DRAFT

BANGLADESH FLOOD ACTION PLAN

FAP 16 Environmental Study

Special Studies Program

THE DEMOGRAPHIC, HEALTH AND NUTRITIONAL IMPACTS OF THE MEGHNA-DHONAGODA EMBANKMENT

December 1992

Prepared for
The Flood Plan Coordination Organization (FPCO)
of the
Ministry of Irrigation, Water Development and Flood Control

by

THE INTERNATIONAL CENTRE FOR DIARRHOEAL DISEASE RESEARCH, BANGLADESH

in collaboration with

THE IRRIGATION SUPPORT PROJECT FOR ASIA AND THE NEAR EAST

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2

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6

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The disastrous floods of 1987 and 1988 stimulated the Government of Bangladesh to undertake a comprehensive review of its flood policy. A major part of the resulting plans involves the construction of embankments to control flooding and drainage. These embankments could have a significant impact on health and demographic behavior, but to date there have been no systematic evaluations in these areas.

The Meghna-Dhonagoda Irrigation Project is a medium-scale flood control, drainage, and irrigation project located in Matlab Thana, about 50 kilometers south-east of Dhaka. The embankment was closed in July 1987, but was breached at the end of August 1987 and again in August 1988. The International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) has been carrying out health research and demographic surveillance, as well as other data collection, in Matlab since 1963, providing a natural laboratory for research on the impact of this embankment.

Analysis of a census conducted in the area in 1982 revealed no major socioeconomic or demographic differences between areas that would eventually be inside and outside the embankment. Households in the inside area owned a few more boats, on average; this should have made them more vulnerable to the reduction in fishing and water transport jobs which the embankment brought about.

The impact of the Meghna-Dhonagoda project was measured by the differences in diarrhoea morbidity, nutritional status, and mortality among children living inside the embankment area compared to those living on the outside. The pattern of diarrhoeal illness was similar on both sides of the embankment between 1986 and 1990. Nutritional status increased slowly during this period, but there were no important differences attributable to the completion of the embankment. The percentage of severely malnourished children fell, but there were no major differences between the two areas. Neither infant mortality nor child mortality, good measures of the adverse effects of disease and malnutrition, revealed significant differences resulting from the embankment.

Out-migration from both areas was compared, since differences in the propensity to leave the areas could have resulted in a selectivity bias, underestimating the negative impact of the embankment. No differences were found. A surprising result was that neither fishermen and boatmen, nor people owning two or more boats, began leaving the area inside the embankment.

Thus, the overall conclusion of this study is that there has been no major negative impact, to date, on the health or nutritional status of people living in areas inside the embankment. This is the optimistic lesson. On the other hand, perhaps more should be expected from a multi-million dollar project. Especially if agricultural output is rising, we would hope to see an improvement in the nutritional status of children living inside the embankment compared with those living outside of it.

1. Background

The disastrous floods of 1987 and 1988 stimulated the Government of Bangladesh to undertake a comprehensive review of its flood policy. After several international studies were completed, the government asked the World Bank to coordinate a five-year Flood Action Plan (FAP), based on these and other studies. In its November 1989 report, the bank presented an action plan that addressed the critical issue of flood mitigation and also provided an environment for sustained social and economic development.

A major part of these plans involves the construction of embankments and the compartmentalization of protected areas into manageable units for controlled flooding and drainage to meet the needs of integrated land and water use. These embankments could have a significant impact on the lives of the people living inside them and in the neighborhood. Changes in the economic activity of the population, changes in the flow of water through the region, and the general change in the environment will profoundly influence a whole range of behaviors including demographic and health behavior. To date, however, there have been few systematic evaluations of the possible impacts of embankment projects in these areas.

The Meghna-Dhonagoda Irrigation Project (MDIP) is a medium-scale flood control, drainage, and irrigation (FCD/I) project located in Matlab thana, about 50 kilometers south-east of Dhaka (Map 1). Constructed between 1982 and 1987, it provides flood control and drainage to 17,000 hectares of land and irrigation to 13,800 hectares. The MDIP will also involve the development of rural roads and the improved delivery of agricultural services. The embankment was closed in July 1987, but it was breached at the end of August 1987 and again in August 1988.

In agricultural development projects elsewhere, the introduction of new technologies (such as high-yield rice strains) has allowed both an increased and a more stable output over time. While this has increased average food availability, there have often been distribution problems as well. New technologies frequently require access to credit and a better education in order to realize all of the benefits. This has often meant that the existing wealthy class, already possessing these factors, have benefitted at the expense of poorer farmers. As land prices rise in these areas, small farmers may sell their land and become agricultural laborers, go into other occupations, or migrate out.

Hall's (1988) examination of the Chandpur Irrigation Project (CIP), where an embankment had been completed in 1980, raises some of these points. In addition, he found some evidence of a deterioration of the health situation inside of the Chandpur embankment. The quality of the drinking water was found to be lower, and the incidence of diarrhoea higher, in villages within the embankment. "The belief that CIP and similar projects cause health problems is widely held in Bangladesh, and does not seem to be unfounded" (Hall, 1988, p.90). Unfortunately, Hall's study, which primarily focused on agriculture and employment, lacked a longitudinal perspective and adequate measures of nutrition and morbidity.

There is general agreement that the MDIP has improved agricultural productivity in the area inside the embankment. Two major concerns about possible negative effects of embankments have been expressed. First, if there are distribution problems associated with the new agricultural technologies used, such as an increase in the number of families without land, a newly impoverished group could be more vulnerable to malnutrition and disease. This would be reflected in the welfare of children through increased morbidity, nutritional deficiencies, and mortality, and in increased out-migration from the area. These would partially offset the beneficial aspects of the increase in agricultural output to the community as a whole, where overall nutritional and survival status should improve.

Second, there are also concerns about the quality of the water inside the embankment. Social practices in Matlab, such as the disposal of feces and the selection of drinking and washing water, have been developed within the context of a flood that flushes the area annually. It is not clear how society will adapt to a new ecological situation, where water supplies that were previously relatively safe are now more contaminated. The possible increase in water quality and sanitation problems would result in increased morbidity due to water-borne diseases such as diarrhoea, especially among children, and potentially increase mortality.

The International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) has been carrying out health research and demographic surveillance, as well as other data collection, in Matlab since 1963. All vital events—births, deaths, migrations, and changes in marital status—are accurately recorded in a population now numbering a little over 200,000. In addition, a Maternal and Child Health—Family Planning project (MCH-FP) conducts research in half of the area (the Treatment area) on health and family planning service delivery systems. These have had a significant impact on the Treatment area, reducing both fertility and mortality. (The other area, usually called the Comparison area, receives government services and has free access to the ICDDR,B field hospital in Matlab bazaar.) Coincidentally, parts of the Treatment and Comparison areas lie inside and outside of the MDIP embankment, providing a natural laboratory for research on the impact of MDIP.

2. Available Data

The data needed to examine the hypotheses discussed above have been collected in the past by various ICDDR,B research projects.

2.1 Demographic Surveillance System (DSS)

The first ICDDR,B census of the study area was taken in 1966 and was primarily just a set of household rosters. This census, taken in 132 villages with a population of 112,000, marked the beginning of the DSS. Shortly after the census, a field organization was established to visit each household in the area once a week (now once every two weeks) to record all vital events and send this information to Dhaka for tabulation. Additional censuses, asking social and economic questions as well as age and sex, were taken in 1974 and 1982. Although the area under surveillance has changed over the past 25 years it has been fairly stable since 1979. All of the DSS data are computerized; those for the period after 1982 are in a database on the ICDDR,B mainframe computer, accessible by individual, family, village, or any of several other dimensions.

The 1982 ICDDR,B census of 149 villages under demographic surveillance is an excellent baseline point from which to measure the impact of the MDIP embankment project, since it was conducted before construction began. It should be noted, however, that the area under DSS surveillance was chosen primarily for epidemiological research (Map 2). Most of the DSS villages are near the Gumti River, within fairly easy access of health researchers. No villages in the center of the MDIP embankment area are covered by the ICDDR,B. Since these areas are likely to be less positively affected by the MDIP, any conclusions based on ICDDR,B data may underestimate any negative impact of the project.

The 1982 census verified the demographic surveillance to date, ensuring that all individuals and families in the DSS area were properly registered. The census also asked the residents a number of socioeconomic questions. The number of years of schooling completed by everyone over age five and the occupation of those over age 10 were determined. Every household was asked which of a list of consumer durables (quilt, kerosene lamp, bicycle, watch or clock, and radio) they owned, the number of boats owned, and the size in square feet of their dwelling. Finally, the census established a new registration number system, allowing all vital registration information to be linked over time as well as allowing the identification of people living in areas that would be inside and outside the embankment.

2.2 MCH-FP Project

The MCH-FP project in Matlab was started in 1977. It has been a comprehensive program, involving health service implementation, demographic and morbidity surveillance, health service research, and epidemiology. The package of services offered by female fieldworkers has been gradually expanded and now includes family planning, ORS, EPI vaccination, acute respiratory tract infections, and nutritional surveillance and referral. All families in the Treatment area, about 100,000 people, are visited every two weeks. In addition to providing services, field workers collect extensive data on factors affecting fertility and family planning and on the nutritional and morbidity status of all children under five years old.

2.3 Diarrhoea

Information on the incidence of diarrhoeal disease is collected every four weeks within and outside the embankment. The mothers of every child under five years of age are asked how many days of diarrhoea their children have had during the previous two weeks, and they are asked to make an assessment of the severity of the illness. (Due to data processing constraints only the incidence, the proportion of children becoming ill with diarrhoea, will be used in the present analysis.) The seasonal and annual incidence of diarrhoea morbidity will be compared for those inside and outside of the embankment before, during, and after its construction.

2.4 Nutrition

Measurement of the mid-upper arm circumference (MUAC) of children under five years of age living in the Treatment area, both inside and outside of the embankment, takes place every three months. (If a child has a MUAC below a critical level the child is referred to a nutrition rehabilitation centre and MUAC is measured monthly; these additional measurements will not be used here.) The collection of these data preceded the completion of the embankment and continues to date. Arm circumference is a sensitive indicator of the nutritional status of young children. Arm circumference of children living inside and outside the embankment will be compared, taking season into account as well.

Table 1
Population Relative to the Embankment, by Age and Sex*

	Males		Females	
Age	Inside	Outside	Inside	Outside
1	13.1%	12.5%	12.0%	11.9%
5	14.6%	14.5%	13.4%	13.8%
10	12.9%	13.5%	12.4%	12.8%
15	11.8%	11.9%	13.0%	12.9%
20	9.8%	9.8%	9.1%	9.2%
25	5.9%	5.8%	5.9%	6.3%
30	4.2%	4.3%	4.8%	5.0%
35	3.8%	4.1%	5.3%	5.5%
40	3.8%	4.0%	4.7%	4.6%
45	4.0%	4.2%	4.3%	4.2%
50	3.3%	3.3%	3.6%	3.0%
55	2.7%	2.8%	2.7%	2.4%
60	2.3%	2.0%	1.9%	1.9%
65	3.8%	3.8%	3.3%	3.0%

*Matlab 1982 census

3. Baseline Results

This baseline comparison of the areas that would be inside and outside the embankment when it was completed in 1987 are based on the 1982 census of the DSS area. Since this was done before construction began, if major socioeconomic or demographic differences existed between the two areas (which could confound the analysis of the impact of the embankment) they would show up in this data set.

3.1 Age and Sex Structure

As Table 1 shows, there were no significant differences in the age-sex structure between the areas which would be inside and outside the MDIP. From birth to age 65 and above there were near-identical proportions, by sex, in each age group. For example, 11.8 percent of males inside were aged 15-19, whereas 11.9 percent of males were in this age group in outside areas. None of the differences were significant at the 5 percent level. Thus, it does not appear that in 1982 major net migration flows into or out of the areas, or important differences in fertility or mortality, had been affecting the areas differently.

In general, the sample sizes involved in this study are large enough to allow the detection of statistically significant differences between groups inside and outside of the embankment. This lets us conclude that there is a 5, 1, or even 0.1 percent probability that the groups differ due to chance. In fact, the sample is so large, up to 200,000 people, that scientifically unimportant differences, those without practical significance, are statistically significant.

3.2 Education

Table 2 shows that educational levels were low in the Matlab area in 1982, as they were throughout Bangladesh, and females, especially those aged 15 and above, had much less formal education than males. No important differences between the inside and outside areas emerge, however. The slightly higher mean years of education shown for people living outside the embankment probably reflects slightly better educational opportunities closer to the town of Matlab bazaar, the administrative centre of the thana. This is one example of the difference between a scientifically and a statistically significant result. The sample size here is so large that small differences in education—two months for males and one month for

Table 2
Mean Years of Education, by Age and Sex*

	Males			Females		
Age	Inside	Outside	t	Inside	Outside	t
5	0.1	0.1		0.1	0.1	
10	1.3	1.5	***	1.0	1.1	***
15	2.9	3.0	**	1.9	2.1	**
20	3.5	3.8	***	1.9	2.0	
25	4.1	4.3		1.5	1.6	*
30	3.8	4.4	***	1.1	1.3	***
35	3.2	3.5	*	0.9	1.0	
40	2.8	2.9		0.7	0.8	*
45	2.3	2.6	*	0.6	0.6	
50	2.4	2.6	*	0.6	0.5	
55	2.7	2.7		0.5	0.4	
60	2.6	2.7		0.3	0.3	
65	2.5	2.6		0.2	0.2	
Total	2.3	2.5	***	1.0	1.1	***

*Matlab 1982 census
t (significance level) * .05 ** .01 *** .001

females, on average--becomes quite (statistically) significant.

3.3 Socioeconomic Differentials

Table 3 shows how the ownership of consumer durables (quilt, kerosene lamp, bicycle, watch, and radio), boats, and larger homes increased with the age of the head of the household in both areas, as would be expected. Households inside and outside the embankment area had virtually the same ownership patterns of consumer durables. (There were very few heads of household under 20 years of age; figures for these younger age groups are therefore less reliable.) Households in inside areas owned a significantly greater number of boats no matter what the age of the head of household, and lived in somewhat smaller houses, 29 square feet smaller on average. Their greater ownership of boats, and probable dependence on them for income from fishing or transport, could have made them vulnerable to the changes brought about by the embankment.

Table 3
Asset Ownership and Dwelling Size, by Age of Household Head*

Age	Number of Durables			Number of Boats			Dwelling Size (sq ft)		
	Inside	Outside	t	Inside	Outside	t	Inside	Outside	t
10	1.7	1.3		0.6	0.3		220.7	224.6	
15	1.3	1.0		0.4	0.4		214.9	385.6	*
20	1.2	1.2		0.4	0.4		235.2	302.1	
25	1.5	1.5		0.5	0.3	***	292.9	273.1	
30	1.6	1.5		0.4	0.3	*	278.3	289.1	
35	1.6	1.5		0.5	0.4	*	274.7	302.5	
40	1.5	1.5		0.6	0.5	***	262.3	310.2	*
45	1.5	1.5		0.7	0.6	***	281.7	304.0	
50	1.7	1.7		0.7	0.7	*	297.1	339.0	*
55	2.0	1.9		0.8	0.7	***	311.6	367.6	**
60	2.0	2.0		0.8	0.7	***	341.5	366.8	
65	2.2	2.1		0.8	0.6	***	380.7	399.5	
Total	1.7	1.6	*	0.6	0.5	***	294.3	323.5	***

*Matlab 1982 census
t (significance level) * .05 ** .01 *** .001

4. Measuring the Impact of the Embankment

4.1 Diarrhoea Morbidity

Since 1986 diarrhoea and dysentery illness data for all children in the MCH-FP intervention area has been recorded by the health worker at her monthly visit. The incidence of diarrhoeal illness, as measured by the proportion with illness in the past two weeks, is shown in Appendix 1. Figure 1 shows the trend component of these changes, as indicated by the centered average of 12 monthly observations (Kendall, 1976, p.38). The seasonal component of diarrhoeal morbidity, as measured by the difference between incidence and the long-term trend, is shown in Figure 2.

The monthly data presented in Appendix 1 show that even before the completion of the embankment the incidence of diarrhoea was greater in the outside area than in the inside area. This difference persisted throughout 1987, except perhaps in October after the breach and ensuing flood. In June 1988 diarrhoea

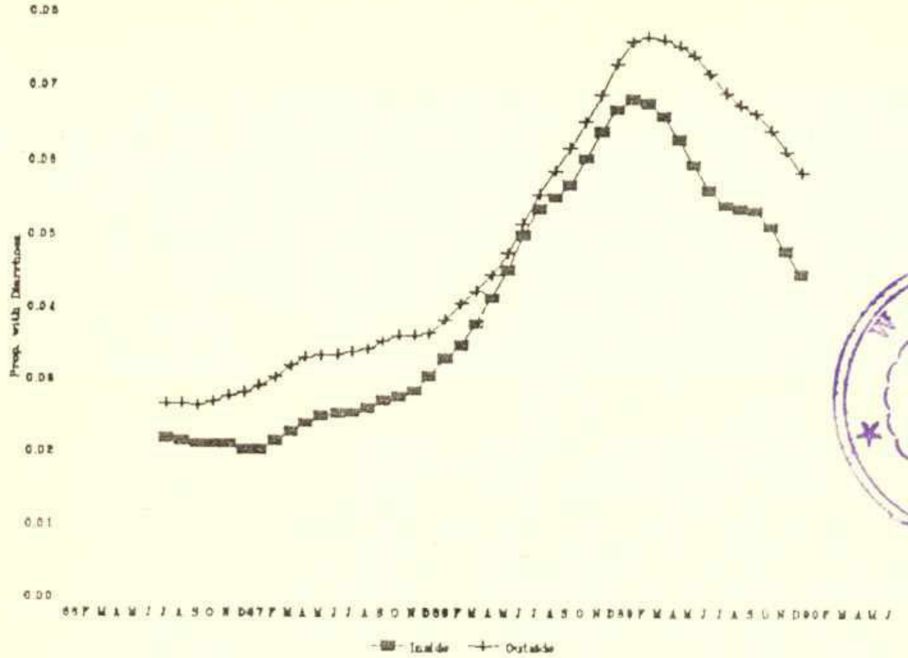

Figure 1: Trend in Incidence of Diarrhoea (centered average of 12)

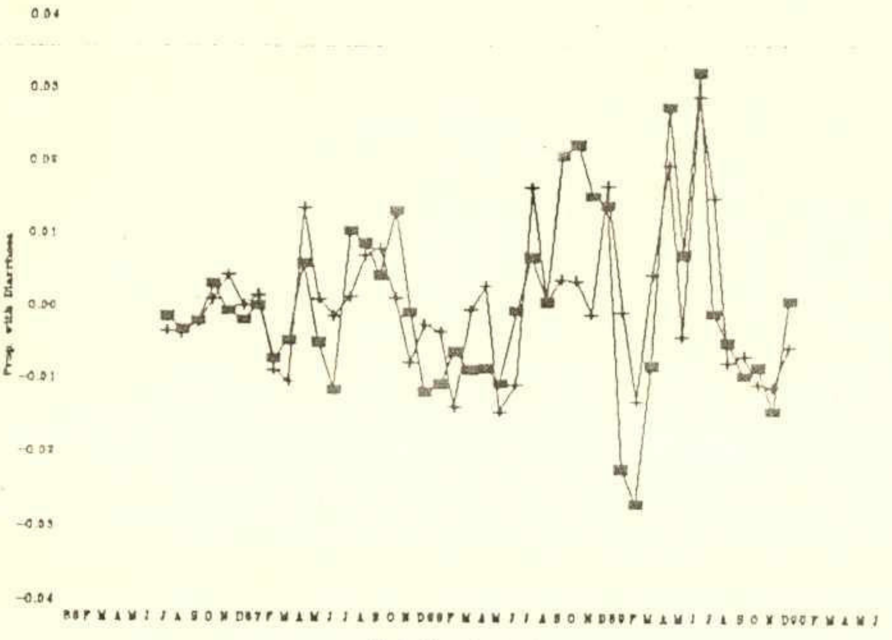

Figure 2: Seasonal Component of Diarrhoea (incidence less trend)

incidence was higher inside the embankment, but the incidence was rapidly increasing in both areas. The disastrous flood of 1988, and the break in the embankment in late August, reversed this pattern: during September, October, and November the incidence of diarrhoea was higher inside the embankment, and was much higher than it had been in 1987. By December diarrhoeal incidence had reverted to its pre-flood pattern, with more diarrhoea reported outside than inside.

These relatively small differences between the two areas are superimposed on the general trend shown in Figure 1: Diarrhoea incidence in general in Matlab increased in 1987, went up dramatically in 1988, and then fell in 1989 and early 1990. The two areas clearly have followed the same long-term trends during the period shown, with the area outside reporting somewhat higher diarrhoea incidence. In addition to the long-term trend in diarrhoeal morbidity in Matlab there is a strong seasonal fluctuation, shown in Figure 2. Although this component is quite erratic it does appear that the completion of the embankment has not dramatically altered the seasonal element of diarrhoeal morbidity inside the embankment.

4.2 Nutritional Status

The nutritional status of children between six months and five years of age is measured every three months in the MCH-FP area, using mid-upper arm circumference (MUAC) as an index. Figure 3 and Appendix 2 show mean arm circumference for children in each area. Before the closure of the embankment children in the area that would be inside the embankment had a small but significantly greater mean MUAC. After the closure in 1987 and the breaches during the floods of 1987 and 1988, and during the subsequent period up to mid-1990, the children in the area outside the embankment have had greater mean MUAC. These differences have also been statistically significant.

An arm circumference under 110 millimeters is an indicator of severe malnutrition and high risk of death in children under five. The proportion of children in an area with MUAC below 110 millimeters is a fairly sensitive indicator of acute nutritional problems in that area. If the construction of the embankment created a newly impoverished group inside the embankment, through changes in occupational structure or landholding patterns, for example, it is likely that any resulting nutritional distress would be shown by this measure. While there has been a narrowing of the differential between the areas inside and outside the embankment, as shown in Figure 4 and Appendix 2, these differences have been small. The proportion with MUAC below 110 millimeters living inside the embankment was greater than that outside the embankment only in the two quarters after the flood of 1988 and the last two quarters shown, those at the beginning of 1990. None of these differences were statistically significant even at the 5 percent level.

Nutritional status, as measured by mid-upper arm circumference, has been slowly increasing in both areas during the period shown, although the overall nutritional status in the Matlab area has been somewhat below the national average (HKI, various dates). Although the mean MUAC has been lower inside the embankment since its completion, the difference has been less than 2 millimeters each quarter, a statistically significant but nutritionally unimportant difference. The proportion of children seriously malnourished, as measured by the proportion with MUAC less than 110 millimeters, has been declining in both areas, but has shown no significant difference between the two areas.

Figure 3: Mean Mid-upper Arm Circumference

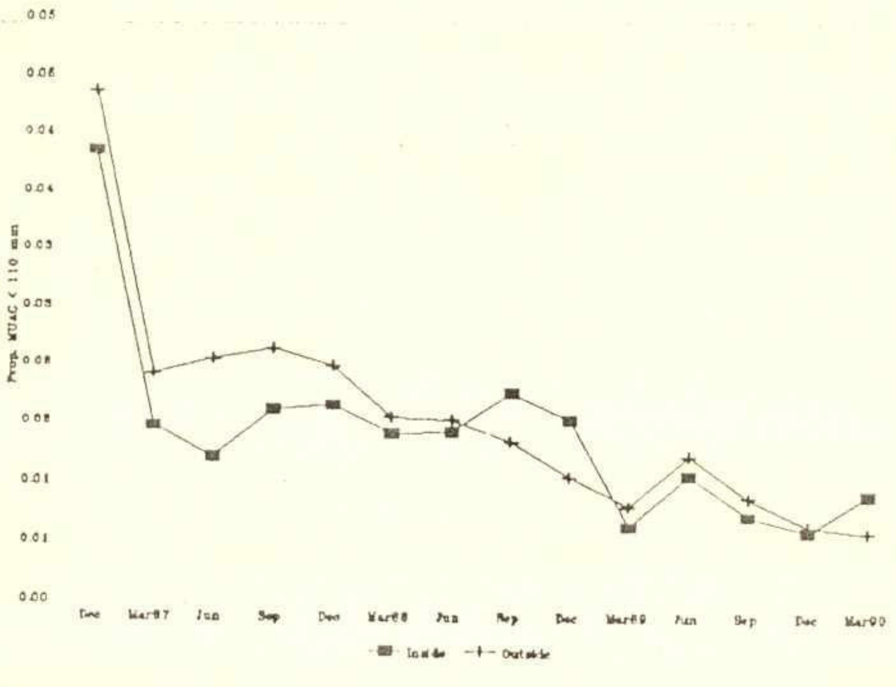

Figure 4: Proportion with MUAC <110 mm

4.3 Infant and Child Mortality

Although they are somewhat less sensitive indicators of socioeconomic changes, infant and child mortality rates are interesting because they provide a more objective measure of an outcome—mortality—and they are available over a longer time period. Infant mortality, the number of deaths of children under one year of age per thousand births in a year, are shown in Appendix 3. These highly variable series are smoothed using a 3-year moving average and presented in Figure 5. The rates inside and outside the embankment have been adjusted for the proportion of the population living in the MCH-FP intervention area and the comparison area. In general, infant mortality was high in both areas, those which would be inside and outside the embankment, until the early 1980s, and then began to fall, first outside (from about 1982-83) and then inside (from about 1984-85). Although infant mortality was higher inside the embankment between 1984 and 1988, and again in 1991, none of these differences were statistically significant.

Since the weaning process increases the exposure of children to environmental contamination and possible nutritional problems, mortality between age one and age five are better indicators of these problems than is infant mortality. Child mortality rates, broken into mortality between age one and age two and between age two and age five, are shown in Figure 6 and Appendix 4. In 1984, just before construction of the embankment began, there was a sharp and significant one-year increase in child mortality in both age groups in the inside area. This increase was perhaps due to a shigella epidemic, and is under investigation, but it was probably not due to effects of the embankment. After 1894 child mortality declined in both areas. The levels were virtually the same in both areas except in 1988, when mortality rates for the area inside the embankment increased slightly. In the following year, however, both rates inside the embankment fell below the rates outside, although once again these differences are not statistically significant.

4.4 Out-Migration

The above analysis shows that the MDIP had little impact on the morbidity, nutritional status, or mortality of children living inside the embankment. It is possible that this result is due to selective out-migration from the area. If the people adversely affected by the embankment, those whose children would have had higher rates of morbidity, malnutrition, and mortality, had a higher propensity to leave the area then a positive selection bias could result.

In order to test for this effect an out-migration life table was constructed for heads of households in various groups inside and outside the embankment. Starting with an initial population in each group of one thousand, the annual out-migration rates of each group and area were applied through 1990. This shows the proportion in each group remaining in an area over time, controlling for mortality. For example, in 1982 0.5 percent of household heads owning only one consumer durable left the area that would be outside the embankment. Thus the initially assumed population of 1,000 in this group (one item, outside) is reduced to 995 at the start of 1983. These results are shown in Figures 7 and 8 (also Appendix 5).

Looking at items owned as a measure of socioeconomic status, there has been virtually no difference in the propensity to leave either area, and surprisingly little difference across items-owned groups, as Figure 7 illustrates. If 1,000 household heads owning four or more consumer durable items started 1982 in each area, 907 would not have left from inside, and 902 would not have left from outside. The only significant

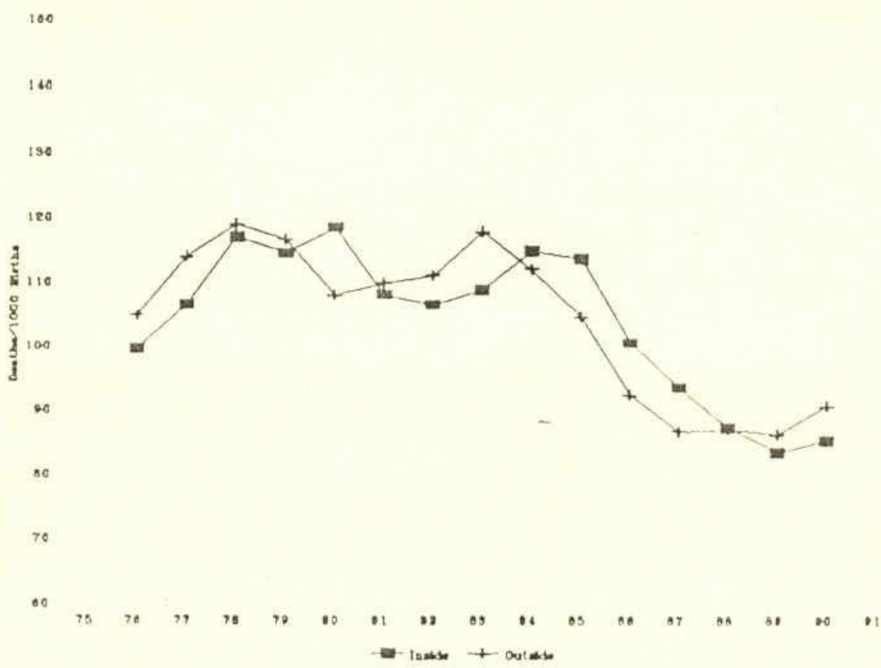

Figure 5: Infant Mortality Rate (adjusted 3-year average)

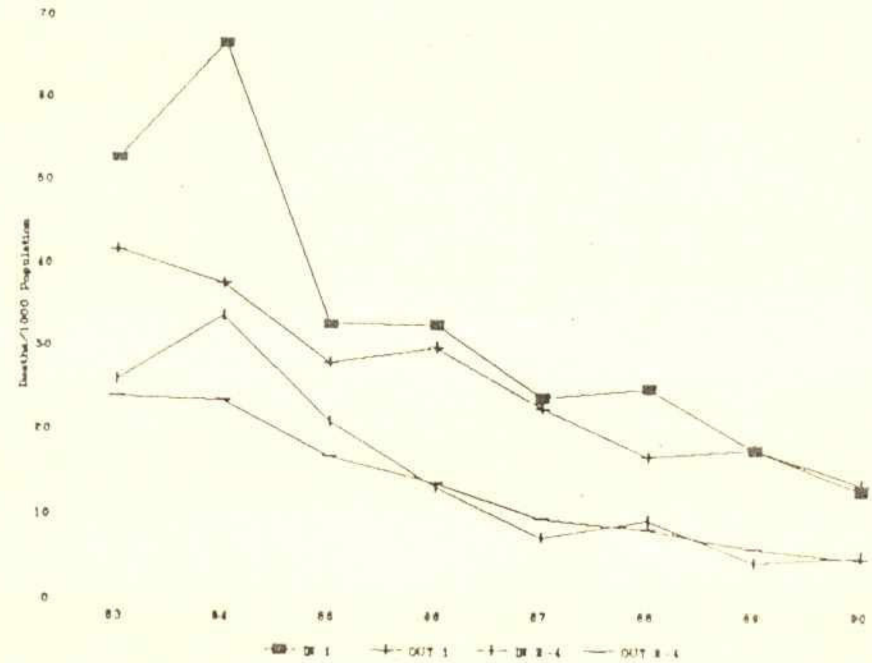

Figure 6: Child Mortality, Ages 1 and 2-4

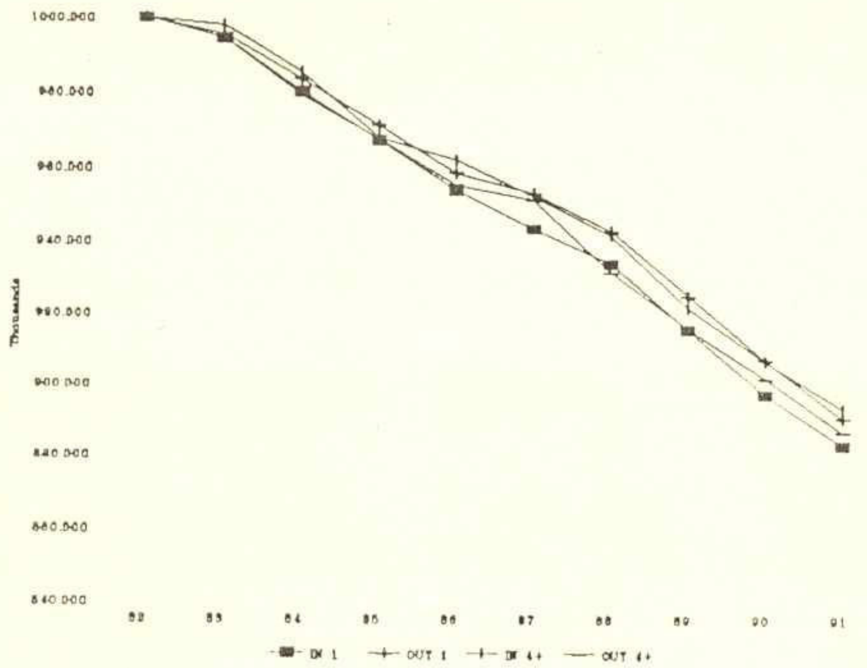

Figure 7: Result of Out-migration by Items Owned

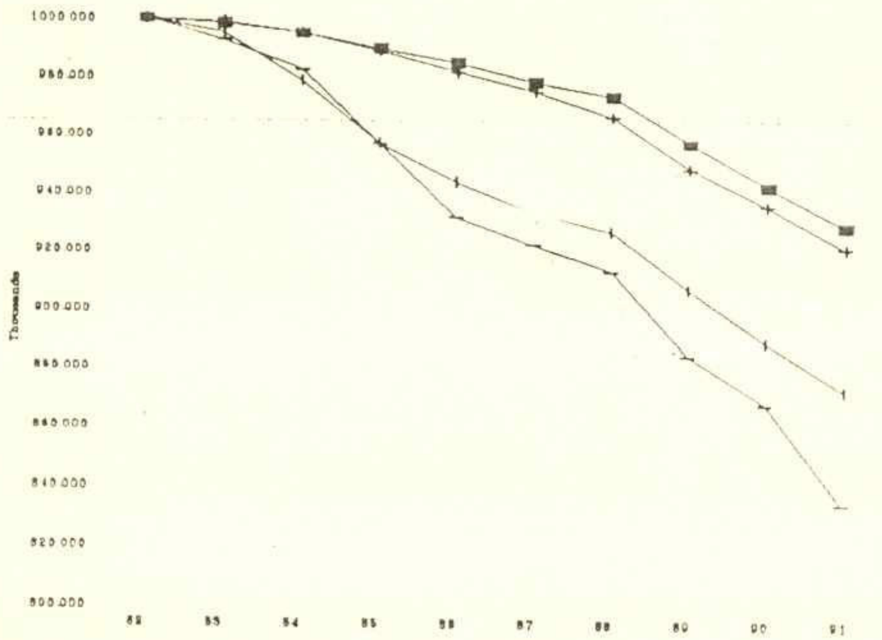

Figure 8: Result of Out-migration by Occupation

difference occurred in 1986, when the rates of out-migration from inside were higher than outside for heads of households with two or fewer durable items.

Area of the dwelling, another indicator of socioeconomic status, was used to divide heads of household into quartiles in each area (Appendix 5, Panel B). Res ts were similar to those for consumer durables. Heads of the wealthiest households, those in the upper quartile of the housing area measure, were the least likely to leave either area. No significant differences between areas in the propensity to leave an area was found for the top three quartiles between 1982 and 1990 (except in 1985, when heads in the next to lowest quartile were more likely to leave the outside area than the inside). Heads of the poorest households were significantly more likely to leave the inside area than the outside area in 1984 and 1985 (before the embankment was completed) and in 1988.

Occupation of the head of household reveals a similar pattern, as shown in Figure 8 (Appendix 5, Panel C). In the area outside the embankment farm owners were the least likely to out-migrate, followed by agricultural laborers and then by fishermen/boatmen and those in service. The pattern is fairly similar inside the embankment. There is one seemingly anomalous result here: fishermen/boatmen are less likely to have left the area inside the embankment than outside, despite the assumed decline in fishing and transport by boat after the completion of the embankment. Virtually none of the differences by occupation between the two areas are significant, however.

5. Discussion and Conclusions

The objective of this study has been to examine the impact of a flood control project in Bangladesh on the health, nutrition, and mortality of people in the affected areas. Three hypotheses were discussed. First, the direct impact of flood control projects should be to improve the agricultural output in the area. This should improve the health and nutritional status of the population, especially of children, and lower mortality. A second question concerns the distribution aspects of "green revolution" agricultural change. If, as has been found elsewhere, these changes benefit only some groups and leave others worse off, there is a chance that there will be a negative impact, in terms of health, nutrition, and survival, among disadvantaged groups. Finally, there has been a growing concern that building an embankment around an area and thus preventing the annual flooding would lead to increased water contamination, with the same negative results.

This study examined the Meghna-Dhonagoda embankment, completed in 1987. Excellent data had been (and continue to be) collected by the ICDDR,B before and after its construction to help evaluate its impact. This embankment should be fairly typical of other planned flood control projects, and the ICDDR,B data are well suited to this study. (If any bias exists it is probably in the direction of underestimating any negative impact of the embankment, since the study area does not include many villages in the interior of the embanked area.) Analysis of a census conducted in the area in 1982 revealed no major socioeconomic or demographic differences between areas that would eventually be inside and outside the embankment. Households in the inside area owned a few more boats, on average; this should have made them more vulnerable to the reduction in fishing and water transport jobs brought about by the embankment.

The impact of the Meghna-Dhonagoda project was measured by the differences in diarrhoea morbidity, nutritional status, and mortality among children living inside the embankment area compared to those living on the outside. There were changes in diarrhoeal incidence between 1986 and 1990, with a major peak occurring late in 1988, but the pattern was similar on both sides of the embankment. There was no decrease in the seasonal pattern of diarrhoea due to the construction of the embankment. The flooding due to the breaches in 1987 and 1988, and the controlled flooding after that, appear to have been sufficient to maintain the seasonality of this disease. Nutritional status in Matlab, as measured by the mid-upper arm circumference of children under five, increased slowly between 1986 and 1990, but there were no important differences attributable to the completion of the embankment. The proportion of severely malnourished children fell throughout the same period, but again there were no major differences between the two areas. Neither infant mortality nor child mortality, good measures of the adverse effects of disease and malnutrition, revealed significant differences resulting from the embankment.

Out-migration from both areas was compared, since differences in the propensity to leave the areas could have resulted in a selectivity bias, underestimating the negative impact of the embankment. No differences were found in the migration probabilities of any of several socioeconomic groups measured. Wealthy and poor people living outside the embankment were just as likely to leave their area as were similar people inside the embankment. A surprising result was that neither fishermen and boatmen, nor people owning two or more boats, began leaving the area inside the embankment.

People living in rural Bangladesh appear to be very good at coping with whatever challenges confront them, whether they are floods, cyclones, or embankments. They seem to have adapted to the change in the environment caused by the construction of the Meghna-Dhonagoda embankment, at least during the period we studied, since there was no major impact on their health. They also seem to have adapted to the change in employment opportunities caused by the embankment without having to leave their community.

Thus, the overall conclusion of this study is that there has been no major negative impact, to date, on the health or nutritional status of people living in areas inside the embankment. This is the optimistic lesson. On the other hand, perhaps we should expect more from a multi-million dollar project. Especially if agricultural output is rising we would hope to see an improvement in the nutritional status of children

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Kendall, Maurice. Time Series. (2nd ed.) Charles Griffin and Company, London, 1976.living inside the embankment compared to those living outside of it.

APPENDIX 1

Percent of Children with Diarrhoea in Past 14 Days*

Month	1986			1987			1988			1989			1990		
	Inside	Outside	t	Inside	Outside	t	Inside	Outside	t	Inside	Outside	t	Inside	Outside	t
Jan	1.8%	2.4%	*	2.0%	3.0%	***	2.2%	3.4%	***	4.6%	7.5%	***	3.1%	5.0%	***
Feb	2.3%	2.7%		1.4%	2.1%	***	2.8%	2.6%		4.0%	6.3%	***	4.3%	5.0%	*
Mar	2.0%	2.3%		1.8%	2.1%		2.8%	4.1%	***	5.7%	8.0%	***	5.1%	6.4%	***
Apr	2.6%	3.2%	**	3.0%	4.6%	***	3.2%	4.7%	***	9.0%	9.4%		4.5%	5.7%	**
May	2.5%	2.8%		2.0%	3.4%	***	3.4%	3.3%		6.6%	6.9%		3.3%	4.0%	*
Jun	2.9%	2.4%		1.3%	3.2%	***	4.9%	4.0%	*	8.8%	10.0%	**	4.3%	6.0%	***
Jul	2.0%	2.3%		3.6%	3.5%		6.0%	7.1%	*	5.3%	8.4%	***			
Aug	1.8%	2.2%	*	3.4%	4.1%	*	5.5%	5.9%		4.8%	5.9%	**			
Sep	1.9%	2.4%	*	3.1%	4.3%	***	7.7%	6.5%	*	4.3%	5.9%	***			
Oct	2.4%	2.8%		4.1%	3.7%		8.2%	6.8%	*	4.2%	5.3%	**			
Nov	2.0%	3.2%	***	2.7%	2.8%		7.9%	6.7%	*	3.3%	5.0%	***			
Dec	1.8%	2.8%	***	1.8%	3.3%	***	8.1%	8.9%		4.5%	5.2%	*			

*Matlab MCH-FP treatment area

t (significance level) * .05 ** .01 *** .001

APPENDIX 2

Mid-upper Arm Circumference (MUAC)*

Date		Mean MUAC			% with MUAC < 110 mm		
		Inside	Outside	t	Inside	Outside	t
1986	Dec	130.0	128.6	***	3.8	4.4	***
1987	Mar	133.7	132.5	***	1.5	1.9	***
	Jun	134.2	133.1	***	1.2	2.0	***
	Sep	133.6	132.6	***	1.6	2.1	***
	Dec	133.7	133.4		1.6	2.0	
1988	Mar	134.1	134.6		1.4	1.5	
	Jun	133.4	134.0	*	1.4	1.5	*
	Sep	133.6	134.6	***	1.7	1.3	***
	Dec	134.3	135.6	***	1.5	1.0	***
1989	Mar	135.6	136.7	***	0.6	0.8	***
	Jun	134.3	135.2	***	1.0	1.2	***
	Sep	135.8	136.7	***	0.7	0.9	***
	Dec	137.1	137.9	**	0.6	0.6	**
1990	Mar	136.6	137.9	***	0.9	0.6	***
	Jun	137.4	137.4		0.8	0.6	

*Matlab MCH-FP treatment area
t (significance level) * .05 ** .01 *** .001

APPENDIX 3

Infant Mortality Rates—Matlab, 1975-1991

Year	MCH-FP			Comparison			Both areas		
	Inside	Outside	t	Inside	Outside	t	Inside	Outside	t
1975	100.7	96.9		82.3	108.0	*	87.8	100.7	
1976	90.4	97.9		95.1	100.4		93.7	98.8	
1977	117.0	115.7		111.6	109.5		113.3	113.4	
1978	115.3	116.0		108.5	143.9	**	110.4	127.1	*
1979	130.1	111.4		119.3	116.9		122.0	113.7	
1980	100.3	91.2		113.2	119.4		109.8	102.6	
1981	134.3	95.7	*	113.1	112.2		118.6	102.4	*
1982	82.3	107.3	*	104.5	132.8	**	98.8	117.6	***
1983	94.9	100.4		109.2	117.6		105.5	107.6	
1984	121.1	118.0		140.6	130.0		135.7	122.9	
1985	106.2	83.7		116.9	121.9		114.2	99.7	
1986	95.2	81.2		101.6	91.8		99.9	85.5	
1987	86.5	78.2		96.1	95.9		93.7	85.6	
1988	76.9	82.2		104.1	89.3		97.3	85.3	
1989	66.3	80.6		92.1	94.2		86.1	86.4	
1990	72.1	76.5		88.1	93.6		84.2	84.1	
1991	77.7	81.5		113.8	116.3		106.0	96.4	

t (significance level) * .05 ** .01 *** .001

APPENDIX 4

Child Mortality Rates—Matlab, 1983-1990

	Age 1 year			Age 2-4 years		
Year	Inside	Outside	t	Inside	Outside	t
1983	52.5	41.4		25.9	23.8	
1984	66.5	37.5	***	33.6	23.5	***
1985	32.5	27.8		20.8	16.7	
1986	32.5	29.7		13.2	13.7	
1987	23.7	22.4		7.2	9.4	
1988	24.8	16.8	*	9.1	8.2	
1989	17.5	17.7		4.4	5.9	
1990	12.6	13.4		5.1	4.7	

t (significance level) * .05 ** .01 *** .001

APPENDIX 5 (cont.)

(C) Occupation of Head of Household											
Inside	farm owner	1000	998	995	990	985	978	974	957	942	929
	agric labor	1000	991	975	959	947	937	924	904	881	862
	fish/boat	1000	995	979	957	944	933	926	907	889	873
	service	1000	992	973	951	931	913	898	877	860	845
	other	1000	987	964	922	905	887	866	828	796	755
Outside	farm owner	1000	999	995	989	982	975	966	948	936	921
	agric labor	1000	994	981	970	961	952	940	925	903	889
	fish/boat	1000	993	982	957	932	922	913	884	868	834
	service	1000	991	971	952	933	918	899	884	862	844
	other	1000	983	963	943	926	896	881	842	817	795
(D) Number of Boats Owned											
Inside	0	1000	990	968	945	925	909	894	870	850	829
	1	1000	997	991	981	975	967	960	943	925	913
	2+	1000	995	993	988	983	972	962	954	943	923
Outside	0	1000	991	974	956	940	926	908	890	868	848
	1	1000	997	991	983	973	966	958	941	925	911
	2+	1000	1000	998	993	984	977	972	955	942	922

28