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BENEFIT-COST ANALYSIS OF DEEP AND SHALLOW TUBEWELL PROJECTS IN THE TANGAIL DISTRICT IN BANGLADESH

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ABSTRACT

This study examines the profitability of deep tubewell (DM and shallow tubewell (STW) projects in the Tangail District in Bangladesh from the viewpoints of participating farmers, managers and society. The appraisal is based on the actual rather than planned levels of utilisation. Only the direct/tangible benefits and costs of these projects are taken into account. Secondary and intangible benefits and costs together with flow-on effects are ignored.

The general findings are that the DTW and STW projects are profitable from the viewpoints of participating farmers and managers, but unprofitable from the viewpoint of society. The results of sensitivity analyses reveal that the profitability of these projects is positively related to command areas.

1. INTRODUCTION

It has long been realised that the dry season in Bangladesh is the safer for successful crop production, provided irrigation facilities are available. To this end, deep tubewells (DTWs) and shallow tubewells (STWs) h-ive been introduced. A major component of the improved agricultural production technology in Bangladesh is irrigation in the sense that the productivities of other inputs, for example, high yielding variety (HYV) of seeds, fertilisers etc., largely depend on the availability of ensured water supply in the cropfields.

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All mechanical water lifting devices in Bangladesh have been sold with subsidy. However, pressures have been placed by donor agencies on the Government of Bangladesh to reduce subsidy on agricultural inputs. As a result, prices of almost all agricultural inputs such as fertilisers, pesticides etc., have gone up. Subsequently, some farmers have been arguing that crops cultivated under DTW and STW projects are unprofitable and some managers of tubewells have been claiming that DTW and STW projects are unprofitable. In fact, few hard data are available about the profitability to farmers or owners/ managers of tubewell projects under specific agro-climatic conditions.

Johnson (1985) argued that the Government of Bangladesh arbitrarily recommended areas irrigated of 24.3 ha (60.0 acres) for a DTW and 5.0 ha (12.0 acres) for a STW project. In fact, the average command areas of tubewells have decreased over the past few years while the number of tubewells has appreciably increased (Hamid 1977, Jaim and Bahman 1978, Chakravorty 1985, Mandal 1986, and Miah 1987). This implies that there is a divergence between what is perceived optimal, by farmers or managers and what national planners believe should be the case.

This study was therefore designed to provide empirical evidence relevant to the abovementioned problematic situations taking into account the actual rather than planned levels of utilisation of the tubewells.

The main objectives of the study were

i. to assess the profitability of growing HYV boro paddy under DTW and S'I`W projects from the viewpoint of participating farmers ;

ii. to assess the performance of DTW and STW projects from the viewpoint of managers;

iii. to assess the performance of DTW and STW projects from the viewpoint of society;

iv. to identify the effects on profitabilities of DTW and STW projects from the viewpoint of managers and the society if command areas under each of the projects vary ; and

v, to suggest policy guidelines/recommendation.

The following hypotheses were tested:

(a) Cultivation of HYV boro paddy under tubewell projects is unprofitable from the viewpoints of participating farmers.
(b) DTW and STW projects are unprofitable from the viewpoints of managers.
(c) DTW and STW projects are unprofitable from the viewpoint of society.

Hypotheses (b) and (c) were tested for the average command areas that are observed in the selected study area. In addition, the effect on profitability of variation in command areas was investigated.

This paper comprises four sections. After this introduction Section II deals with research methods. In this section, data source and methods of appraisal are presented. Section III embodies that results of the appraisal and sensitivity analysis of the tubewell projects. Policy implications are included in Section IV.

II. RESEARCH METHODS

Data Source

Fulki Union of Basail Upazila (i.e., sub-district) in the district of Tangail, which is located about 13 km east of Tangail town, was purposively selected for the investigation. The area had the largest number of both DTW and STW projects in the Basail Upazila. The area is one with typical low-lying farms growing HYV of paddy in the boro season irrigated from DTWs and STWs.

Data were collected from primary sources. A two-stage sampling procedure was followed. In all, 20 projects, 10 out of 23 DTWs and 10 of 135 STWs, were randomly selected. At the second stage, an accidental sampling technique had to be used. In total 100 farmers, at the rate of five farmers from each of the sampled projects, were selected as the ones first encountered during the visits to the study area.

Two sets of questionnaires, one for project managers and the other for farmers, were used to collect relevant information. The fieldwork covered the period from March 1985 to April 1986. However, formal survey data were collected during the period d from July 5 to August 15, 1986. The data so collected were then summarised for each farm/ project, tabulated and analysed to obtain data useful in the project appraisal calculations. It was found that four of the sample often DTWs were powered by electricity. The casts of diesel and electrically-powered DTWs were therefore calculated separately. (Appendix Tables 7 and 8).

Methods of Appraisal

The method of project appraisal suggested by Gittinger (1982) was -followed, since it is widely used by the World Bank and also many other donor and planning-agencies, particularly for agricultural and/or rural based projects. Moreover, the method is well-suited to testing the hypotheses and so to achieving the ultimate objectives of the study. Both financial and economic analyses were done for DTW and STW projects.

Financial analysis was conducted as follows

(a) Financial analysis from the viewpoint of participating farmers under oath of DTW and STW projects. In this analysis there is no need to employ discounted cash flow techniques, since farmers incur no major capital costs such as purchasing a DTW and/or STW. The results are expressed on a per hectare basis. The per hectare analysis is conceptually simple and analytically advantageous to use in the further appraisal calculations.

(b) Financial analysis from the viewpoint of a typical manager taking into account his 25 per cent share of income from a porject (i.e., the actual situation). In other words, managers of tubewell projects bear all costs (fixed and operating) for irrigation in exchange for 25 per cent of the harvested HYV boro paddy from each participating farmer who cultivates under the projects.

(c) Financial analysis from the viewpoint of a project manager who incurs all costs and obtains full income, as if he irrigates owned land only (i.e., a hypothetical but feasible situation).

In the financial analyses, all costs and benefits were determined in domestic currency using farm-gate prices. In pricing in economic analyses, the opportunity costs to the society of the inputs used and outputs generated are considered. These prices are known as shadow or accounting prices. The shadow prices are generally calculated for the rate of interest, wage rate and foreign exchange rate. Since shadow prices of these items with the exception of foreign exchange rate, are available (Appendix Table 2), the economic analysis has been done using these values. However, for some non-traded commodities such as Kheshari (a kind of inferior pulses), by-products etc., no conversion factors were available. It is assumed that the finanial values of these goods reflect their true opportunity costs/values to the society.

To obtain the shadow exchange rate (SER), the official exchange rate (OER) was multiplied by 1 plus 30 per cent foreign exchange premium (i.e., Tk 30.40 x 1.30 = Tk 39.52 = US $1). Note that the OER during the period of data collection (1986) was Tk 30.40 = US $ 1, while the foreign exchange premium was 30 per cent (Miah 1987). This shadow exchange rate was applied to all traded and import substitute items in the financial analyses to obtain true social costs.

The shadow prices of imported materials and equipment were calculated from CIF (cost, insurance and freight) prices. The CIF price reflects the marginal import cost (MIC), where import duty or any other tariffs and sales tax on imports are excluded. On the other hand, some payments that appear in the cost streams of the financial analysis do not represent direct claims on the society's resources but merely reflect a transfer of the control over resource allocation from one member or sector of society to another (Squire and van der Tak 1975). In this study, for example, payments of water charge by farmers to managers, and bribes to the relavant officials both for having a tubewell and making an electric connections to the tubewells, are transfer payments. Therefore, these transfer payments have not been taken into account in the economic analysis. The value of subsidies was added to the cost of inputs and deducted from the farm-gate prices so as to reflect all commodities at their true economic price (Brown 1976).

For both financial and economic analyses, only tangible benefits and costs were taken into account. Secondary effects, intangible benefits and costs as well as flow-on effects were not taken into consideration.

'With' versus 'Without' the Project

The benefit-cost analysis has been done taking into account the 'with' and 'without' situation for DTW and STW projects. In this study, non-irrigated crops refer to those crops such as Kheshari, and mixed aus and amon paddy which were grown 'without' the tubewell project. Irrigated crops, on the other hand, imply only HYV boro paddy which has been grown in the same area under the 'with' project situation. Accordingly, activity budgets (see Dillon and Hardaker 1980) have been prepared for non-irrigated crops (Appendix Tables 3 and 4) and irrigated HYV boro under different systems of irrigation (Appendix Tables 5 and 6).

The net benefits from the 'without' project situation were deducted from the benefits 'with' the project situation in the usual way to arrive at incremental benefits. A comparison was made of the present worth of benefits and costs to arrive at benefit-cost ratio (BCR), net present value (NPV) and internal rate of return (IRR). Mathematical formulations of these discounted measures are presented in Appendix 1.

Benefits of Tubewell Projects

The items under the benefits of DTWs and STWs are :

(a) Gross value of production—this includes the value of main product and the value of by-products; and

(b) Salvage value—estimated at 15 per cent and 30 per cent on the initial value of a DTW and STW, respectively, and shown as benefits to the projects in the last years of the relevant project life. The average lives of DTWs and STWs were set as 15 and 10 years, respectively.

Costs of Tubewell Projects

The costs of DTW and STW projects can broadly be classified under the following heads :

(a) Investment costs;

(b) Operation and maintenance (0 and M) costs ; and

(c) Production costs.

Investment costs. These include; capital cost of the tubewell itself including the cost of the pump and motor, cost of pump house and cost of electricity connection (where applicable).

In this study, the ownership pattern (rented or owned) was ignored. It was assumed that tubewells were purchased by managers. The initial purchase value was taken as one of the components of investment costs. Each of the DTWs surveyed was installed by the BADC, and it had a permanent pump house, which was also constructed by the BADC to protect the DTW equipment. The cost of the pump house was therefore ignored in the financial analysis but was considered as a component of investment costs in the economic analysis. No permanent pump house was seen in the study area for STWs.

Since the BADC has no responsibility for providing electricity connections to DTWs and STWs, project managers had to arrange this with the Power Development Board (PDB) or the Rural Electrification Board (REB). The managers of tubewells had to pay the concerned officials for making the electricity connections. The entire amount spent for the purpose of electric connection was considered as one of the components of investment costs in the financial analysis. In the economic analysis, bribes to the official of the PDB or the RED for the purpose of electric connection were ignored since these were viewed as transfer payments.

(b) O and M costs. These costs involve: cost of fuel/electricity, cost of spare parts and mechanics fees, and salaries for the fieldman and operator. All O and M costs were borne by the managers of the projects.

(c) Production costs. As stated before, the financial analysis was classified into three distinct categories. As a result, items of production costs vary according to the type of analysis.

When a costs and returns analysis was done from the viewpoint of individual farmers, production costs were defined to include costs of human labour, animal labour, seeds/ seedling, water charges, fertilisers, tools and equipment, and interest on operating capital. Benefits to farmers were reduced by the proportion of the value of production going to managers. Production costs from the viewpoint of managers under the actual situation are the investment and 0 and M costs. Managers were assumed not to incur any costs for crop production other than the investment and 0 and M costs, while 25 per cent of the benefits from crops grown were allocated to managers. When the financial analysis was done as if the full costs would be incurred and full benefits would be received by managers (i.e., hypothetical but feasible situation), the production costs included all costs, as stated above, associated with crop production, plus investment and 0 and M costs. All -benefits were assumed to flow to the manager in this case.

Discount Rate

In selecting appropriate discount rates for financial and economic analyses, an effort was made to capture the real world situation. The interest rate policy for rural credit is highly complex and debatable subject in low-income countries such as Bangladesh. The policy is based not only on economic criteria but also on social and political factors. Often socio-political consideration outweigh economic consideration as a determinant of the policy (Gangopadhyay 1978).

In the event, the lending rates on agricultural credit from banks are highly subsidised and vary from one financial institution to another. The lending rate for agriculture (production) is 16 per cent, while the available latest (1984) consumer price inflation rate is 12 per cent (EIU 1986). The interest rates chosen for financial analysis should be inflation free when cash flows are projected using constant (inflation free) prices. On the other hand, it has been argued that the opportunity costs of capital in less developed countries (IDCs) vary from 8 to 15 per cent (Mukhopadhyay 1973, Anderson and Settle 1978, and Gittinger 1982).

In view of these circumstances the financial analyses were performed using a wide range of discount rates from 4 per cent (for inflation-free borrowing rate), 15 par cent (the true opportunity cost of capital), and 16 per cent (ignoring the current inflation rate). Such a range reflects the range of possible real situations faced by investors. For the economic analysis a 15 per cent discount rate was chosen, since it is the opportunity cost of capital that is relevant for assessing social profitability.

III. RESULTS AND DISCUSSION

The appraisal results of the projects from the viewpoints of participating farmers, Project managers and society are presented in this section. First, the results of financial and economic analyses are presented, followed by those of the sensitivity analyses.

Financial Analyses

The financial appraisal calculations of the tubewell projects are based on the following assumptions.

i. All tubewells are purchased for cash.

ii. The average command areas under each of diesel and electrically operated DTWs are the same, ie., 15.5 ha, while these are 5.0 ha in the case of STW. There is no change in the command areas throughout the project life.

iii. Cropping patterns, production technology and yields remain constant over time for each type of project.

iv. Prices of all inputs and outputs are given and constant.

To test the hypotheses stated earlier, three discounting measures of BCR, NPV and IRR have been calculated. However, when the IRR criterion has been used in financia analyses, the result is called the internal financial return (IFR), while it is identified as the internal economic return (IER) in the economic analyses.

Hypothesis (a), that the cultivation of HYV boro paddy under tubewell projects is unprofitable fom the viewpoints of participating farmers, can be written:

H_0 : Annual net benefit is less then zero.

H_1 : H_o is not true.

It is evident from Table 1 that the annual net benefits per hectare are greater than zero, hence, H_o is rejected. This implies that the cultivation of HYV boro paddy is profitable under DTWs and STWs from the viewpoint of individual farmers. The results, however, indicate that the farmers in DTW projects earn slihtly higher benefits than the farmers in STW projects.

TABLE 1. RESULTS OF FINANCIAL ANALYSIS FROM THE VIEWPOINT OF FARMERS IN DTW AND STW PROJECTS

Project category	Annual net benefits
	Tk 10^3 / ha
Farmers under DTW projects	1.54
Farmers under STW projects	1.29

Source : Miah (1987, p. 58)

Hypothesis (b), that DTW and STW projects are unprofitable from the viewpoints of managers ,can be writteen :

H_o : BCR of the DTW and STW project is less than unity, or NPV of the DTW and STW project is less than zero, or IFR of the projects is less than the cost of capital.

H_1 : H_o is not true.

Table 2 indicates that the BCR of the diesel and electrically operated DTW and STW project is more than unity and NPVs are also positive at all the selected discount rates. All these projects yield much higher IFR than the possible opportunity costs of capital. H_0 is therefore rejected. In other words, these projects are attractive to individual managers considering the actual situation, It is evident from the results of all three criteria

(Table 2) that the electrically operated DTW project will bring a higher profit than the diesel operated DTW project.

Now attention is turned to the hypothetical situation. The hypothesis set for the actual situation is also equally applicable for the hypothetical situation (i.e., DTW and STW projects are unprofitable from the viewpoints of managers considering the hypothetical situation).

The results of financial analysis presented in Table 3 support rejection of H_0. These imply that all projects are attractive to the managers in terms of profitability under the hypothetical situation.

Economic Analyses

Apart from the prices used for inputs and outputs, all assumptions that are made in the financial analyses apply to the economic analyses. The economic analyses have been done using the accounting prices (Appendix Table 2).

The hypothesis (c), that DTWs and STWs are unprofitable from the viewpoint of society, can be written as

H_0 : BCR of the DTW and STW project is less than unity, or NPV of the DTW and STW project is less than zero, or IER of these projects is less than the opportunity cost of capital.

H_1 : H_0 is not true.

TABLE 2. RESULTS OF FINANCIAL ANALYSES OF THE DTW AND STW PROJECT FROM THE VIEWPOINTS OF MANAGERS CONSIDERING THE ACTUAL SITUATION

Discounted measure	Diesel operated DTW	Electrically operated DTW	STW project (diesel)
BCR at 4%	1.67	2.0	1.23
BCR at 15%	1.41	1.62	1.18
BCR at 16%	1.39	1.59	1.17
NPV at 4% (Tk 10^3)	495	625	54
NPV at 15% (Tk 10^3)	190	248	27
NPV at 16% (Tk 10^3)	175	230	25
IFR (per cent)	48	54	74

Source : Adapted from Miah (1987, p. 59).

TABLE 3. RESULTS OF FINANCIAL ANALYSES OF THE DTW AND STW PROJECT FROM THE VIEWPOINTS OF MANAGERS CONSIDERING THE HYPOTHETICAL SITUATION

Discounted measure	Diesel operated DTW	Electrically operated DTW	STW project (diesel)
BCR at 4%	1.65	1.85	1.33
BCR at 15%	1.49	1.63	1.30
BCR at 16%	1.47	1.60	1.29
NPV at 4% (Tk 10^3)	781	911	111
NPV at 15% (Tk 10^3)	341	399	62
NPV at 16% (Tk 10^3)	319	374	59
IFR (per cent)	88	90	371

Source : Adapted from Miah (1987, p. 61).

The results presented in Table 4 support acceptance H_o. Hence, H_1 is rejected. As can be seen from the table, the DTW (both the diesel and electrically powered) and STW projects failed to achieve the unit BCR and the NPV is also negative at the 15 per cent discount rate for all projects. The IERs of these projects are far below the opportunity cost of capital. In other words, none of the projects is profitable from the viewpoint of society. Since the BCR of the STW project is quite close to unity, society may prefer the STW to the DTW projects.

One of the main reasons for the difference in results between the private and social profitability of these projects lies in the different prices used. In particular, the social value of rice, reflected in the shadow price used, is appreciably less than the farmers' price.

As stated in the assumptions, the survey average of 15.5 ha (with a sample standard deviation of 4.7 ha) of cropland has been considered in the analyses as the command area for a DTW project. The recommended area for a DTW, on the other hand, is

24.3 ha. As a result, there is a considerable underutilisation of water. By contrast, the average irrigated area for STW projects found in the survey was 5.0 ha (with a sample standard deviation of 1.0 ha), equal to the recommended area (Miah 1987), Because economics of tubewell projects is likely to depend strongly on area irrigated, sensitivity analysis of these projects was undertaken taking into account the deviations in command areas from the sample means.

Sensitivity Analysis

Upper and lower values for command areas for the sensitivity analysis were set as the survey mean plus and minus one standard deviation, respectively. Assuming that the distribution of command areas is approximately normal, some two-thirds of cases should fall within this ranges. Thus, the areas analysed for DTW projects were 20.2 ha and 10.8 ha. Similarly, the command areas considered for a STW project were 6.0 ha and 4.0 ha.

The previous analyses have been reworked using these command areas to see what happens to profitability under the changed conditions. In O and M costs, salaries of the operator and fieldman will virtually remain the same as command area changes, but some costs such as fuel/electricity may vary slightly with area. For analytical simplicity, however, it was assumed in sensitivity analyses that there will be no change in the O and M costs.

TABLE 4. RESULTS OF ECONOMIC ANALYSES OF THE DTW AND STW PROJECT

Type of project	BCR at 15%	NPV at 15%	IER
		Tk 10^3	%
Diesel operated DTW	0.76	-188.0	1
Electrically operated DTW	0.68	-270.0	<0
Diesel operated STW	0.85	-27.0	<0

Source : Miah (1987, p. 63).

Effects on financial analyses were explored for the actual as well as the hypothetical situations. As can be seen from Table 5, BCRs and NPVs of diesel and electrically operated DTW projects indicate that the managers who have 20.2 ha of command areas earn quite substantial profits under the actual and hypothetical situations. Table 2 shows that the IFRs of diesel and electrically operated DTW projects under both the actual and hypothetical situations were 48 and 54 per cent respectively. By contrast, the IFR stands as high as 105 per cent for both the diesel and electrically operated DTWs having 20.2 ha (Table 5). Similarly, in the hypothetical situation, the IFR of the DTWs with the average command area was 90 per cent (Table 3), while Table 5 shows that the IFR has become more than 200 per cent. In other words, the profitabilities of these projects are highly sensitive to changes in command areas.

Table 5 shows that the electrically operated DTW is still more profitable in terms of BCR or NPV than the diesel operated DTW from the viewpoint of managers under both actual and hypothetical situations. This finding, however, contradicts the indications in terms of IFR, especially in the case of the hypothetical situation. The reason for the anomoly is presumably due to variations in net benefits of the two types of DTW projects over the project life.

Table 6 indicates, as expected, that the managers of a diesel operated DTW project having 10.8 ha under the actual situation earn less profit in terms of the BCR and NPV than for projects having higher command area. In fact, they face a loss at 15 and 16 per cent discount rates.

These results support the claims of some managers that DTW projects are no longer profitable under the existing situation. Projects with as little as 10.8 ha irrigated are unprofitable at the 15 and 16 per cent discount rates. Table 6, however, shows that the managers could still make profits on such an area if they could irrigate their own cropfields or could drive the DTWs by electricity.

TABLE 5. RESULTS OF SENSITIVITY ANALYSES OF DTW PROJECTS FROM THE VIEWPOINT OF MANAGERS CONSIDERING 20.2 HA OF COMMAND AREA

Type of project	BCR at			NPV at			IFR
	4%	15%	16%	4%	15%	16%	
				Tk 10^3	Tk 10^3	Tk 10^3	%
Actual Situation							
DTW (Diesel)	2.15	1·84	1.81	868	386	362	105
DTW (Electric)	2.61	2.11	2.07	998	445	417	150
Hypothetical Situation							
DTW (Diesel)	1.93	1.76	1.74	1241	583	549	237
DTW (Electric)	2.14	1.90	1.88	1371	641	604	211

Source : Adapted from Miah (1987, p. 68).

TABLE 6. RESULTS OF SENSITIVITY ANALYSES OF DTW PROJECTS FROM THE VIEWPOINT OF MANAGERS CONSIDERING 10.8 HA COMMAND AREA

Type of project	BCR at			NPV at			IFR
	4%	15%	16%	4 %	15%	16%	
				Tk10³	Tk10³	Tk10³	%
Actual Situation							
DTW (Diesel)	1.16	0.99	0.97	121	-6	-12	14
DTW (Electric)	1.40	1.13	1.11	251	52	43	22
Hypothetical Situation							
DTW (Diesel)	1.30	1.16	1.14	321	99	88	30
DTW (Electric)	1.48	1.28	1.26	451	157	143	36

Source : Adapted from Miah (1987, p. 69).

As can be seen from Table 7, managers of STW projects having 6.0 ha of cropland earn good profits under the actual situation. The BCRs and NPVs for all discount rates (i.e., 4, 15 and 16 per cent) are attractive to the managers. And the IFR of the project stands as high as 338 per cent.

Once again, the BCRs and NPVs are highly sensitive to changes in command areas. In the worst cases considered where the coverage of the project is only 4.0 ha, managers are making a loss at 4, 15 and 16 per cent discount rates under the actual situation. In this situation, a STW project yields only 1 per cent IFR.

Table 7 indicates that is possible to earn a profit from a STW project having 4.0 ha if a manager could irrigate his own cropfields. In this hypothetical case the table shows that the BCR is more than unity, the NPV is positive at 4, 15 and 16 per cent discount rates, and the project yields 55 per cent IFR.

Although the profitability of electrically powered STW projects was not investigated in this study, it may be inferred from the DTW results that, if electricity could be extended to the projects, benefits might have been higher than the existing situation.

Effects on Economic Analyses

In addition to the command areas considered above based on survey results, the recommended 24.3 ha for a DTW project is considered to examine the impact on profitability from the viewpoint of society. In the case of STW projects, the average command area is the same as the recommended area (i.e., 5.0 ha), so no further case needed to be examined.

As can be seen from Table 8, society is making loss from DTW projects with the exception of the project having 24.3 ha command area. For the diesel operated DTW project having 24.3 ha, the BCR is more than unity and the NPV is Tk 49000 at 15 per cent discount rate. The IER of the project is 18 per cent which is higher than the opportunity cost of capital (i.e., 15 per cent). Although an electrically powered DTW project having 24.3 ha earns less profit than the diesel operated DTW from the viewpoint of society, the BCR is still just more than one, the NPV is Tk 7000 and the IER is 15 per cent. The abovementioned evidence strongly supports the government recommended area for the DTW project (i.e., 24.3 ha), which is economically desirable from the viewpoint of society as well as managers.

It appears from Table 9 that society is making a loss whether STW projects are operating at the higher or lower command areas. The loss, however, is negligible in the case of projects having 6.0 ha command area.

TABLE 7. RESULTS OF SENSITIVITY ANALYSES OF STW PROJECTS FROM THE VIEWPOINT OF MANAGERS CONSIDERING 6 AND 4 HA COMMAND AREAS

Type of project	BCR at			NPV at			IFR
	4%	15%	16%	4%	15%	16%	
				Tk 10^3	Tk 10^3	Tk 10^3	%
Actual Situation							
STW having 6 ha	1.47	1.41	1.40	111	62	59	338
STW having 4 ha	0.98	0.95	0.94	-3	-8	-9	1
Hypothetical Situation							
STW having 6 ha	1.51	1.47	1.46	179	104	100	a
STW having 4 ha	1.13	1.10	1.09	43	20	19	55

Source : Adapted from Miah (1987, p. 70).

a : Indeterminate since the flow of net benefits was always positive.

TABLE 8. RESULTS OF SENSITIVITY ANALYSES OF DTW PROJECTS FROM THE VIEWPOINT OF SOCIETY CONSIDERING 24.3, 20.2 AND 10.8 HA COMMAND AREAS

Type of project	BCR at 15%	NPV at 15%	IER
		Tk 10^3	%
Considering 24.3 ha			
DTW (Diesel)	1.06	49	18
DTW (Electric)	1.01	7	15
Considering 20.2 ha			
DTW (Diesel)	0.93	-61	11
DTW (Electric)	0.88	-104	8
Considering 10.8 ha			
DTW (Diesel)	0.57	-315	< 0
DTW (Electric)	0.53	-357	<0

Source : Miah (1987, p. 72).

TABLE 9. RESULTS OF SENSITIVITY ANALYSES OF STW PROJECTS FROM THE VIEWPOINT OF SOCIETY CONSIDERING 6 AND 4 HA COMMAND AREAS

Type of project	BCR at 15%	NPV at 15%	IER
		Tk 10^3	%
STW having 6.0 ha	0.97	-5	4
STW having 4.0 ha	0.71	-48	< 0

Source : Miah (1987, p. 73),

It is evident from the sensitivity analyses that the command area has a strong influence on the profitability of both DTW and STW projects. As expected, profits are positively correlated with the command areas of the project. With the exception of projects having the lowest command areas, all cases considered were found to be profitable from the viewpoint of managers. In contrast, none, except DTW projects having 24.3 ha command areas, is profitable from the viewpoint of society. The managers of DTW projects (and probably of STW projects) could earn more profits if they could run the projects by electricity. On the other had, the reverse is true from the viewpoint of society.

It should be noted here that the variation in command areas is, no doubt, one of the most important parameters of the environment of DTW and STW projects, changes in market/shadow prices, yields, technology, etc., are also likely to be important in determining profitability. In this study, only variation in command areas was considered in the sensitivity analyses. The study is therefore an incomplete attempt to handle risk and uncertainty.

IV. POLICY IMPLICATIONS

Under the assumptions made and the accounting prices used, none of these DTW and STW projects is economically justifiable from the viewpoint of society. Society's aim, however, for these projects may not necessarily be limited to profit earning alone. The aim is generally interrelated with other objectives of planning such as to improve income distribution, guarantee food security for the country etc., at both sectoral and national levels. Some considerations relevant to these objectives are discussed below.

The intensive use of resources and higher yields from irrigation imply that both DTW and STW projects can provide greater scope for a seasonal employment of landless/marginal farmers. Moreover, these projects can contribute to the goal of national self-sufficiency in food. In fact, paddy production can be more than doubled in irrigated projects over the non-irrigated situation. This increased production can help to save hard-earned foreign currency and to make society free from the curse of chronic food deficit.

Since these mutually exclusive DTW and STW projects have different project lives, substantial variation in command areas and capital outlays, none of the selected discounting criteria is suitable for the direct comparison of the projects. Ceteris paribus, one would expect a more costly or longer lasting project to have a higher NPV, yet for the same money and over the same period one might be able to implement several smaller projects. The difference in length of life of the projects, of course, can easily be handled by using the equivalent annuity criterion i.e., share of NPV over project life. Agricultural land in Bangladesh may be said to be the limiting resource to which returns are to be maximised. The equivalent annuities have therefore been expressed on a per hectare basis considering the different command areas for each of the projects to allow comparison of their profitabilities. It is evident from Table 10 that the DTW projects are more profitable than STWs if the recommended areas could be followed in practice.

However, the engines of STWs are often used during the off season in other parts of Tangail District either for mechanical rice husking or to convert an ordinary wooden boat into mechanical form. If these practices are introduced in the study area, the profitability of the projects could be other way round, i.e., STWs may earn higher benefits than DTWs. Moreover, the corruption associated with STW projects is less than for DTW projects. In addition, implementation of more DTW projects may create income distribution problem in the rural areas of Bangladesh.

As noted, policy decisions on whether or not to promote investments in DTWs and/or STW projects are likely to be made with several considerations in mind. The decisions are properly the domain of politicians and their policy advisers. The findings of this study may, however, contribute to more informed choices.

TABLE 10. SUMMARY RESULTS OF EQUIVALENT ANNUITY PER HECTARE OF TUBEWELL PROJECTS FROM THE VIEWPOINT OF SOCIETY

Type of project	Amount (per year)
	TK
DTW (Diesel) having 24.3 ha	347.0
DTW (Electric) having 24.3 ha	51.0
DTW (Diesel) having 20.2 ha	-519.0
DTW (Electric) having 20.2 ha	-876.0
DTW (Diesel) having 15.5 ha	-2076.0
DTW (Electric) having 15.5 ha	-2982.0
DTW (Diesel) having 10.8 ha	-4988.0
DTW (Electric) having 10.8 ha	-5655.0
STW (Diesel) having 6.0 ha	-173.0
STW (Diesel) having 5.0 ha	-1066.0
STW (Diesel) having 4.0 ha	-2411.0

Source : Miah (1987, p. 127).

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Investments from the viewpoint of managers in these projects are likely to continue to be made unless distortions in prices paid and received by tubewell owners are removed. Since electrically operated DTW projects are highly profitable to their owners, they face high temtation to bribe the concerned officials to secure electric power. Therefore, if the subsidy on electricity were to be reduced, society's burden would be decreased and a step would have been taken towards a corruption free society. On the other hand, the extension of electricity supply to rural areas is important for welfare reasons in that it allows rural people to enjoy some modern amenities.

This study confirms that the participating farmers can be better off from the cultivation of HYV bore paddy compared with farming of non-irrigated traditional varieties. Extension workers can therefore encourage farmers to grow more HYV bare using pro, per doses of fertilisers under tubewell irrigation to increase their farm incomes. However bribes taken by the officials of the Bangladesh Krishi Bank (BKB), BADC and PADB/ RED must be stopped to remove the bottlenecks in expanding efficient irrigation practices, while ensuring that regulations on command areas are enforced.

Since the data were collected from only six villages in the low-lying areas of Bangladesh, these appraisal results should be interpreted with considerable caution if any greater generalisations are sought, especially to areas of different topography.

APPENDIX 1 : MATHEMATICAL FORMULATION

$$\text{Benefit-cost ratio (BCR)} = \frac{\sum_{t=1}^{n} \frac{B_t - B'_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t - C'_t}{(1+i)^t}}$$

$$\text{Net present value (NPV)} = \sum_{t=1}^{n} \frac{(B_t - B'_t) - (C_t - C'_t)}{(1+i)_t}$$

Internal rate of return (IRR) is that discount rate i such that

$$\sum_{t=1}^{n} \frac{(B_t - B'_t) - (C_t - C'_t)}{(1+i)^t} = 0$$

Where

B_t = benefits in each year from the DTW/STW project.

B'_t = benefits in each year without the project.

C_t = costs in each year of the DTW/STW project.

C'_t = costs in each year without the project.

t = 1, 2,..........n.

n = number of years.

i = interest (discount) rate.

APPENDIX 2 : ACCOUNTING PRICES

	Product/Services	Conversion factor
1.	Power/gas	1.67
2.	Transport services	0.60
3.	Skilled labour	1.00
4.	Semiskilled labour	0.61
5.	Unskilled labour	0.50
6.	Rate of interest	0.15
7.	Petroleum	0.65
8.	Spares	0.60
9.	Machinery	0.60
10.	Diesel/HSD	0.94
11.	Animal labour	1.00
12.	Seeds/seedlings	0.67
13.	Manure	0.50
14.	Pesticides	1.00
15.	Tools and equipment	0.66
16.	Housing services	0.90
17.	Everything else	0.67
18.	Contingencies	0.66
	Traded Goods	
19.	Rice	0.68

Source : Adapted from Chakravorty (1985, p. 153).

APPENDIX 3. PER HECTARE BENEFITS AND COSTS OF NON-IRRIGATED KHESHARI

Items	Total Quantity	Financial Value/Costs	Economic Value/Costs
A. Gross Returns			
		Tk.	Tk.
Kheshari	1435 kg	3588	3588
By-product(bran)	n.a.	259	259
Total returns		3847	3847
B. Gross Costs			
Human labour	50 manday	1000	500
Seeds	95 kg	323	216
Interest on OC		26	—
Total costs		1349[a]	716
C. Net Return (A—B)		2498	3131

Sources : Adapted from Miah (1987, pp. 45 and 97).

[a]The production costs of non-irrigated kheshari from the viewpoint of managers are Tk. 1323 (=1349—26) per hectare.

APPENDIX 4. PER HECTARE BENEFITS AND COSTS OF NON-IRRIGATED MIXED AUS AND AMON PADDY

Items	Total Quantity	Financial Value/Costs Tk.	Economic Value/Costs Tk.
A. Gross Benefits			
Aus paddy	1053 kg	5686	3866
Amon paddy	1252 kg	6886	4683
By-product(straw)	n.a	754	754
Total benefits		13326	9303
B. Gross Costs			
Human labour	128 manday	2560	1280
Animal labour	80 pairday	3200	3200
Seeds	92 kg	552	370
Tools and equipment		140	92
Interest on OC		290	—
Total costs		6742 a	4942
C. Net Returns		6584	4361

Source : Adapted from Miah (1987,pp 46 and 98)

aThe production costs of non-irrigated aus and amon paddy from the viewpoint of managers are Tk. 6452 (=6742−290) per hectare.

APPENDIX 5. PER HECTARE BENEFITS AND COSTS OF IRRIGATED HYV BORO PADDY UNDER DIESEL AND ELECTRICALLY OPERATED DTW PROJECTS

Items	Total Quantity	Financial Value/Costs Tk	Economic Value/Costs Tk.
A. Gross Benefits			
HYV boro paddy	5347 kg	28339	19271
By-product (straw)	n.a.	247	247
Total returns		28586	19518
B. Gross Costs			
Human labour	210 manday	5250	2625
Animal labour	62 pairday	3100	3100
Seedlings	46 kg	368	247
Fertilisers :			
Urea	176kg	986	936
TSP	75kg	420	296
MP	10kg	40	35
Insecticides	n.a.	85	85
Water charges		7147	—
Tools and equipment		130	86
Interest on OC		438	—
Total costs		17964[a]	7410
C. Net Returns(A—B)		10622	12108

Source : Adapted from Miah (1987,pp. 47 and 99).

[a] Production costs of HYV boro paddy from the viewpoint of managers are Tk. 10379 (=17964—7585) per hectare.

APPENDIX 6. PER HECTARE BENEFITS AND COSTS OF IRRIGATED HYV BORO PADDY UNDER STW PROJECTS

Items	Total Quantity	Financial Value/Costs Tk.	Economic Value/Costs Tk.
A. Gross Returns			
HYV boro paddy	5225 kg	27693	18831
By-product (Straw)	n.a.	251	251
Total returns		27944	19082
B. Gross Costs			
Human labour	202 manday	5050	2525
Animal labour	62 pairday	3100	3100
Seedlings	46 kg	368	247
Fertilisers :			
Urea	176 kg	986	936
TSP	76 kg	426	300
MP	8 kg	32	28
Insecticides	n.a.	85	85
Water chrages		6986	—
Tools and equipment		111	73
Interest on OC		429	—
Total costs		17573[a]	7294
C. Net Returns(A—B)		10371	11788

Source : Adapted from Miah (1987, pp. 98 and 100).

[a] Production costs of HYV bora from the viewpoint of managers are Tk 10158 (=17573—7415) per hectare.

APPENDIX 7. SOCIETY'S COSTS FOR A DIESEL OPERATED DTW

Items	Financial Costs Tk.	Economic Costs Tk.
Investment Costs		
Pump, engine, etc.	175000	260000
Installation and housing	—	135000
Bribes	5500	—
Total investment	180500	395000
O and M Costs		
Spare parts	2917	1750
Mechanics fees	1817	1817
Diesel	32133	30205
Lubricant oil	2907	2849
Salaries :		
Operator	5750	5750
Fieldman	5667	3457
Drain maintenance	800	400
Total O and M costs	51991	46228

Source : Miah (1987, p. 101).

APPENDIX 6. SOCIETY'S COSTS FOR AN ELECTRICALLY OPERATED DTW

Items	Financial Costs Tk.	Economic Costs Tk.
Investment Costs		
Pump, engine, etc.	175000	260000
Installation and housing	—	135000
Electricity connection	20000	20000
Bribes	12500	—
Total investment	207500	415000
O and M Costs :		
Spare parts	1088	653
Mechanics fee	1075	1075
Electricity	23250	38828
Salaries :		
Operator	6000	6000
Fieldman	5750	3508
Drain maintenance	800	400
Total O and M costs	37963	50464

Source : Miah (1987, p. 102).

APPENDIX 9. SOCIETY'S COSTS FOR A STW

Items	Financial Costs	Economic Costs
	Tk.	Tk.
Investment Costs		
Pump, engine, etc.	18994	15600
Installation	355	355
Bribes	800	—
Total investment	20149	15955
O and M Costs :		
Spare parts	2540	1524
Mechanics fee	831	831
Diesel	16162	15192
Lubricant oil	1332	1305
Salaries :		
Operator	5250	5250
Drain maintenance	253	177
Total O and M costs	26368	24279

Source : Miah (1987, p. 103).

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