows the changes in NPV of the project for various discount rates.

Figure 5: Net Present Value of MDIP by rate of discount

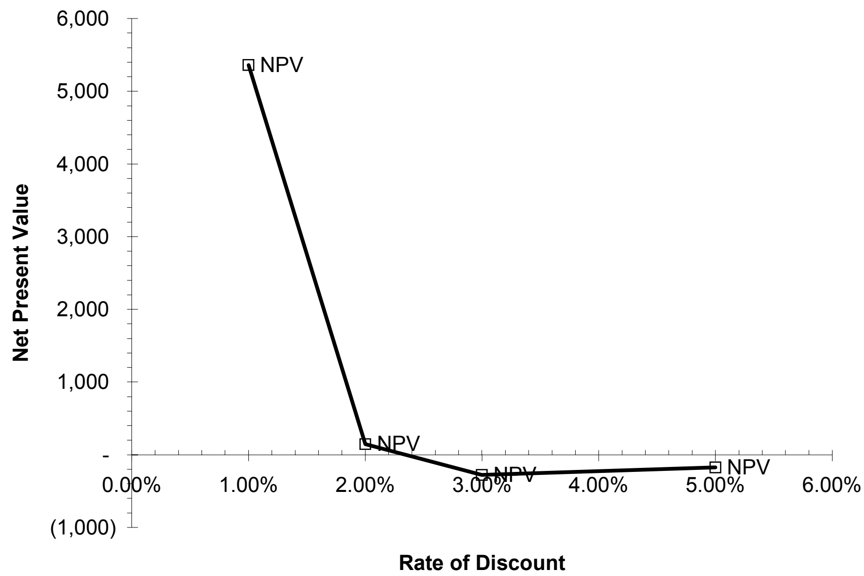



Figure 6. Net present value of MDIP by discount rate

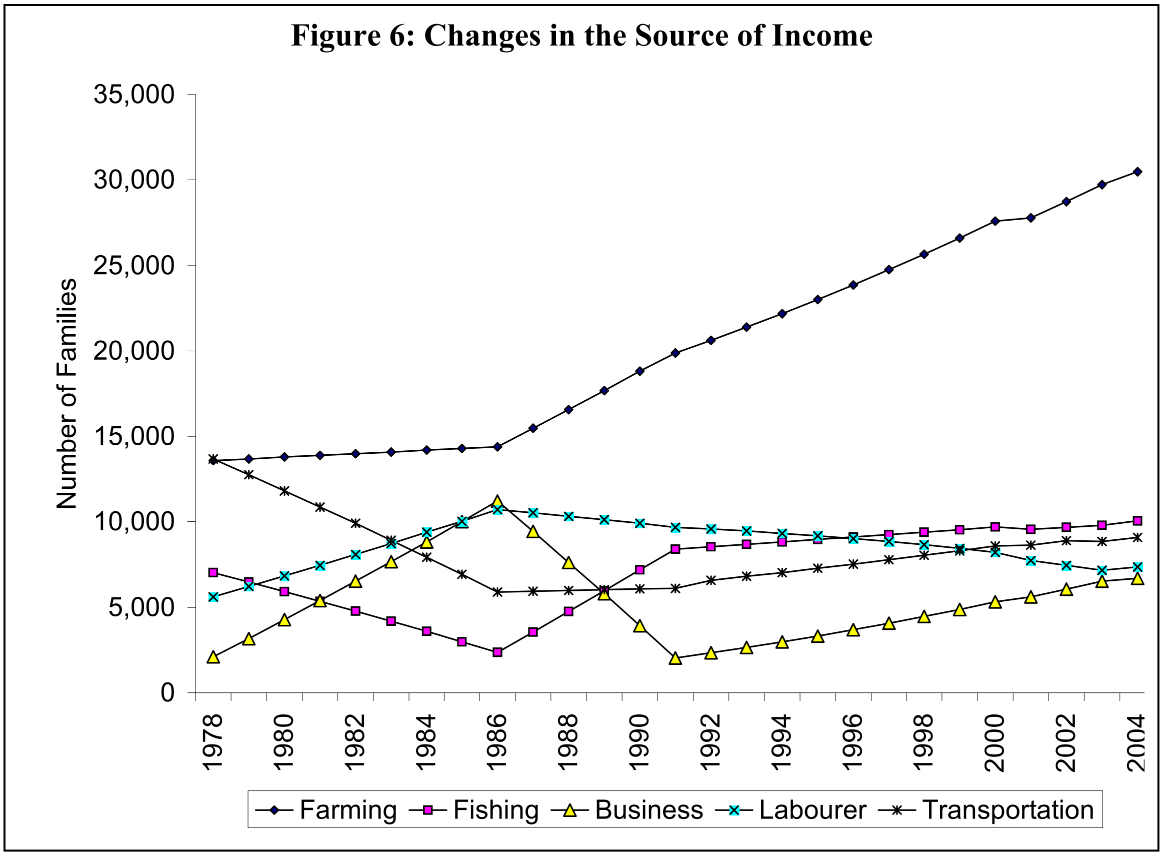


Figure7. Changes in income sources.

In terms of the distributional aspect benefits, the result shows that the poverty aspect is even worse. A majority of the fishing household are poor and figure 6 shows that since 1988 (when the project was launched after completion), there has been a growth in the number of people dependent on farming, fishing, business and transportation activities. Number of people supplying labour has been decreasing. This cannot be seen as a negative one because these people might be switching to other lucrative jobs. Figure 7 however, shows a different picture. It reveals that the three most important source of income of a farming household is farming, poultry and livestock, and capture fisheries. For a fishing family they are culture fisheries, poultry and livestock and farming. For a business family they are business, poultry and livestock, and agriculture. For a boatman and road transportation workers, they are boat, and poultry and livestock. And for a labourer they are labour income, poultry and livestock and farming. We can use this to deduce the poverty impact of the embankment. It shows that growth in culture fisheries mostly benefited the farming group. Growth in agriculture benefited farming, business, and labourers. Poultry and livestock is more neutral in terms its livelihood impact on people. Every occupational group seem to have gained from this. Reduction in river transportation services is likely to affect (negatively) the boatman groups, who are also poor group of people.

Considering these, it is important to note 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 group of people did not migrate to other sectors as many had predicted.

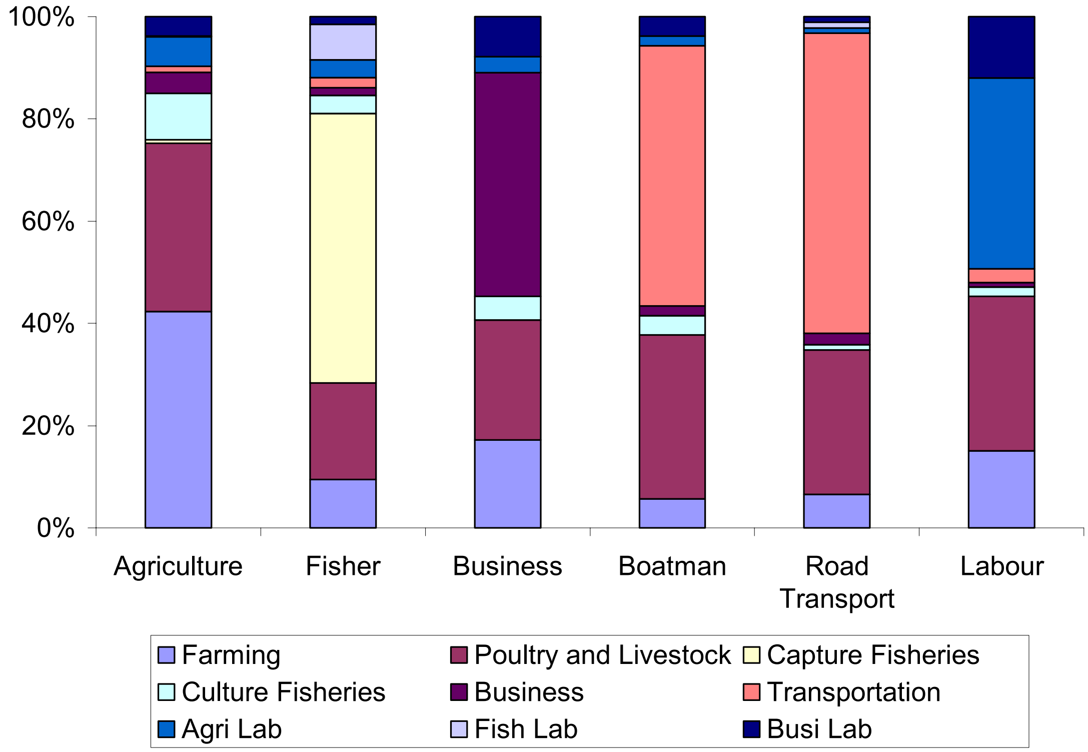



**Figure 8: Pattern of livelihood engagement by occupation groups**

## 4. Conclusions

The analysis presented in this chapter shows that the Meghna-Dhonagoda Irrigation Project 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, and the unanticipated highly negative impact on capture fisheries. The combined result is a negative net present value for the project of 172 million Taka. 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 land owners 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.

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